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tips & tools

FEEDLOTS

Heat load in feedlot cattle

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Managing heat load in feedlot cattle – an overview

Excessive heat load (EHL) in feedlot cattle during the summer months can result in significant production losses and animal welfare considerations. High body heat loads can develop in feedlot cattle when a combination of local environmental conditions and animal factors exceed the animal's ability to dissipate body heat.

Initially EHL will lead to a reduction in feed intake and therefore production losses. However, with severe or prolonged elevations in body temperature, tissue organ damage can result, and in some instances large numbers of cattle in individual feedlots have been lost during these extreme weather conditions.

The ability for feedlot operators to adopt management strategies to reduce the risk of EHL in cattle can minimise its impact on animal production, health and welfare if it does occur.

Management of EHL

Feedlot operators can influence the severity of the heat load burden placed on cattle during hot conditions by implementing a range of management strategies. If implemented individually these strategies may only have a limited effect, but when applied in combination they can reduce the significance of EHL on feedlot cattle.

It is important that management of EHL be **proactive** rather than **reactive**. A pre-season review of each feedlot's risk profile, infrastructure and resources together with the development of EHL monitoring strategies and action plans will assist you in minimising EHL before an event occurs, rather than simply responding to an event, if and when it does occur. There are three main components to an effective EHL management plan:

1. A **pre-summer review** of the feedlot's preparedness for an EHL event.
2. A **summer management program** to reduce the risk of an EHL event and to be alert to the earliest signs of an event occurring.
3. The preparation and implementation of an **EHL event strategy** when an EHL event is forecast or occurs.

Key benefits

- Prevent production losses and possible cattle deaths from EHL by conducting a pre-summer review to assess the preparedness of a feedlot for an EHL event.
- Identify the early warning signs of an imminent EHL event.
- Minimise the occurrence of EHL in cattle by implementing summer management strategies.
- Determine how to prepare an EHL event strategy for your feedlot.

Pre-summer review

A pre-summer review of each feedlot's site, design, infrastructure and management can provide a wealth of information to identify at-risk regions and lots; determine the adequacy of facilities such as shade, sprinklers and watering troughs; identify high and low risk pens; and prepare management plans to reduce the impact of EHL on vulnerable cattle. The Risk Analysis Program (RAP) software, outlined in *Tips & Tools: Assessing the risk of an excessive heat load event occurring*, can be used during this review.

Components of a pre-summer review

1. Examine the feedlot's natural site, infrastructure and condition, including the use of the new RAP software. Upgrades can be implemented as needed.
2. Conduct a management review of the feedlot's preparedness for an EHL event.
3. Prepare a summer nutrition program.
4. Prepare an EHL event strategy.

Step 1: Examine the feedlot's natural site, infrastructure and condition

This will provide an appreciation of the characteristics of the feedlot that may influence the local microclimate and contribute to, or assist in preventing, a local EHL event. The microclimate within a feedlot often differs from its surroundings. Pens may experience higher temperatures and humidity than the feedlot surrounds. The pen micro-environment is the product of:

- climate and weather
- local influences such as site aspect, shade, mounds, drainage, sprinklers, obstacles to air movement, pad depth and moisture
- animal factors such as stocking density, animal size, days on feed and diet
- management factors such as pen cleaning and trough overflows or discharges

Site review

A **regional seasonal climate and weather audit** using meteorological records can assist in predicting the likely probability, incidence and severity of EHL events in your region. New computer software, outlined in *Tips & Tools: Assessing the risk of an excessive heat load event occurring*, is now available to obtain risk information on EHL conditions in various geographic locations around the country using the new heat load index (HLI) that correlates well with observed cattle comfort.

Evaporative cooling of water from the skin and respiratory tract are the main means of body heat loss from cattle during hot weather. As the effectiveness of evaporative cooling is reduced by humidity, it is much easier to prevent overheating by cattle in hot dry areas compared to hot humid areas.

A local climate and weather audit will identify the natural qualities of the feedlot site, such as slope, aspect, natural air movements, obstructions and wind barriers, that may predispose to, or help prevent, EHL events. Mounds in feedlot pens and sloping sites tend to cause small updrafts of air when there is little natural air movement, providing a small but significant improvement in body cooling.

A review of the feedlot will usually identify individual pens that have a higher or lower risk for an EHL event. Knowledge of individual pen risk can be used to advantage to improve the care of the most vulnerable animals to best effect. The incidence of an EHL event in individual pens can be minimised by:

- Examining variations in air movement patterns in individual pens – consider such factors as up-slope pens versus down-slope pens; location of pens within the lot, eg centre versus edge; obstructions to airflow of individual pens such as buildings, natural structures and crops.
- Observing the differences in drying out among individual pens – pens dry out due to factors such as aspect, presence of shade structures, overflow from water troughs, sprinklers and pad depth. Wet pads have a darker surface, absorb more solar radiation and become hotter than dry pads, which are a light brown to grey colour. Wet pads can also increase the humidity within the pen, reducing the ability of cattle to cool their bodies by evaporative cooling.

The RAP software can also be used to assist in identifying individual at-risk pens within a feedlot.

Infrastructure review

A review of your feedlot infrastructure can identify features capable of adversely influencing EHL in cattle during hot conditions and can suggest possible improvements. Factors to consider include:

- **Air movement –** identify obstacles to air movement such as buildings and structures
- **Shades –** determine if shades are installed and if so their probable effectiveness in assisting vulnerable animals to tolerate EHL conditions. Determine upgrade desirability. For further information on the design and management of shade structures for feedlots refer to *Tips & Tools: Feedlot shade structures*.
- **Sprinklers –** determine if sprinklers are installed and if so their effectiveness and upgrade desirability. Sprinklers may aid or aggravate an EHL event depending on their design, the effectiveness of their management and the prevailing weather conditions. **They are likely to be of most value under hot, dry conditions and may be counter-productive under hot, humid conditions.**

Caution when using sprinklers

Sprinklers, like rain, can contribute to local feedlot humidity, pad moisture and ammonia levels. Sprinklers appear to be most effective when used to periodically wet cattle with large droplet sprays that penetrate through to the skin surface, assisting with evaporative cooling. Misting or fogging is not recommended as it can add to humidity problems, while providing little cooling benefit to the cattle, as only the hair coat is wetted.

The following recommendations have been suggested if sprinklers are used:

- o Sprinklers should produce large water droplets of at least 150 micron diameter.
- o Provide a minimum of two and preferably three sprinklers per pen.
- o Sprinkler range should avoid areas adjacent to water troughs, shades and feed bunks and cover at least 2.5 to 3.0m^2 per standard cattle unit (SCU).
- o Sprinklers should be supplied by a stand-alone water supply that does not compete with water trough requirements.
- o It is believed that sprinklers are best applied for 5–10 minutes on and 15–20 minutes off (to allow cooling by convection to be most effective), rather than continuously and their use should be guided by observing the cattle's response and the pen environment.

- o Night sprinkling has been found to be more effective than daytime sprinkling in reducing body temperatures in some situations. The respiratory rate of cattle should always be assessed one hour after sprinklers have been turned off. If respiratory rates increase sprinklers should be turned back on.
- o If sprinklers are used, particular attention must be paid to good pad management.

- **Water –** assess water quality, adequacy and efficiency. This will include trough numbers, length, supply capability, location, backup supply and distribution and wastewater controls. Determine upgrade desirability. For further information on the design and management of water systems for feedlots refer to *Tips & Tools: Summer feeding of feedlot cattle*.
- **Pen micro-environment –** evaluate and determine influencing factors and determine upgrade desirability. Shade, sprinklers, overflow from water troughs, and pad management can all affect the local environment within pens. Particular attention to pen cleaning and pad maintenance during the summer period promotes drainage and reduces the amount of moisture stored in the manure pad following a rain event. This allows the manure pad to dry quicker and reduces the potential impact of humidity in the event of adverse weather conditions occurring. Regular pen cleaning should be implemented to ensure that the depth of manure (above the soil/manure interface layer) in the feedlot pens does not exceed the maximum allowed under the various state guidelines for the particular class of feedlot. It is recommended that manure not be allowed to exceed an average depth of 100mm under any circumstances during the summer period, remembering that a depth of 100mm of dry, compact manure can store about 280mm of water in what will become more than 300mm of wet manure.

Step 2: Conduct a management review of the feedlot's preparedness for an EHL event

A review should be conducted to assess the preparedness and adequacy of management strategies prior to the summer season.

Livestock management

Review the livestock management factors that may influence the impact of EHL within a feedlot including:

- identification of the most susceptible cattle
- timing of livestock movements and animal handling
- nutrition and feeding programs
- buying practices for cattle to be fed over the summer period

The groups of cattle most vulnerable to EHL are:

- heavily finished cattle approaching market specifications (fat score 4.5–5)
- newly received cattle
- hospitalised cattle, particularly those suffering from respiratory illness

Bos taurus breeds of cattle are more susceptible to EHL than *Bos indicus*, while black animals are more vulnerable compared to lighter coloured animals. Vulnerable animals may be assisted by allocating them to pens which provide maximum cooling effects such as pens with shade, sprinklers, multiple water troughs and maximum natural air movement.

Cattle handling, movement and transportation should be minimised during hot conditions and should cease all together when an EHL event is imminent or underway.

Personnel management

It is important that all employees, staff members and management are informed of the strategies in place to reduce the occurrence of, recognise the signs of, and appreciate the steps to take to limit the effect of, EHL on feedlot cattle.

Staff involved in the day-to-day feedlot operations can worsen an EHL situation by being unaware of requirements. Pen riders and feed truck drivers need to have appropriate training to detect animals that may be approaching or experiencing an EHL situation, by monitoring their behavioural and physiological changes such as bunching activity and panting. Feedback from the pens to management is an essential link.

Step 3: Prepare a summer nutrition program

Metabolic heat produced during digestion and metabolism of food is the primary source of body heat load in cattle. The proactive management of cattle nutrition and diet during hot weather conditions can help to reduce the incidence of EHL and its effects on production and mortality. There are two main components to summer nutrition programs:

1. A routine seasonal review of diets and feeding practices in order to achieve optimum summer productivity whilst minimising animal heat load to reduce the incidence of EHL.
2. Preparation of an EHL event feeding strategy that can be implemented just prior to, or during, an EHL event to try to reduce the impact of the adverse conditions.

A more detailed investigation of summer feeding strategies is outlined in *Tips & Tools: Summer feeding of feedlot cattle*.

Summer diets and feeding practices

For optimum efficiency, summer diets need to maximise the use of low heat increment feed ingredients that are locally available and commercially acceptable. Fats and oils have the lowest heat increment, followed in general by the oilseeds, grains, high quality roughages such as corn silage or cottonseed hulls and finally high fibre roughages such as stubble hay.

While the animal is able to successfully control its body temperature by dissipating excess body heat, highly digestible high energy diets produce less metabolic heat per unit of production and are the most efficient forms of summer production. However, under hot conditions when cattle reduce their dry matter intake, a higher roughage diet may help cattle to maintain their feed intake and reduce the risk of acidosis occurring.

A diet adequacy review should ensure that summer diets are adequate in all nutrients and that excess dietary protein is avoided as this can produce an unnecessary source of metabolic heat.

Alterations to feeding practices can also assist the animal to dispel excess body heat. Body temperature rises after feeding. As cattle are generally better able to dissipate body heat during the cooler night hours, an increased emphasis on afternoon and early evening feeding will encourage animals to better match the period of increasing body temperature with the cooler parts of the day when dissipating excess body heat is easiest.

Step 4: Prepare an EHL event strategy

It is much more effective to have a pre-prepared plan in place when an EHL event is forecast or occurs than to respond after the event is underway. The components of an EHL event strategy are detailed below.

Summer management program

A summer management program is designed to minimise the occurrence of EHL in cattle, whilst maintaining vigilance for an event throughout the summer, and having a prepared strategy in place should an event occur.

The main components of the program are:

- ongoing infrastructure upgrades and maintenance
- implementation of summer diet and feeding programs and an EHL feeding strategy as required
- ongoing management of resources, livestock and personnel
- ongoing monitoring of weather, animal behaviour, and the new HLI and accumulated heat load units (AHLU) index

EHL event strategy

An EHL event strategy should be prepared prior to the hot season during the pre-summer review. The strategy should include a plan of action to be implemented when an EHL event is predicted to be imminent and when an EHL event is actually occurring.

