MEAT & LIVESTOCK AUSTRALIA

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.

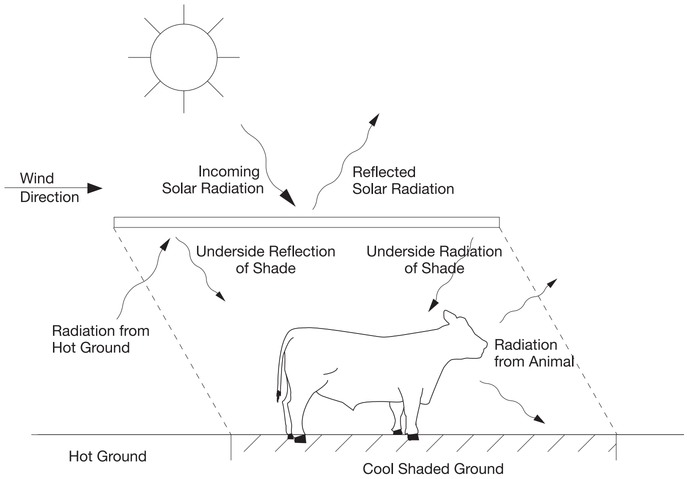

Figure 3: Radiation energy balance of a horizontal shade structure (adapted from Owen, 1994 and Esmay, 1978)

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.