The assessment of heat load status in cattle is difficult, however feedlot staff can be trained to recognise the early signs of EHL within cattle, using a cattle panting score photo guide.

A new accumulated heat load units (AHLU) index has recently been developed. This index can progressively record accumulated heat load in cattle over several days. The progressive tally can be used in conjunction with the HLI forecasting service (http://www.katestone.com.au/mla) and ongoing visual examination of the animals to alert feedlot management to approaching EHL problems, especially among vulnerable cattle. More detailed information on recognising when an EHL event may be imminent or occurring can be found in *Tips & Tools: Recognising excessive heat load in feedlot cattle*.

The pre-prepared response plan can be implemented if an EHL event is imminent or is actually occurring. The response plan may include a combination of all or some of the following actions:

- pre-planned dietary changes
- cessation of animal movements, handling and any other practices that may increase cattle stress
- judicious use of sprinklers, if humidity is low
- use of additional portable water troughs for vulnerable pens of cattle.

More detailed information on summer nutrition and feeding programs and on dietary and feeding management strategies in advance of, or during, an EHL event is available in *Tips& Tools: Summer feeding of feedlot cattle*.

The bottom line

Feedlot site, infrastructure and management reviews prior to the summer months can identify the preparedness of a feedlot to avoid production losses and possible cattle deaths resulting from excessive heat load in vulnerable cattle during very hot and/or humid spells.

Infrastructure upgrades such as shade structures, sprinklers and enhanced watering points together with pad and animal management strategies and dietary adjustments can help stock cope with hot conditions and limit production and cattle losses due to EHL.

A **proactive** approach to the management of EHL is more effective than a **reactive** response once an EHL event has occurred.

Further information

This *Tips & Tools* is part of a series on understanding, recognising and managing heat load in feedlot cattle.

For a copy of *Heat load in feedlot cattle* call MLA on 1800 023 100, email info@mla.com.au or visit www.mla.com.au/publications

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Understanding excessive heat load in feedlot cattle

In Australia, persistent hot or humid weather conditions can reduce livestock production efficiency. The effect of these extended adverse weather conditions is most noticeable in the intensive cattle feedlot industry where, in extreme cases, a significant number of cattle may die as a result of excessive heat load (EHL). An understanding of the factors that contribute to heat load in cattle and the strategies available to avoid or reduce the effects of an EHL event are important for feedlot operators, as high body heat loads can impact significantly on the performance and welfare of feedlot cattle.

Mortalities due to EHL usually only occur in extreme situations, however economic losses associated with reduced dry matter intake (DMI) and subsequent lowered production may occur during less severe weather conditions. These low-level losses often go unreported or unnoticed.

Key benefits

- Understand the causes of excessive heat load in cattle and the strategies available to reduce the effects of an EHL event occurring.
- Better manage cattle during adverse weather conditions by understanding how cattle shed body heat.
- Identify the combination of environmental, animal and nutritional factors that contribute to the development of EHL in cattle.

What is EHL?

Cattle are **homeotherms** – they need to maintain their body temperature within a reasonably narrow temperature range, so that body cells and tissues can function optimally. The core body temperature of cattle is normally about 39°C, however body temperature fluctuates throughout the day by between 0.5 and 1.2°C. This is a rhythmic fluctuation, which usually reaches a peak during the early hours of the evening and drops to its lowest level early in the morning.

EHL occurs when a combination of local environmental conditions and animal factors lead to an increase in body heat load beyond the animal's ability to cope. With severe or prolonged elevations in body temperature above acceptable levels body tissues and organs can be damaged and the animal may die.

The main source of body heat accumulation in cattle is **metabolic heat**. This is heat produced within the body when feed is converted by biochemical reactions to supply energy for various body functions including maintenance and production needs such as pregnancy, lactation and growth.

Under cold conditions, metabolic heat production can be of value in maintaining body temperature; however, under hot conditions, metabolic heat must be dissipated from the animal. Most metabolic heat is generated in the 'core' of the animal and is transported by the blood to the skin and the extremities, where it is transferred to the animal's surroundings when the ambient environment is cooler, as it usually is, than the body's surface. If the animal is unable to transfer sufficient heat to the environment it can build up in the body leading to EHL and **hyperthermia**.

Although metabolic heat production is the major contributor to body heat load, cattle also take in additional heat from solar (sun) radiation, reflected radiation from the feedlot pad and other physical structures in the pen, and from the air itself, if air temperature is higher than the animal's body temperature. Figure 1 shows the range of factors that will contribute to the heat or energy balance of a lotfed steer.

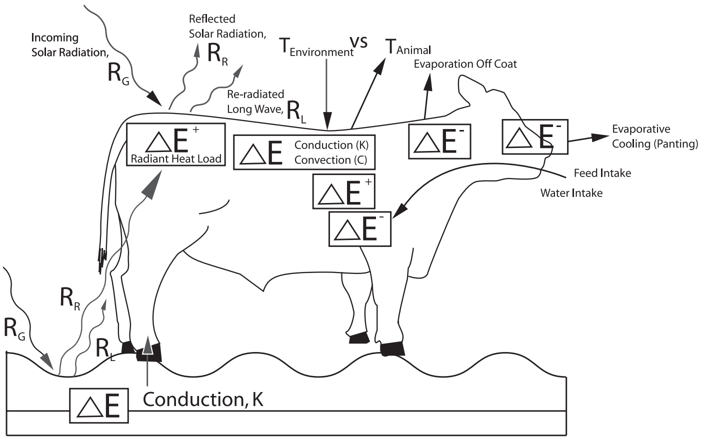

Figure 1: The energy balance of a lotfed steer

How do cattle cool their bodies?

Cattle lose a small amount of heat from their bodies in faeces and urine, however the majority of body heat is transferred from the animal to its surroundings by a combination of the following four mechanisms:

Conduction

Conduction is the transfer of heat due to the physical contact of the animal with a surface, air or liquid that is cooler than the animal. Conduction of heat to solid surfaces is usually minimal in standing animals as only 2% of the body surface area (the hooves) is in contact with the ground, however when lying down 20–30% of the body surface may be in contact with the ground. Animals tend to stand in hot weather to avoid contact with the hot surface of the ground. Similarly in hot weather cattle may stand in water, as significant amounts of heat can be transferred from the animal to the water if it is cooler than the skin.

Conduction of heat can also occur to air trapped in the haircoat and at the surface of the skin. However, the amount of heat lost by conduction to air will be minimal unless the heated air is quickly moved away from the animal by wind or forced air movements in a process known as convection. Cool drinking water will provide a small but significant 'heat sink' as heat will be lost from the body when consumed drinking water is brought up to body temperature.

Convection

Convection losses occur when heated air around the surface of an animal is moved away by either **passive** or **forced** air movement. Passive convection is a natural process in which hot air rises and is replaced by cooler air from below. Forced convection results from air movement due to wind, fans or other mechanical means.

In a feedlot during calm, still-air situations passive convection plays a small but important role in heat transfer from cattle to the environment. Warm air eddies develop at the surface of the animal and carry heated air away from the skin, particularly in animals with short sleek coats. Eddies also develop from the heated surface of the feedlot pad and may aid in cooling cattle by drawing in cooler air to replace the rising warmer air.

Forced convection by wind, fans or mechanical blowers can play an important role in the removal of heat from an animal as long as the air temperature is lower than the surface temperature of the animal and the air is not fully laden with water vapour. The movement of cool, low humidity air can achieve significant body cooling for cattle, however movement of hot, high humidity air provides little relief in hot situations.

Convection is particularly important in animals that pant as the enhanced airflow through the nasal passages and upper respiratory tract can carry away a large amount of body heat. For panting animals in hot situations the majority of metabolic heat load is lost via the respiratory tract.

Radiation

Animals continually emit and receive radiant energy (as heat rays) from the sun and other objects in their environment. If the temperature of the animal's body is greater than the temperature of the surroundings, a greater quantity of heat will be radiated from the body than is radiated to the body. However in situations of direct sun exposure or when the animal is surrounded by hot surfaces, which can occur in a feedlot, radiation may actually increase the temperature of the animal rather than reduce it.

Solar radiation intensity is highest when there are clear cloudless skies. At night, however, a clear sky has no incoming radiation and is an important heat sink for animals. Night cooling occurs largely from exposure to a clear night sky.

Dark coloured cattle absorb more heat from radiation than light coloured cattle, while red cattle appear to be intermediate. The feedlot pad and structures absorb solar radiation, become hot and can be a major source of radiation for cattle. The surface of the pad and structures in the feedlot can reach 60°C to 80°C but cool rapidly once the sun sets. There is, however, little information available at this time to provide reasonable practical estimates of the effects of radiation on cattle in feedlots.

Evaporation

Feedlot cattle depend greatly on their ability to vaporise moisture as a means of generating heat loss, particularly as the temperature rises. Cattle have a limited ability to sweat so the main source of evaporative cooling is through the respiratory system by panting. The main site of evaporative cooling in cattle is the nasal passages, mouth and lungs. During hot weather cattle increase their breathing rate to increase the movement of air over the moistened surface of the upper respiratory tract.

> The main route of heat loss in cattle during hot weather is evaporative cooling from the respiratory tract. However, if humidity levels are high, the effectiveness of evaporative cooling is decreased and cattle may be unable to dissipate accumulated body heat.

Factors that may predispose cattle to EHL

The factors that contribute to body heat load in cattle are complex. They include both external factors such as ambient temperature, humidity and wind speed and internal factors such as the quality and quantity of feed consumed.

Environmental factors

Adverse environmental conditions can severely limit the ability of cattle to shed body heat, which is generated predominantly by metabolic processes during digestion.

An understanding of the mechanisms by which cattle cool their bodies provides an indication of how environmental factors can contribute to EHL and is important in the care and management of feedlot cattle during the summer. The table below lists a range of environmental conditions that are commonly observed, usually in combination, when feedlots experience an adverse EHL event.

Environmental conditions that may predispose cattle to EHL

A combination of two or more of these conditions has been present in recorded instances where EHL has caused cattle deaths in Australia:

- recent rainfall
- a high ongoing minimum and maximum ambient temperature
- a high ongoing relative humidity
- an absence of cloud cover with a high solar radiation level
- minimal air movement over an extended period (4–5 days)
- a sudden change to adverse climatic conditions

Recent rainfall

Most instances of cattle losses from EHL in Australia have been preceded by rainfall. Rainfall often associated with a slow moving frontal system provides the humidity and low wind situations that impact on cattle body heat loads. Often an EHL event has occurred after a period of rainfall followed by 1–2 days of cloudy weather. After the front moves on and cloud cover disappears, the combined effect of humidity (moisture from the manure pad), higher temperatures (day and night), increased solar radiation and low wind speeds (resulting from the slow moving front) creates conditions that can tip cattle over the edge into an EHL crisis, if these conditions persist for a couple of days.

High ambient temperatures (both minimum and maximum)

When daytime temperatures are close to an animal's body temperature, excess body heat is lost extremely slowly by convective cooling. At these times cattle become dependent on cooler night time temperatures to shed an accumulated heat load. If night time temperatures are also high, the heat load that the animal has built-up during the day may not be lost and may be carried into the next day.

High ongoing relative humidity

High humidity reduces the ability of cattle to cool their bodies by evaporative cooling. Cattle increase their breathing rate to increase airflow over the moist surfaces of the nose, mouth and respiratory tract. If evaporation of this moisture is possible, large amounts of heat can be shed from the body, but when humidity is high, the rate of evaporation, and thus body cooling, is reduced. Factors which increase local humidity within pens can increase the risk of EHL. These factors include rainfall prior to a period of high temperatures, use of misters or foggers for cattle cooling and irrigation of paddocks surrounding the feedlot.

High solar (sun) radiation

The heat load of cattle can be increased by radiation from the sun and from hot surfaces in the animal's environment such as the feedlot pad and other structures. The amount of heat gained in this way is low compared to metabolic heat generated within the body; however, it does add to the total body heat load and may be sufficient to cause an EHL event or to increase the magnitude of such an event. Solar radiation intensity is high in areas where there are clear cloudless skies. The effect of solar radiation on heat load can be reduced by the use of shade structures in feedlot pens.

Low wind speeds

Air movement increases heat loss from the animal's body by convection. As long as the air temperature is lower than the surface temperature of the animal, increasing air velocity increases heat loss by convection. In calm-air conditions convective heat loss is dramatically decreased.

Animal factors

Breed effects

Bos indicus cattle such as Brahmans have a greater natural heat tolerance compared to most *Bos taurus* breeds such as the Angus, Hereford and Shorthorn breeds. There are also genetic differences within breeds resulting in some individuals that have a higher tolerance to heat compared to others of the breed.

Coat colour and type

Although there is some contradictory research on the effects of coat colour on heat tolerance it is generally accepted that light coated cattle are less susceptible to EHL compared to cattle with dark coats. Black cattle absorb more solar radiation, which in turn contributes to total body heat load, compared to light cattle which reflect a large percentage of the solar radiation. Red-coated cattle are believed to be intermediate. It has also been reported that the effect of coat colour becomes more pronounced as cattle become fatter.

Cattle with dull woolly coats tend to have a higher body temperature than similar animals with slick glossy coats. Glossy coats reflect more solar radiation than woolly coats. Hair length also impacts on heat transfer from the skin, and animals with a longer hair coat may lose less heat from their body via sweating and conduction/convection. In a commercial feedlot, haircoat can impact on the effectiveness of sprinkler systems, especially if droplet size is insufficient to wet the animal's skin.

Body condition/days on feed

Generally, heavier, fatter cattle are more susceptible to the effects of high heat load. When deaths have been reported in feedlots due to an EHL event the heavier cattle, close to market weight, often have higher mortality rates than lighter animals. These heavier animals consume more feed, probably because they are more productive and have a higher maintenance requirement. Remember that metabolic heat production resulting from feed digestion is the major contributor to body heat load in cattle.

Adaption to heat

Most cattle can adapt to prevailing environmental conditions provided the temperature range is not too wide. Cattle that adapt to hot conditions usually do so by decreasing heat production or increasing heat dissipation. They increase heat loss by sweating, drinking more water and increasing their respiratory rate to enhance evaporative cooling. This will work up to a point, usually when the heat load is of short duration (1–2 days).

If high heat load conditions continue cattle must reduce heat production to control their body temperature. This is usually achieved by a reduction in feed intake. Cattle on high energy grain diets may reduce dry matter intake by more than 25% and once high heat load conditions abate, may not return to previous levels of DMI. Cattle on low quality roughage (low energy) diets experience variable intake reductions, often around 10%, and are more likely to return to full feed when conditions return to normal.

Provided that cattle do not overheat, they will normally adapt to substantially hotter conditions after about four days of exposure.

Health status

Animals that are suffering from ill health usually have a reduced ability to cope with hot weather conditions. Any disease that raises body temperature or reduces lung capacity will increase the susceptibility of the animal to a heat load related death. Respiratory disease is the most common underlying health problem seen in cattle that die from heat related stress.

Nutrition

An animal's diet will directly influence their body heat load and contribute to their ability to withstand EHL. Under very hot conditions cattle will reduce their DMI and consequently the amount of metabolic heat generated from feed digestion and metabolism. This reduction in DMI is an attempt by the animal to bring metabolic heat production in line with heat shedding capabilities.

Feed ingredients

Different feed ingredients produce different amounts of body heat. Fats have the lowest heat increment, followed by carbohydrates and then protein. Carbohydrates such as cellulose have higher heat increments than more soluble carbohydrates such as starch and sugar.

The ingredients with the lowest heat increments are the fats and oils, generally followed by oilseeds, grains and concentrates, and roughages and forages. High quality roughages such as corn silage will have a lower heat increment than high fibre stubble hays.

During periods of hot weather when cattle are still able to satisfactorily control their body temperature by dissipating excess body heat, low fibre, high grain diets are favoured as they produce the lowest heat increment. However, under hot conditions when cattle reduce their DMI, a higher roughage diet will reduce the risk of acidosis occurring due to variable feed intake.

Frequency and time of feeding

The act of refilling the feed bunk stimulates eating behaviour in feedlot cattle. The heat production of feedlot cattle in a hot environment is closely related to the time of feeding, increasing during and after feeding. Feeding in the cooler hours of the day may improve dissipation of heat from the body to the environment.

The bottom line

The severity of EHL in feedlot cattle depends on a combination of many factors including the quantity and quality of the diet, the animal's level of productivity, acclimatisation, breed and the environmental conditions that can affect the animal's ability to rid itself of excess body heat.

The main source of body heat load is metabolic heat produced during digestion and metabolism of feed ingredients. The main route of heat loss during hot weather is evaporative cooling from the skin and the respiratory tract. If heat loss mechanisms cannot reduce body heat load below acceptable levels, body tissues and organ function can be impaired and death can result.

Further information

This *Tips & Tools* is part of a series on understanding, recognising and managing heat load in feedlot cattle.

For a copy of *Heat load in feedlot cattle* call MLA on 1800 023 100, email info@mla.com.au or visit www.mla.com.au/publications

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Recognising excessive heat load in feedlot cattle

Feedlot cattle exposed to Australian summer conditions, particularly during periods of high heat, high humidity and low wind speed, may suffer the effects of excessive heat load (EHL). It is important that feedlot management are able to predict an approaching EHL event and that feedlot personnel are trained to recognise when cattle are experiencing increasing heat load. Forewarning of an imminent EHL event can allow pre-prepared action plans to be implemented, avoiding or minimising the impact on cattle.

There are two main components to consider when assessing heat load in cattle:

1. An evaluation of the cattle's response to the conditions.
2. A measurement of the climatic conditions prevailing in the feedlot.

Assessing cattle

It is important to remember that cattle are the key to recognising EHL – they will tell you when they are getting hot by their appearance and behaviour.

A number of observations and measurements can be used to assess the impact of hot and/or humid conditions on feedlot cattle. These include:

- respiration rate and panting score
- cattle behaviour
- dry matter intake (DMI)
- internal body temperature

Ideally all cattle in the feedlot should be assessed. Where this is not possible the most vulnerable cattle should be monitored (see tint box, right). Assessment should commence before any anticipated periods of adverse weather conditions based on weather forecasts.

Key benefits

- Minimise production losses and possible cattle deaths by observing animal behaviour for signs of EHL during hot weather.
- Use tools such as the heat load index (HLI) and the panting score photo guide to recognise EHL in feedlot cattle.
- Use accumulated heat load unit (AHLU) calculations to determine if cattle have adequate time to cool overnight or are carrying heat loads into the next day.
- Be prepared for an EHL event by assessing both the cattle and climatic conditions on a frequent basis during summer.

Factors that make cattle vulnerable to EHL

- Days on feed – heavily finished cattle approaching market specifications are the most vulnerable animals.
- Newly arrived cattle – may not be acclimatised to the weather nor adapted to the feedlot environment.
- Hospitalised cattle – particularly those suffering from respiratory disease.
- Black cattle are more susceptible than light coloured animals. Red cattle are intermediate.
- *Bos taurus* breeds (eg Angus, Shorthorn, Hereford) are more vulnerable than *Bos indicus* (eg Brahman) breeds.

Respiration rate and panting score

Respiration rate and panting score are very useful indicators of heat load in cattle. They are the first visual responses seen during hot conditions, and panting score, in particular, can be quickly assessed by feedlot personnel.

A visual photo guide for panting scores has been developed as a result of a Meat & Livestock Australia (MLA) funded research project. It is recommended that during adverse weather the panting score of vulnerable cattle should be assessed at about 6am and then at two hour intervals throughout the day until at least 6pm.

Panting scores range from 0 (normal) to 4.5 (animal severely stressed) and are described in table 1. For management purposes, if more than 10% of cattle are exhibiting panting scores of 2 or above, all handling and movement of the affected cattle should be stopped and only resumed when conditions become cooler and cattle have returned to normal. Cattle with a panting score of 3.5 or greater are in danger of death if they do not receive some form of relief from the hot conditions. If more than 10% of cattle are exhibiting panting scores of 3.5 or greater, there is potential for a serious problem to develop if they do not have the opportunity to dissipate the accumulated heat load. The photos provided clearly indicate the appearance of cattle experiencing increasing levels of EHL. The transition from 2.5 to 4.5 can happen quickly (less than 2 hours) under extreme conditions.

Table 1: Breathing condition and panting score

Breathing condition	Panting score (PS)	Associated respiration rates (breaths/min)
No panting – normal Difficult to see chest movement	0	<40
Slight panting, mouth closed, no drool or foam Easy to see chest movement	1	40-70
Fast panting, drool or foam present No open mouth panting	2	70-120
As for 2 but with occasional open mouth, tongue not extended	2.5	70-120
Open mouth + some drooling Neck extended and head usually up	3	120-160
As for 3 but with tongue out slightly, occasionally fully extended for short periods + excessive drooling	3.5	120-160
Open mouth with tongue fully extended for prolonged periods + excessive drooling Neck extended and head up	4	>160
As for 4 but head held down Cattle ‘breath’ from flank Drooling may cease	4.5	Variable~ RR may decrease

Panting score 0

Panting score 1

Panting score 2

Panting score 2.5

Panting score 3

Panting score 3.5

Panting score 4

Panting score 4.5

Photos courtesy of John Gaughan, University of Queensland

Cattle behaviour

During hot weather cattle often change their behaviour in an attempt to maintain acceptable comfort levels. These behaviour changes should be used together with panting scores to assess the impact of EHL on the animals.

The following list shows some of the behavioural signs that may be seen in cattle as they are progressively exposed to EHL conditions. In most cases cattle will usually cope up to symptom nine.

The onset of open-mouthed and laboured breathing (symptom 10) is an indication that the animal's system is failing to cope with the hot conditions.

1. Body alignment with solar (sun) radiation
2. Shade seeking
3. Increased time spent standing
4. Reduced dry matter intake (DMI)
5. Crowding over water trough
6. Body splashing
7. Agitation and restlessness.
8. Reduced or absent rumination
9. Bunching to seek shade from other cattle

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10. Open-mouth and laboured breathing
11. Excessive salivation
12. Staggering or inability to move
13. Collapse, convulsions, coma
14. Physiological failure and death

↓ *Failing to cope*

Cattle will seek out and use shade during periods of high solar (sun) radiation. Research indicates that *Bos taurus* breeds of cattle will begin to seek shade when the temperature exceeds 20˚C, although similar cattle that are adapted to hot environments may not seek shade until the temperature is around 28˚C. It appears that natural shade, such as trees, are their first preference, however if only artificial shade structures are available they will choose the structure that provides the highest protection from the sunlight.

Feedlot cattle often crowd around water troughs when they are exposed to EHL. This is not necessarily an indicator of increased water intake. It is believed that cattle place their heads over water troughs in order to cool their heads, as water evaporating from the trough will lower the air temperature immediately above it. Cattle may also dunk their muzzles into the water without drinking in an attempt to shed body heat. Crowding around troughs can cause problems as it restricts water access for less dominant animals.

During hot weather cattle may bunch together, possibly to obtain shade from each other, to escape flies or as a natural 'herding' response when under stress. Bunching reduces the ability of animals to dispel body heat and therefore management should have strategies to reduce this phenomenon.

Dry matter intake

Dry matter intake (DMI) usually decreases when cattle are exposed to hot environmental conditions, particularly when high-energy diets are being fed. This reduction in DMI is an attempt by the animal to bring metabolic heat production into line with its heat dissipation capabilities. Metabolic heat production during the digestion and processing of feed is the major source of heat load in cattle.

Internal body temperature

The monitoring of internal body temperature is a very useful method of assessing changing heat load in cattle, however it is very difficult to measure under field conditions. Recent advances in 'telemetry' technology may, in the near future, be able to provide real time measurements of the body temperature of 'indicator' cattle using signals transmitted via radio transmission from small devices placed in the rumen. Unfortunately this is currently unavailable for commercial use.

Assessing microclimate within the feedlot

There are a number of climatic conditions that may predispose feedlot cattle to high body heat loads, including:

- recent rainfall
- high daytime temperatures
- high night time temperatures
- high humidity
- little or no cloud cover
- calm or low wind conditions
- a sudden change to adverse conditions

It is usually a combination of some or all of these conditions that leads to an EHL event.

Feedlot managers need to be able to monitor their local weather conditions and predictions for three to five days in the future. They must also be able to interpret these weather conditions in terms of the likely impact on cattle body heat loads.

For a number of years a temperature humidity index (THI) has been used as an indicator of the effect of local climatic conditions on cattle. The THI is usually displayed as a grid with values ranging from 72 (no stress) to 95 (extreme stress). However, the THI does not take into account the effects of solar radiation or wind speed on the animals' heat load balance.

Heat load index

An improved thermal indicator has been developed with funding from MLA. The heat load index (HLI) uses a combination of black globe temperature, relative humidity and wind speed in the calculation of a value to assess the environmental heat load placed on cattle. The use of black globe temperature in this index, rather than ambient temperature, takes into account air temperature, solar radiation and air movement effects. The HLI was developed based on data collected at Australian feedlots. As it stands, the HLI is applicable to a 'reference' animal. That is a grainfed, healthy, black, *Bos taurus* steer with a body condition score of 4+, and no access to shade. This animal will gain body heat when the HLI is greater than 86 and will dissipate body heat when the HLI is less than 77. The HLI has proved to be a good indicator of physiological stress.

The formula used to calculate the HLI when BG is greater than or equal to 25°C is:

Heat Load Index (HLI) = 8.62 + (0.38 x RH) + (1.55 x BG) + EXP (-WS + 2.4) – (0.5 x WS)

The formula used to calculate the HLI when BG is less than 25°C is:

Heat Load Index (HLI) = 10.66 + (0.28 x RH) + (1.30 x BG) – WS

where BG = black globe temperature (°C), RH = relative humidity as a percentage (eg 45 not 0.45) and WS = wind speed (m/s) {EXP = exponential and is a mathematical term ~ e raised to power of a given number}

A table of adjustment factors for the HLI is shown in table 2. A positive number means that the threshold at which cattle will gain heat is increased by that number, and a negative number means that the threshold will be lower. For example if 2m^2 of shade is available then the threshold for the 'reference' animal is 86 + 5 = 91. That means the animal will gain heat when the HLI is 91. Positives are additive but only up to a maximum of 96. Once an HLI of 96 is reached, *Bos taurus* cattle will gain heat. In regard to *Bos indicus* cattle, there are also benefits of shade for these animals and adjustments have been made as with *Bos taurus* cattle. If the reference animal is sick then the threshold is adjusted by –5 (86 – 5 = 81). This means the animal will gain heat when the HLI is 81, ie it is more susceptible to EHL. It is important to remember that these thresholds are only a guide and may be higher or lower depending on other factors such as diet and feed intake. Therefore feedlot management should always use cattle observations such as panting scores in conjunction with the HLI estimates.

Accumulated heat load assessment

Heat load accumulated by cattle over time can also be calculated. This is known as the accumulated heat load units (AHLU) index, and it records the number of hours over a day or days, when the HLI is above a threshold value (nominally 86). Above the threshold, cattle will gain body heat ie they will have a positive heat load balance. The AHLU will give a better indication of high heat load than a spot measure of the HLI, because it combines intensity and duration of exposure to EHL.

The ALHU can also be used to calculate recovery times from EHL. The best recovery from heat load occurs when the HLI is below 77 for between four to six hours during the night. However, longer periods may be needed if exposure to EHL has been prolonged. A HLI below 77 will allow cattle to dissipate body heat to their surroundings. Using AHLU feedlot management can calculate the amount of time needed to bring body temperature back into the normal range, depending on the accumulated heat load carried by the animals. Cattle entering a new day with carryover heat may be vulnerable to EHL if the new day comes in hot.

The thresholds for the calculation of the 'heat load balance' and the AHLU are based on the reference animal. The

Table 2: The effect of various factors on the upper HLI threshold

Factor	Effect on upper HLI threshold	Factor	Effect on upper HLI threshold
Bos taurus genotypes	0	Manure management feedlot class = 1	0
Bos indicus cross (25%)	+4	Manure management feedlot class = 2	-4
Bos indicus cross (50%)	+7	Manure management feedlot class = 3	-8
Bos indicus cross (75%)	+8	Manure management feedlot class = 4	-8
Bos indicus genotypes	+10	No shade	0
Wagyu	+4	Shade (1.5m^2/SCU – 2m^2/SCU)	+3
European genotypes	+3	Shade (2m^2/SCU – 3m^2/SCU)	+5
Black coat colour	0	Shade (3m^2/SCU – 5m^2/SCU)	+7
Red coat colour	+1	Temperature of water in troughs = 15 – 20°C	+1
White coat colour	+3	Temperature of water in troughs = 20 – 30°C	0
Days on feed (0 – 80)	+2	Temperature of water in troughs = 30 – 35°C	-1
Days on feed (80 – 130)	0	Temperature of water in troughs > 35°C	-2
Days on feed (130 +)	-3	Install extra water troughs (emergency mitigation)	+1
Healthy	0	Implement heat load feeding strategy (emergency)	+2
Sick/Recovering/Unacclimatised	-5	Strategic clearing of high manure deposition areas	+2

* SCU = standard cattle unit

upper threshold is 86 and the lower threshold is 77. At HLI values between those thresholds, the animal is neither gaining nor losing heat. When the AHLU reaches 0 there is no further heat loss from the animal. Negative values for HL balance do not accumulate once the AHLU is 0. The calculation of the AHLU is based on measurement of the HLI over time in relation to those thresholds. An example is shown in table 3.

Weather monitoring in feedlots

The detailed meteorological data needed to calculate the HLI can be obtained from an automatic weather station situated in the feedlot or from a local Bureau of Meteorology (BOM) weather station if one is available close to the feedlot site. However, it is difficult to use a BOM weather station for this purpose and specialist input will be required, as BOM weather stations do not record black globe temperature.

Further information on weather monitoring is available in *Tips & Tools: Weather monitoring in feedlots.*

A new weather forecasting service is available that forecasts HLI and AHLU values for a range of locations in the major lotfeeding regions of Australia (www.katestone.com.au/mla). This internet based service provides a six-day weather forecast for the location including:

- expected rainfall
- expected maximum and minimum HLI
- expected AHLU
- graphical presentation of prior and forecast AHLU conditions
- a colour-coded warning of an approaching EHL alert or emergency situation

Table 3: The change in AHLU over a 14 hour period – based on the reference animal

Time	HLI	HL balance	AHLU
8:00	85	0	0
9:00	86	0	0
10:00	88	2	2
11:00	92	6	8
12:00	94	8	16
13:00	95	9	25
14:00	97	11	36
15:00	96	10	46
16:00	89	3	49
17:00	85	0	49
18:00	79	0	49
19:00	70	-7	42
20:00	64	-13	29
21:00	62	-15	14
22:00	61	-16	0

Heat load assessment summary

- Use the heat load forecast service to obtain predictions of the HLI and AHLU for today and the next 3–5 days.
- Use an onsite automatic weather station to generate the HLI and AHLU, so that you have reliable information on the current weather conditions.
- Use AHLU calculations to determine if cattle have adequate time to cool overnight or are carrying heat loads into the next day.
- Assess panting scores from 6am to 6pm on hot days (if HLI is expected to exceed 80). A panting score of 1 at 6am indicates a potential problem if a high HLI is encountered.
- Observe cattle behaviour in the pen.
- Remember that the cattle are the key – they will tell you when they are getting hot.

The bottom line

The factors that contribute to EHL in cattle are complex. They depend on both local environmental conditions within pens, together with animal factors such as diet, breed, colour, condition score and days on feed.

Feedlot management must assess both the cattle and the climatic conditions on a frequent basis during the summer in order to recognise when EHL may be imminent or occurring so that corrective action to reduce production losses and improve animal welfare can be quickly implemented.

The use of tools such as the new Heat Load Index and the Panting Score Photo Guide will assist feedlot personnel to predict and recognise the condition.

Further information

This *Tips & Tools* is part of a series on understanding, recognising and managing heat load in feedlot cattle.

For a copy of *Heat load in feedlot cattle* call MLA on 1800 023 100, email info@mla.com.au or visit www.mla.com.au/publications

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tips & tools

FEEDLOTS

Summer feeding of feedlot cattle

During the Australian summer, excessive heat loads (EHL) in feedlot cattle can result in lost production and, in extreme cases, catastrophic stock losses. Although a range of factors influence the rate of heating of an animal, the largest contributor is metabolic heat, produced during digestion and metabolism of feed. Metabolic heat contributes over 70% of the heat input to the animal. It may be possible to alter rations and feeding practices to reduce the heat load placed on cattle in hot environments.

Key benefits

- Reduce the impact of adverse weather conditions and excessive body heat loads on cattle by preparing a summer feeding strategy for your feedlot.
- Increase the ability of feedlot cattle to control their body termperature by formulating a general summer diet that includes highly digestible high-energy rations.
- Minimise the risk of acidosis occurring during hot periods by including high energy feed ingredients such as fat, oil or molasses to replace grain in cattle diets.
- Understand the benefits of an adequate supply of cool, good quality water for feedlot cattle.

Effect of heat on food intake by cattle

In general the first response of cattle exposed to hot conditions is to decrease their dry matter intake (DMI), especially when fed high energy diets. This reduction in DMI is an attempt by the animal to bring metabolic heat production in line with their heat shedding capabilities. Table 1 provides a summary of the changes in voluntary food intake seen in beef cattle under a range of environmental conditions.

Cattle with access to shade or night-time cooling tend to have a higher feed intake compared to those without access to these facilities. In commercial feedlots a reduction in overall feedyard DMI during summer may indicate the onset of a severe heat load event in the animals. Cattle on high energy finishing diets are most at risk of heat stress under these conditions.

Summer diets

The aim when formulating a summer diet for feedlot cattle is to minimise animal heat load while achieving productivity objectives.

Feed ingredients

Different feed ingredients may produce different amounts of body heat despite having similar energy levels. This is known as the **heat increment** (HI) of the feed. Fats have the lowest HI, followed by carbohydrates and then proteins. Carbohydrates such as cellulose have a higher HI than more soluble carbohydrates such as starch and sugar.

The ration ingredients with the lowest HI are the fats and oils, generally followed by oilseeds, grains and concentrates, and then roughages and forages with increasing HI associated with decreasing digestibility. For example, high quality roughages such as corn silage have a lower HI than high fibre stubble hays.

For efficiency, summer diets need to maximise the use of low HI ingredients from those that are locally available and commercially acceptable.

During periods of hot weather when cattle are still able to satisfactorily control their body temperature by dissipating excess body heat, highly digestible, high energy diets produce the lowest amount of **metabolic heat per unit of production** and are the most efficient type of summer ration.

A highly digestible, high energy ration can be achieved by feeding low fibre, high grain diets. However, cattle fed diets with a high content of rapidly fermentable grain often display irregular feeding patterns characterised by bouts of overfeeding followed by periods of low feed intake. This

Table 1: Summary of voluntary feed intake of beef cattle in different thermal environments

Thermal environment	Dry matter intake relative to the values tabulated in nutrient requirements of beef cattle (NRC)
> 35°C	• Marked depression in intake, especially with high humidity and/or solar radiation and where there is little night cooling - Cattle on full feed – 10% to 35% depression - Cattle near maintenance – 5% to 20% depression - Intakes depressed less when shade or cooling available and with low fibre diets
25°C to 35°C	• Intake depressed – 3% to 5%
15°C to 25°C	• Preferred conditions
5°C to 15°C	• Intake stimulated – 2% to 5%
-5°C to 5°C	• Intake stimulated – 3% to 8% • Sudden cold snap or storm may result in digestive disturbances in young stock
-15°C to -5°C	• Intake stimulated – 5% to 10%
< -15°C	• Intake stimulated – 8% to 25%

increases the potential for acidosis and resulting damage to the gut lining, which predisposes cattle to endotoxic shock, laminitis and liver abscesses. During hot conditions when cattle reduce their DMI, a higher roughage diet may help cattle to maintain their feed intake and reduce the risk of acidosis occurring. Feeding management can also assist in this endeavour through more frequent calling of bunks, removal of stale feed from the bunks and the regular supply of fresh feed.

Feedlot management, in conjunction with nutritional consultants, should consider the use of dietary fats or oils to replace some grain in the ration. This will decrease the risk of acidosis and further reduce the HI of the diet. Fats and oils are usually included in feedlot rations at rates of 2–6% of dry matter (DM).

Molasses can also be used as a high energy substitute for some of the grain content in the ration. Conventional inclusion rates for molasses in Australian feedlots range from 3–8% of DM, however research and industry experience indicate that much higher inclusion rates are possible and practical.

An excess of dietary protein should be avoided in summer rations, as the HI of protein metabolism is greater than that of nutrient fats and carbohydrates.

Summer diets should be reviewed for adequacy of all nutrients including vitamins and minerals. Mineral losses increase during the summer due to drooling, sweating and increased urinary excretion. Particular attention should be paid to dietary potassium levels. Vitamins A and E can be quickly depleted in stored ingredients and feeds, and this deterioration rate may be accelerated in hot weather.

Feeding practices

Cattle exposed to high heat loads tend to eat more frequent meals of smaller size. Body temperature will vary throughout the day, usually peaking in the evening and decreasing to a minimum during the early morning hours. Heat production by cattle increases during and after feeding. The act of refilling a feed bunk will stimulate eating behaviour in feedlot cattle.

Feeding in the afternoon or early evening may improve heat loss from the animal, as body heat production peaks should coincide with cooler night-time conditions. There is no advantage to afternoon feeding when limited night-time cooling occurs.

EHL event feeding strategy

In addition to formulating a general summer diet, feedlot management should also prepare a feeding strategy that can be implemented during extreme weather conditions that may lead to EHL.

As mentioned earlier, DMI decreases as heat load increases. Some feedlot operators decrease the amount of feed offered to lotfed cattle by up to 20% when adverse hot conditions are forecast, in an attempt to reduce metabolic heat production during periods of heat stress. However, restricting feed intake can lead to feed engorgement when full feeding resumes, increasing the risk of death due to acidosis or bloat. Additionally, high feed intakes after a period of restricted feeding can cause elevated body heat loads that can be catastrophic if they coincide with another period of hot and/or humid weather.

An alternative feeding strategy is to increase the roughage content of the diet in response to an EHL event. This can be achieved by dropping the cattle back a level in their ration to effectively increase dietary fibre and potassium levels. However, there is an animal response lag time of 3–4 days following dietary adjustment in terms of metabolic heat production, so cattle may not be able to gain full benefit from the dietary changes. When the EHL event has passed the dietary adjustments can be reversed and the original diet re-established.

Feed restriction or changes in diet composition represent a trade off between reduced risk of death from hyperthermia and reduced income due to slower growth rates during the feeding of such diets. Specific advice from a nutritionist may assist operators to balance these competing demands.

Water

Water is an essential nutrient for feedlot cattle and intake increases dramatically during hot periods. Cattle obtain water from drinking water and from water contained in food. Water is lost from the body in urine, manure, evaporation from the skin and respiratory tract, and during hot conditions significant losses occur through drooling.

The water requirements of feedlot cattle depend on their liveweight, ration composition, DMI, physiological state, environmental factors and water quality.

Factors that can affect water intake include:

- **Air temperature –** as air temperature rises above 25°C water consumption rises sharply due to sweating, panting and evaporative cooling (see table 2). Above 30°C cattle tend to drink every two hours or less and night water consumption increases.
- **Water temperature –** some studies have shown that British breed cattle increase feed intake, weight gain and energy utilisation when water is cooled to 18°C compared to 32°C.

  Brahman X British crossbred cattle under the same conditions performed similarly on cold or warm water.
- **Drinking water flow rates –** in dairy cattle, higher flow rates into drinking bowls results in increased water intake.
- **Animal's physiological state –** young cattle generally have higher water intakes per kg of DMI than older cattle.
- **Physical form of the diet –** the need for water increases with increasing intakes of protein, salt and roughage.
- **Water quality –** poor quality water (eg bore water) can reduce intake while water from streams may deteriorate in quality after increased flows following storms.

Table 2: Water requirements of beef cattle in different thermal environments

Thermal environment	Water requirement
> 35°C	• 8 to 15kg water per kg DMI
25°C to 35°C	• 4 to 10kg water per kg DMI
15°C to 25°C	• 3 to 5kg water per kg DMI (young and lactating animals require 10%–50% more water)
-5°C to 15°C	• 2 to 4kg water per kg DMI
< -5°C	• 2 to 3kg water per kg DMI

Water supply recommendations for feedlot cattle

- Recent work conducted in the US concludes that it is advantageous to provide at least two water troughs per pen. While this may not be practical in existing pens, it may be worth considering for new developments. This will assist in overcoming the problems associated with cattle crowding around water troughs and restricting access for less dominant animals.
- A minimum of 25mm/head of linear trough space should be provided during normal conditions and 75mm/head during very hot conditions.
- Provide additional portable water troughs in pens of vulnerable cattle during hot weather to reduce the influence of dominant animals and crowding behaviour around troughs.
- Troughs should supply at least 15L/100kg body weight of penned animals each day and should be able to meet the daily peak consumption needs in a four hour demand period.
- For water coolness all pipes to water troughs should be entirely underground.
- Troughs should be lengthy and relatively shallow with a robust high volume water delivery.
- Removable drainage stand pipes should drain to an integrated feedyard wastewater collection and disposal system, clear of pens and alleys. This will eliminate trough overflows and pen wetting during trough cleaning, reducing pad wetting and pen humidity.
- A reliable backup and secondary delivery system should be available.
- The quality of the water source should be considered when designing water supply systems as poor quality water can limit intake.

The bottom line

Dietary manipulation may reduce the impact of adverse weather conditions and excessive body heat loads on feedlot cattle during the Australian summer. Feedlot operators should seek nutritional advice when formulating summer diets and when developing a nutritional strategy for use during EHL events.

Further information

This *Tips & Tools* is part of a series on understanding, recognising and managing heat load in feedlot cattle.

For a copy of *Heat load in feedlot cattle* call MLA on 1800 023 100, email info@mla.com.au or visit www.mla.com.au/publications

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tips&tools

FEEDLOTS

Feedlot shade structures

Shade can have a large impact on the body heat load experienced by cattle by reducing solar (sun) radiation and slowing the rate of body heat gain. Recent research in beef cattle in the USA has shown under experimental conditions that the provision of shade can improve cattle comfort and productivity and increase profitability under some climatic conditions.

The design of shade structures should ensure that wind speeds are maximised in the feedlot pen and, where possible, air temperatures are kept below body temperature.

Key benefits

- Shade can improve cattle comfort and productivity and increase profitability.
- Shade can reduce the impact of body heat load. experienced by cattle by reducing solar (sun) radiation and hence slowing the rate of body heat gain.
- Use the principles of shade design and structure to build effective shade systems.

Principles of shade design

The benefits of shade to cattle exposed to both high temperatures and high solar radiation are influenced by a number of factors:

- the size of shadow cast by the shade
- the location of the shade
- the orientation of the shade
- the type of shade material

Practical design constraints

Lotfeeders have considerable practical experience in the design and installation of shade. The design of existing shade structures has proven itself in the time they have been in use. Improvements that have been made over time are the result of observation and trial and error.

Two types of shade structures are used by the feedlot industry – **shadecloth** that is either permanently fixed or furlable (figure 1) or **iron sheets** attached to cables (figure 2).

Shadecloth is generally less expensive than solid roofing material and the supporting structure required for shadecloth may not be as substantial. However, shadecloth does not provide as much protection from solar radiation and its durability may not be as good as that of solid roofing materials.

Figure 1: Feedlot shadecloth structure
Photo courtesy of Rockdale Beef Pty Limited

Natural air movement under a shade structure is affected by the ease with which air can move through the structure. As such, shade cloth does have the advantage of allowing air to pass directly through the material, whilst structures constructed from galvanised sheeting require openings to assist air movement.

Current feedlot shade designs have evolved over time. Most are of simple design to minimise capital and ongoing maintenance costs. However, structures of such size should be engineer-designed and certified. This includes the structural connection details, especially where

Figure 2: Feedlot iron sheet shade structure
Photo courtesy of Sandalwood Feedlot, Dalby, Queensland

tensioned cables are involved, and the fixing details for the corrugated iron sheeting.

Sizing of shade structures

A relationship between shaded area, stocking density, and cattle performance has not been defined in the available literature. However, general recommendations have been made by some researchers.

The minimum requirement is that the shade structures must create a shadow on the ground of sufficient size to cover all animals. Guidelines relating to the ideal amount of shade that should be provided vary. Recommendations derived from US dairy research suggest that cattle should be provided with anywhere from 1.9 to 6.0m^2 of shade per head.

The size of the shadow is most affected by the angle (or slope) of the shade material. The height of the structure does not change the size of the shadow, but does affect the rate at which the shadow moves across the ground.

Higher shade structures also provide more cool air for cattle and studies have shown that cattle show a preference for higher shade structures. However, higher structures typically cost more to construct as they are subject to greater wind loads.

Positioning of shade structures

It is important to locate shade structures so that their shadow covers an area of the ground that is easily accessible by the animals. This is the primary reason that shade structures are typically erected towards the centre of feedlot pens. This ensures that cattle are able to occupy the shaded area as it moves across the pen during the day.

The orientation of shade structures will also affect their performance. Structures orientated with the long axis in a north-south direction have the advantage of providing dryer pen surfaces as the shadow provided by the shade moves over a greater area than that of structures orientated east-west. Shade structures constructed with an east-west orientation require openings between the sheeting, to allow the shaded area to move during the day.

Allowing the shaded area to move within the pen throughout the day has a number of advantages including:

- improved drying of the pen surface
- breaking up of social groupings within the pens to reduce dominance

Determining the ideal orientation also requires consideration of the prevailing winds, which should be utilised to assist in ventilation and cooling.

Shade materials

At present a wide range of materials are used in the construction of shade structures. The most common materials used in Australian feedlots are galvanised sheeting or shadecloth, due to availability and relatively low

Practical design issues for feedlot shade structures

(Comments from *Industry shade system survey*)

- Shadecloth is not the preferred roofing material as the stitching can deteriorate, requiring replacement of the cloth or stitching every three to five years. New technologies are now offering life spans of up to 10 years.
- Shadecloth can be affected by hail damage, bird chewing or pen cleaning machinery exhaust pipes that can burn holes in the cloth. Cloth must be placed well above machinery.
- Corrugated iron sheets on some shade structures were still considered to be in the same condition as when erected, five years later. Ammonia levels increase with manure moisture content. As ammonia is a corrosive agent, particularly in humid climates, this may also reduce the life of corrugated iron in wet humid climates.
- Galvanized iron sheets can be very dangerous if they work loose in high winds or a storm. Some stock have been killed by flying sheet metal.
- Designs have incorporated concrete pillars to protect the base of the main steel posts from corrosion caused by manure on the pen floor.
- Maintenance of pen floors under shade can be problematic. Shaded areas do not dry as well as unshaded areas, which can contribute to greater wear on the pen surface and increased maintenance costs, aside from problems such as holes being formed, which can trap water and become odourous.
- If shadecloths are removed and stored during the winter mice can damage the stored material.
- An ideal shade structure would have no posts in the pens, would be durable, cheap, and able to be taken down easily and folded for storage in winter.

cost. The effectiveness of shade structures is highly dependent on the type of material used.

Any material that intercepts direct solar radiation will heat up. If the lower side of the shade material becomes hot it will then radiate heat to the air and the animals below. An advantage can be gained by having shade structures that are reflective on the top surface, absorptive on the bottom surface, and allow free airflow.

In dairies it has been suggested that the most effective shade roof is an aluminium or white coloured galvanised metal roof that is fitted with insulation directly beneath the roofing to reduce the radiation heat load. Figure 3 below shows the radiation energy balance for an artificial shade structure.

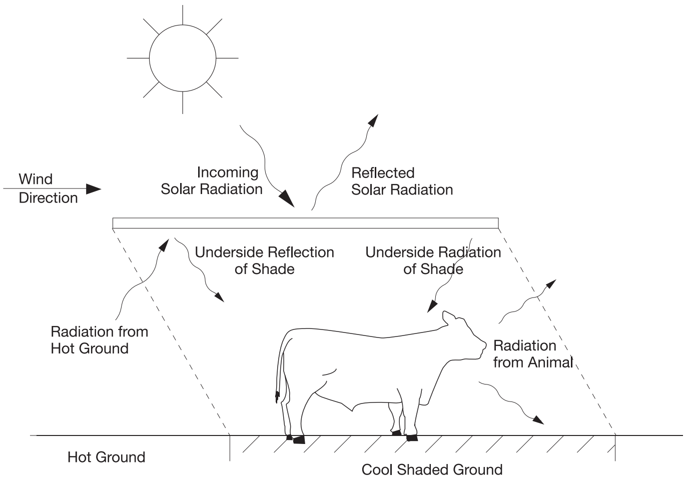

Figure 3: Radiation energy balance of a horizontal shade structure (adapted from Owen, 1994 and Esmay, 1978)

Ventilation

Air movement is an important factor in the relief of heat stress in cattle. The design of shade structures should ensure that ventilation is not restricted. Natural air movement under a shade structure is affected by its size (height and width), the slope of the roof and the ease with which air can move through the structure. Shadecloth has the advantage of allowing air to pass directly through the material, whilst structures constructed from galvanised sheeting require openings to assist air movement.

The heating of shade material by incoming solar radiation causes the air immediately beneath the shade material to become considerably hotter than the surrounding air, and therefore it rises. This 'buoyancy' can be used to passively create air movement beneath shade structures by allowing hot air to slide upwards on the inside of a sloping roof. As this air moves upward, it draws air in from the side of the structure. Rate of upward movement is related to the slope of the roof, buoyancy of the air, and roughness of the material. It is generally recommended that slopes of three horizontal to one vertical be used. This equates to a slope of 18°. It is known that for larger roof structures, slopes of 10–15° will utilise this phenomenon to similar effect. It is important to note that shade slopes over 15–20° may have a net negative effect on shaded areas.

Height

Meat & Livestock Australia (MLA) funded research projects have proven that many existing shade structures restrict air movement beneath the structure. Most existing structures are about four metres high. These effects can be profound. To combat the restricted ventilation the structures should be higher and the stock more spaced out to allow air movement in and around the cattle. While increasing the height of the structure will improve ventilation, it will also result in increased wind loads.

Management of shaded areas

The use of shades will result in a moist area beneath the shade due to the deposition of urine and faeces. This area, if not well managed to limit manure accumulation and moisture build up, may result in increased humidity and elevated ammonia levels within the pen and beneath the shade.

Repair and maintenance of the pen surface will also be high in this area. It is strongly recommended that areas beneath shade structures be regularly cleaned of wet manure to limit odour production and ammonia emissions. Increasing the height of a proposed shade structure will provide both a greater exposure of the pen to drying by morning to midday sun, and a greater movement of shade which will act to limit the occurrence of shade related wet pen conditions.

Key tips

- The provision of shade should be considered for susceptible cattle being housed in feedlots located in areas prone to high temperatures and radiation loads.
- In dry arid areas, shades should be placed on a north-south axis.
- In hot humid areas, shades should be placed on an east-west axis.
- Shades should be constructed to maximise ventilation, afternoon shade and a cool aspect.
- Manage shaded pen areas to limit potential increases in repairs, maintenance and environmental problems.
- Seek engineering advice on the design of the shade structure.

Structural design of shade systems

Wind loads

The movement of wind against a solid structure results in directional loads on the structure. If wind is moving against a wall it causes a **static side load**. As wind moves up and over a roof structure it causes a **download** on the front face of the roof and an **upload** on the downwind face as a result of an induced area of low pressure over the inclined surface. These forces must be taken into account when designing a shade structure, especially if the shade itself is sloped to obtain advantages in shading and ventilation. A sloping shade structure will act either as a wing or as an aerofoil depending upon the direction of the wind. These forces are shown in figure 4.

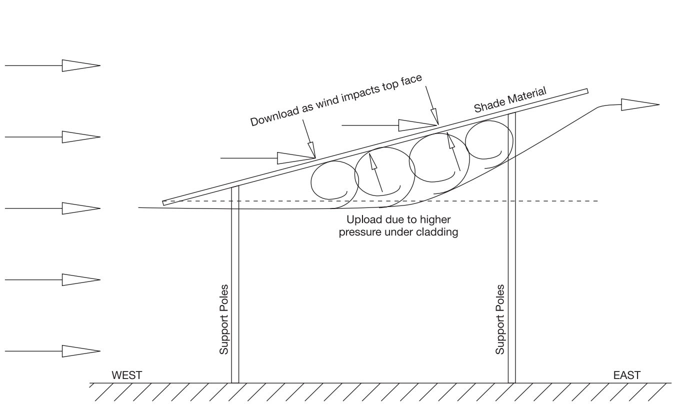

Figure 4: Static direction loads for wind

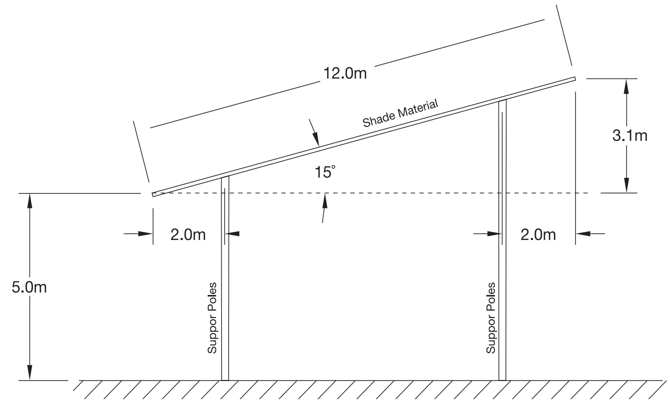

Figure 6: Conceptual shade design

Dead loads

A 'dead load' is the load supported by a structure and is equivalent to the mass of the materials held by the structure. The load is applied vertically downward due to gravitational force. This means that the load is passed either vertically downward through a support column or is restrained from movement downward by horizontal forces through systems such as tension cables. This is shown in figure 5. The dead load of galvanised sheeting is greater than that of shadecloth. Consequently, the support structures holding up galvanised iron shading need to be more substantial.

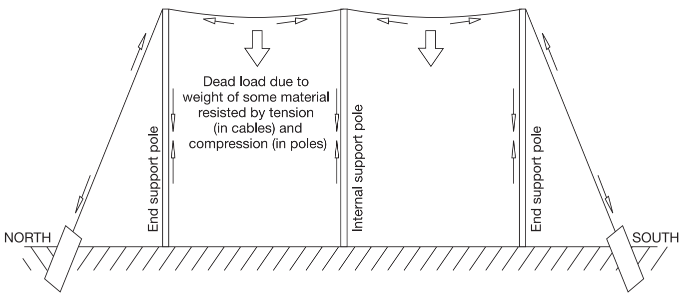

Figure 5: Tension cables

Dynamic loading

A dynamic load is a load that varies in character. It typically results from movement of a structural component or other variable or oscillating force. Wind gusts cause dynamic loading of structures. In the case of shade structures, wind driven movement of the shade will cause dynamic loading through swinging of the structure or alternating uplift or down draft loads.

The ability of the structure to shed load and dampen out oscillations becomes important when taking account of dynamic loads. The weight of the moving section is also of critical importance as the energy contained in movement of the part is the squared function of its mass and velocity. Consequently, a heavy moving structure becomes difficult to constrain.

The ideal design

By drawing on the theoretical outcomes of research and practical experience, a new generation of shade structures can be formulated. A conceptual design is presented in figures 6 and 7.

The design is based on a feedlot with pens 60m deep and 63m wide, containing 250 bullocks at a stocking density of about 15m^2/head.

The shade is located as a strip that runs across the feedlot pens in a north-south direction. The shade is pitched with the 'eave' towards the west. The upper side of the material is white and the bottom side is matt black. It is assumed that the material is a heavy-duty shadecloth that will allow high winds and rainfall to pass through the material.

Because the shade is on an angle its profile to winds will either make it an aerofoil or wing. Structural design to counter these aerodynamic features becomes important and the pervious nature and lightness of shadecloth provides this material with design efficiencies over coloured galvanised iron. The use of galvanised iron in this type of structure would significantly increase loading rates and thus the size of support structures.

Because the shade material is high and pitched, the shade will move across the pen quickly. Shade providing the largest area per animal is most important late in the afternoon when stock have been accumulating heat for the longest and daytime temperatures are at their greatest. Research has found that the highest daytime temperatures often occur between 2–4pm EST and that typically heat stress occurs in the period between 2–6pm, with cattle often showing most stress in the period between 3–5pm EST.

Some care needs to be taken in the location of the shade structure to ensure that shade is kept within the pen during the afternoon. By 4pm (EST) 20 January the throw of the shade from the 15° shade will be 10.75 metres (9.3 metres for 10°), and by 6pm (EST) the throw will be 41.2 metres (36 metres for 10°). This gives reason to place the shade on the western side of the pen.

Conflict with the placement of the water trough needs to be avoided because this is an area where moisture accumulates. It is recommended that in earth-based yards, troughs are located away from shaded areas to limit the build up of wet manure.

Figure 7 shows a simple plan of the position of the shade as described. It is located 15m off the western fence line allowing sufficient room to place a water trough on the dividing fence line whilst providing some distance between the pen gate and the trough, and the trough and shade structure. The throw of the shade at 6pm would result in the shade being cast onto the feed bunk if the pitch of the shade was 15°.

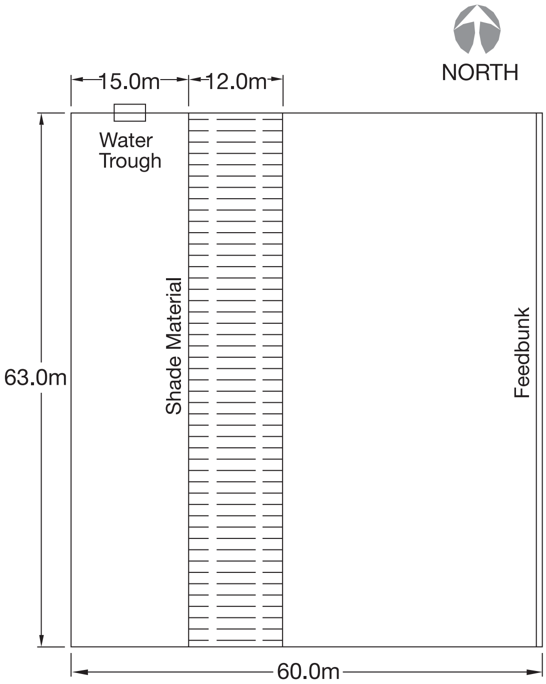

Figure 7: Conceptual shade location within a feedlot pen

Conceptual shade design specifications

- The western 'eave' is 5m (or higher) off the ground to improve airflow through the side of the shade system.
- The shade is 12m wide, which allows for effective use of materials as most are provided in 6m widths or lengths.
- If the pitch is 15° the top of the shade is 3.1m above the lower eave of the shade. If the slope is 10° the upper edge is 2m higher than the western edge.
- The 12m wide strip of shade will have an 11.6 or 11.8m planar width, given the pitch of 15° or 10° respectively. This equates to a shade cover of 2.92 m^2/head or 2.97m^2/head if the sun were immediately overhead.
- In the afternoon an increase in shaded area due to the western pitch will become available to cattle. Based on the position of the sun on 20 January at Toowoomba between 3–4pm the average increase (over the hour) in shaded area is 28.5% (15°) or 18.4% (10°). Therefore the shaded area increases to 3.75m^2/head or 3.51m^2/head, respectively.

The bottom line

Shade structures can be used in feedlots to improve cattle comfort and to decrease the risk of reduced productivity due to excessive body heat loads. Shades should be designed to maximise ventilation and afternoon shade. It is recommended that engineering advice be sought in the design and placement of feedlot shade structures.

Further information

This *Tips & Tools* is part of a series on understanding, recognising and managing heat load in feedlot cattle. For a copy of *Heat load in feedlot cattle* call MLA on 1800 023 100, email info@mla.com.au or visit www.mla.com.au/publications

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tips & tools

FEEDLOTS

Automatic weather stations in feedlots

Accurate weather monitoring is an important aspect of feedlot management. Adverse weather conditions can impact on cattle production and welfare, particularly during the hotter months. Feedlot operators should closely monitor local climatic conditions and review future weather forecasts to monitor and manage the risk of cattle experiencing elevated body heat loads that can impact on production and animal welfare.

Weather monitoring may also be required to support feedlot environmental licenses or development applications, particularly if there is the potential for odour or dust to impact on neighbouring properties.

Key benefits

- An automatic weather station can be used to record detailed meteorological data on feedlots to assist with management decisions and animal welfare.
- Meteorological data is readily available should it be required for environmental licences or development approvals.

Tips

- Determine clear objectives for use before selecting and installing your automatic weather station.
- Here are some things to consider when selecting your automatic weather station:

  o How accurate is it?

  o How reliable will it be?

  o How easy is it to use?

  o How easy is it to maintain?

  o Are maintenance services readily available?

  o Is the data easy to manage?

  o Will it be compatible with your current communication systems and application software?

  o How much does it cost?
- To get the most accurate data from your automatic weather station, make sure it is regularly maintained and serviced.

Bureau of Meteorology weather stations

The Bureau of Meteorology (BOM) records weather at selected stations across Australia. The type and amount of data collected by these stations varies. At many locations only daily rainfall is recorded. In a few strategic locations very detailed measurements are taken to allow detailed modelling of atmospheric conditions for weather forecasting.

Feedlot managers can tap into the information collected by the BOM to get quality historical climatic records or short-term weather predictions. Information is available from the BOM Climate and Consultancy Services in each state via either email or from their website using a program called 'Datadrill'.

Weather forecasts can be obtained from a number of locations including:

- Weather (satellite maps) by fax – 1902 935 255
- BOM website provides general information, weather forecasts and radar tracking of storm movements – **www.bom.gov.au**
- Queensland Department of Natural Resources and Mines Long Paddock Season Outlooks – **www.longpaddock.qld.gov.au/SeasonalClimateOutlook**
- Katestone Environmental has six-day climatic forecast at specific locations within the major lotfeeding regions around Australia – **www.katestone.com.au/mla**

There is a large expanse of rural Australia where few BOM stations exist, and if they are local they may only record daily rainfall. This means that it is not possible to get a detailed historical picture of some local conditions, and forecasts may not take local factors into account. In these situations an automatic weather station at the feedlot can be well justified to provide accurate measurement and recording of local conditions. This information can be used for both historical records and for real time measurement of ambient conditions used in management of on-ground operations.

Automatic weather stations

An automatic weather station is a set of equipment constructed to measure and record specific attributes of the ambient environment (see figure 1). It relies on sensors to measure a physical property or condition over time. Sensors are the heart and soul of a weather station.

As a general rule, the cheaper the weather station and sensors, the less accurate the data, the more prone the electronics and sensors are to fail, and the higher the maintenance costs. It is also important to note that while some software in a weather station may look great, it may not warrant the investment required.

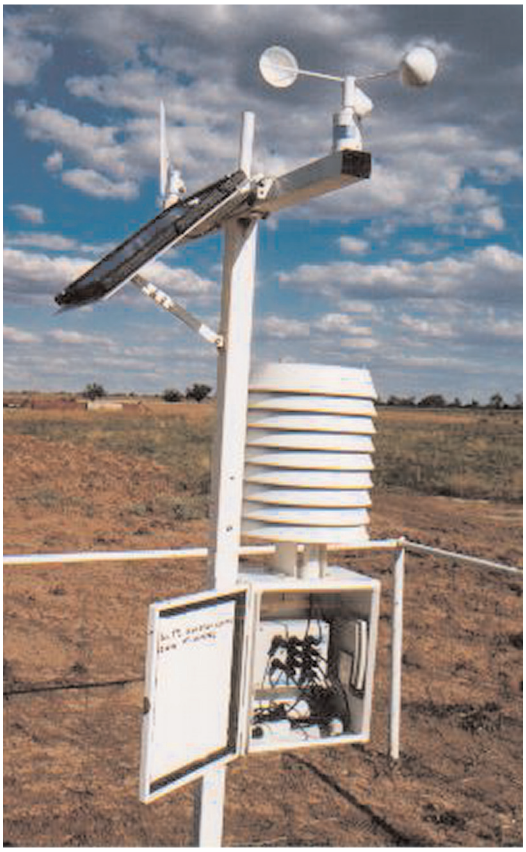

Figure 1: An automatic weather station
Photo courtesy of E.A. Systems Pty Limited

Sensors

The pivotal component of the sensor is a 'transducer' which converts a signal from one medium, such as temperature of a probe, into an electrical signal. Electronic circuitry in the sensor itself, or in a centralised processor, gathers these signals.

As the properties of probes and circuitry components can change, the characteristics of the transducer and signal may alter over time. This underpins the need for high quality transducers and sensors and regular sensor calibration to reduce error.

Automatic weather stations are able to record a host of different measurements including:

- rainfall
- ambient temperature
- relative humidity
- wind speed
- wind direction
- incoming solar radiation
- barometric pressure

Using this information it is possible to calculate a host of important variables for feedlots including heat load on stock and potential evaporation. For example, irrigation requirements can be determined using potential evaporation readings to determine the rate of water loss from irrigation areas receiving wastewaters.

Communications

It is important that the communications system used by the weather station allows for easy data transfer from the station to the user. The communication system will depend on both software and hardware, such as mobile phones, UHFs and modems. Systems should be reliable, inexpensive and follow standard protocols for data transfer. Most feedlots use UHF communication systems because they are similar to other telemetry used in agriculture, such as pump control systems or mobile phone links. Recent advances in data transfer using CDMA and GSM now allow remote access to many areas that are not able to be reached by UHF.

Data management

The capture, retention and subsequent output of data must be carefully considered when selecting a weather station. The formats used should be:

- **practical –** the system should be flexible enough to allow additional sensors to be added in the future
- **simple –** the system should not need specialist programs to decode the stored data
- **easy to use –** the data should transfer directly between applications software, eg from an ASCII file straight into an Excel spreadsheet
- **independent of the manufacturer –** the data management should not be dependent upon manufacturer's software, which may limit the ability to transfer files and data, and impede competition between manufacturers.

The use of standard software and standard formatting allows easy management of data and increases useability and functionality. The BOM has standard data formats and the data collected by a local weather station should be configured to comply with one of these formats.

Siting

The BOM has a standard for the installation of weather stations which sets out the requirements for their operation and management. The BOM states that a 12m by 12m enclosure should be used for the layout of the weather station sensors. The fence must be robust enough to ensure that sensors are not damaged by stock.

If the weather station has sensors that are housed together, the area of the enclosure can be reduced. However, it is extremely important to note that the fence must not affect sensor readings (eg by shading, influencing wind movement or producing a rainfall shadow). The minimum suggested area for a weather station enclosure is 5m by 5m.

Another important standard is AS2923-1987 *Ambient Air – Guide for Measurement of Horizontal Wind for Air Quality Applications.* This standard is particularly important where data is being collected for the purpose of odour impact assessments, including dispersion modelling. It notes that the weather station should be placed away from trees, buildings, etc at a distance from the largest obstacle to wind movement of 10 times its height. For example, if the largest obstacle is 5 metres high, the weather station would be placed 50 metres from that obstacle.

Maintenance

The weather station should be easy to maintain, and maintenance should be possible without affecting the climate record. For instance, sensors should be able to be unplugged whilst they are being cleaned without affecting the recording of other variables.

The lifetime cost of a weather station should be considered rather than only its initial purchase price. Lifetime cost will include initial purchase cost (hardware and software), installation cost, annual maintenance cost, sensor replacement frequency and sensor cost, software update costs and data loss costs. Often, the lower the initial purchase costs, the higher the ongoing costs and the number of times when little or no useable data is recorded.

Frequent maintenance will be required if the weather station is in an aggressive environment. Ideally maintenance should be limited to once per quarter or less, with sensor replacement every two years or thereabouts. Some cheaper stations have less accurate sensors that need to be replaced more frequently. In this case, a cost compromise must be struck between initial costs and ongoing maintenance and repair costs. Regardless, some transducers do degrade and despite quality constraints even the best sensors will need to be replaced.

Poor maintenance can result in lost data and increased repair costs down the track. Figure 2 shows dust accumulation on a sensor. The resultant blockage prevented recording of data required by an environment protection agency licence.

Figure 2: A rainfall sensor clogged with dust
Photo courtesy of E.A. Systems Pty Limited

Setting objectives for microclimate measurements

Clear objectives must be set when monitoring weather conditions in a feedlot.

In some cases, feedlot environmental licences and development approvals require – the operator to collect meteorological measurements that may be – as simple as daily rainfall or as complex as wind stability on a 10 minute basis. Climate data can be obtained from a local BOM weather station, although in many regions the detailed meteorological data required may not be available locally. In NSW, the Environment Protection Authority guidelines for odour assessment require the collection of at least 12-months' meteorological data for development applications where odour impact is expected. This data is used in odour dispersion modelling for the proposed site. A weather station must be installed at the site to collect data for a minimum of two to three months so that the results can be correlated with a local BOM station if available.

Objectives for using automatic weather stations in feedlots and associated farms could include:

- collecting weather data (rainfall, wind speed and direction etc) to provide records for reports to government agencies
- collecting wind speed and direction data to confirm or defend possible complaints
- calculating a heat stress index to provide real time indications of heat load on stock
- collecting solar radiation, wind, ambient temperature and relative humidity data to calculate evaporation rates to determine crop water requirements for irrigation purposes
- collecting soil temperature data to determine planting times for crops
- collecting barometric pressure, temperature and humidity data to assist in managing feed supply to stock (changes to pressure have been associated with changes in feed intake)

Using automatic weather stations in feedlots

Once a clear objective for the use of the weather station has been determined it should be sited in an area that represents this purpose. There may be competing objectives on a property, for instance the microclimate of a feedlot may be very different from its associated irrigation farm, either one location or the other must be chosen, or two weather stations used. The site should be kept clear of all future developments that may impact on the microclimate of the area, eg keep it clear of a possible site for silo construction.

In-pen weather stations

In an attempt to measure the actual conditions experienced by cattle some feedlots have placed weather stations inside a pen. However, pen conditions can be extremely aggressive and can result in:

- dust accumulating on, and in, sensors
- corrosive attack by organic matter
- sensor damage by cattle
- wiring damage by rodents
- sensors and wiring damage by birds
- sensors and circuitry damaged by electromagnetic fields from welding during pen repairs
- equipment damage by cleaning machinery and pen riders

All of these factors may significantly accelerate equipment wear and tear and damage.

Locating a feedlot weather station

The best location for a weather station in a feedlot is:

- outside a pen
- about 500m from the office in a place readily visible to the feedlot manager
- well away from the feedmill, stock, stock facilities, stockmen and machinery
- in an area representative of the area surrounding the feedlot, eg a grassed paddock without any trees or buildings around it
- in an accessible area so that the surrounds can be maintained

While the weather station will not record the exact conditions the cattle are experiencing in the pens, it can provide quality local data that can be used for assessment of pen conditions. Further information on the formula used to provide this information can be found in *Tips & Tools: Recognising excessive heat load in feedlot cattle*.

Maintenance of feedlot weather stations

If the weather station is located close to dust generating areas the primary maintenance problem will be dust accumulation on, and in, sensors. The minimum recommended service interval is once per quarter with interim wipe down servicing in extreme seasonal circumstances.

Sensors should be checked, serviced and calibrated on a regular basis. Simple calibration checks should be made using thermometers (ambient air temperature), sling psychrometers (relative humidity), hand held anemometers (wind speed), a sight compass (wind direction) and other calibrated sensors to benchmark readings.

Sensors should only be returned to the manufacturer when the deviation from the calibration reading is unacceptable. Most good quality sensors simply need recalibration rather than replacement.

Handy hints

Do:

- purchase a weather station for accuracy, reliability and ease of data management
- use a simple communication system that is reliable and not dependent upon special software
- download data on a regular basis
- use the data as much as possible to get the best return on your investment (when data is used regularly the true worth of the station is realised)
- have the weather station serviced regularly by someone independent who can provide infield checks of sensor competence
- ensure the weather station is installed to prevent access by mice or attack on elevated cables by birds

Do not:

- locate the station near a boundary fence where unauthorised persons can access it
- weld near the weather station - it may blow up!
- use a lawn mower or whipper-snipper near the weather station until all cables are located and moved out of the way – cut cables are the best shot you can get at losing data
- put the weather station near large metal objects that attract lightning - this is the best frying system nature invented
- allow the weather station to be accessed by anyone that does not have the appropriate knowledge or training
- believe all the data the station collects for the above reasons

The bottom line

Automatic weather stations can provide a wealth of local feedlot microclimate data that can be used in property management and can provide required historical weather data to support government and regulatory requirements.

Further information

This *Tips & Tools* is part of a series on understanding, recognising and managing heat load in feedlot cattle.

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tips & tools

FEEDLOTS

Assessing the risk of an excessive heat load event occurring

Assessing the risk of an excessive heat load (EHL) event is an essential part of a feedlot's risk management process. To assist feedlots in undertaking this process, a Risk Analysis Program (RAP) has been developed. The RAP is a Windows based computer program that can be used to identify regions, individual feedlots and even individual pens within feedlots that are at risk of an EHL event occurring.

An initial assessment will provide valuable insight into the level of risk associated with feeding a particular class of cattle in the specific feedlot operation. However, the true value of the RAP is recognised when it is incorporated into the pre-summer review of the feedlot's preparedness for an EHL event. Areas identified as being at risk by the RAP software can then be targeted by feedlot operators in their summer management plans and in the development of the feedlot's EHL event strategy. Further information on summer management plans and EHL event strategies can be found in *Tips & Tools: Managing heat load in feedlot cattle – an overview*.

Key benefits

- The RAP software allows feedlot operators to quantify the risk of an EHL event occurring at their feedlot.
- The RAP software can also be used to identify specific high risk pens within individual feedlots.
- The RAP software also allows feedlot operators to examine management factors and mitigation strategies to reduce the risk of an EHL event occurring.This allows management strategies to be put in place to better plan and prepare for summer, to reduce the risk of an EHL event occurring.

The RAP software

The RAP Software uses a number of critical heat load variables to determine the risk of EHL events occurring at individual feedlots. These include:

- regional climate
- animal factors
- feedlot management variables
- EHL event mitigation strategies

Regional climate

Data from the Bureau of Meteorology Automatic Weather Stations has been collected for the major lotfeeding regions in Australia. The weather stations used were chosen on the basis of the reliability of their data and the period of time that reliable data could be accessed from each station (figure 1). This data is then used to quantify the risk of an EHL event occurring at a regional level. Within the RAP software, climatic variability is quantified on the first page, when the operator is asked to identify the weather station(s) closest to their operation.

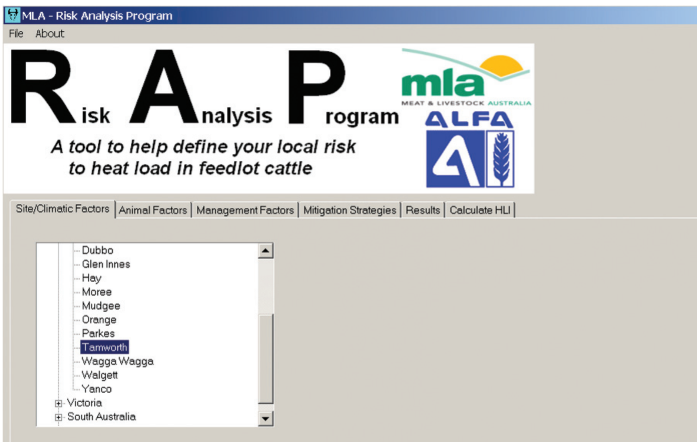

Figure 1: Quantifying regional climatic risk within the RAP

Animal factors

A number of animal factors are considered in the RAP (figure 2). These factors include:

- genotype
- coat colour
- body condition score
- health status

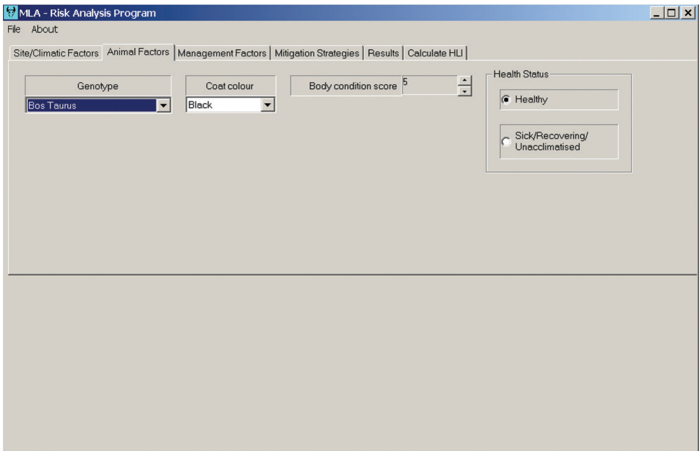

Figure 2: Quantifying the effects of specific animal factors within the RAP

Management factors

The management factors included in the RAP were selected based on previous research into feedlot site factors that affect heat load (see figure 3). The management factors considered within the RAP are:

- shade (type and amount)
- trough water temperature
- manure management

The type of shade material used is not considered in the RAP, nor is shade design (shade height, slope, etc). These factors are not considered as it is impossible, at this stage, to incorporate and quantify the effect of all shade design and material permutations into the software.

The temperature of drinking water influences the animal's ability to dissipate body heat. Therefore, it is important that trough water temperature is determined and included in the RAP.

The amount of manure in a pen, together with the manure water content, can impact on the heat load imposed on the cattle in that pen due to microclimatic effects (mainly increases in relative humidity). To quantify the effects of various manure management strategies, a manure management feedlot class is included within the RAP. The classes are as used in the national guidelines, and define the manure pad depth maintenance requirements and associated pen cleaning frequencies.

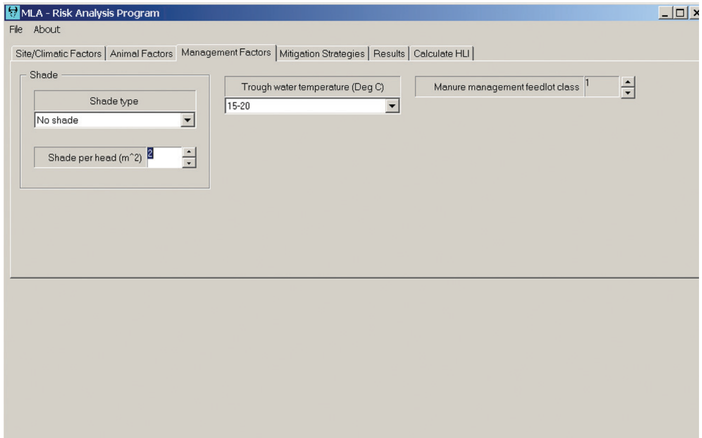

Figure 3: Quantifying the effects of specific feedlot management strategies within the RAP

EHL event mitigation strategies

Specific EHL event mitigation strategies are also considered by the RAP (see figure 4).

These strategies include:

- installation of extra temporary water troughs
- implementation of a heat load feeding strategy
- strategic cleaning of high manure deposition areas

The heat load feeding strategy will vary between feedlots. However, if the feedlot has a pre-planned feeding management strategy which can be implemented prior to the onset of EHL events, this will reduce the risk of an event occurring. Further information can be found in *Tips & Tools: Summer feeding of feedlot cattle*.

Strategic cleaning of areas with a high level of manure deposition (eg around water troughs and feedbunks and under shade structures) prior to and during an EHL event can assist by reducing the amount of wet manure which contributes to a reduction in the relative humidity within the pen microclimate.

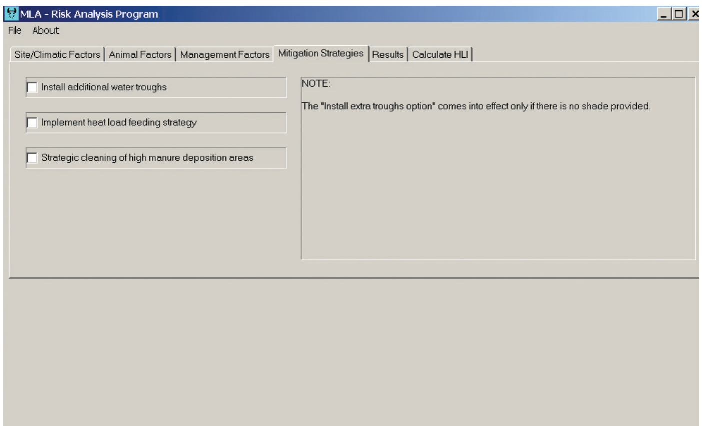

Figure 4: Quantifying the effects of EHL event mitigation strategies within the RAP

The mechanics of the RAP

The RAP software quantifies the effect of the variables outlined above by estimating the effect they have on the upper heat load index (HLI) threshold. The HLI is a thermal indicator developed by Meat & Livestock Australia (MLA) that uses a combination of black globe temperature (either measured directly or derived from ambient temperature and solar radiation measurements), relative humidity and wind speed measurements to calculate a value which is used to assess the environmental heat load placed on cattle. The 'HLI thresholds' are outlined in *Tips & Tools: Recognising excessive heat load in feedlot cattle*. The RAP software calculates an adjusted HLI threshold for each feedlot, or feedlot pen, which can then be used to more accurately predict the heat load on the animals within that feedlot, or feedlot pen.

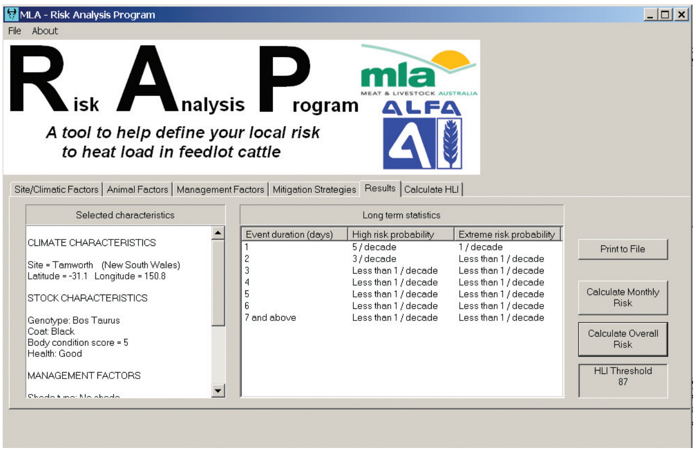

Figure 5: The output from the RAP software, showing the risk of EHL events occurring

RAP software output

The output from the RAP software expresses the probability of a high risk or extreme risk EHL event occurring in the feedlot or in a specific pen in the feedlot (depending on the information entered), and the number of days over which those events are likely to continue (figure 5). A calculated upper HLI threshold is also shown. This threshold indicates the HLI level above which the cattle in that feedlot or feedlot pen will begin to accumulate body heat.

Once the output from the RAP software has been obtained, it is possible to predict the onset of an EHL event. A forecasting service has been developed (visit http://www.katestone.com.au/mla) that allows feedlot managers to obtain a six-day forecast for the environmental conditions at certain sites in lotfeeding regions around Australia. By applying the specific HLI threshold output generated by the RAP software, the accuracy of the forecasting is increased.

Operators can also use the RAP to examine combinations of management factors and mitigation strategies that can be employed to reduce the risk of an EHL event occurring for the particular class of animal that they are examining.

The bottom line

The RAP software is an important tool to assist feedlot operators to quantify the risk of an EHL event occurring at their feedlot. It can also be used to identify at risk pens within individual feedlots.

The RAP software should be used as part of a risk review conducted prior to the onset of summer, so that summer management programs and EHL event strategies can be prepared.

Further information

This *Tips & Tools* is part of a series on understanding, recognising and managing heat load in feedlot cattle.
For a copy of *Heat load in feedlot cattle* call MLA on 1800 023 100, email info@mla.com.au or visit www.mla.com.au/publications

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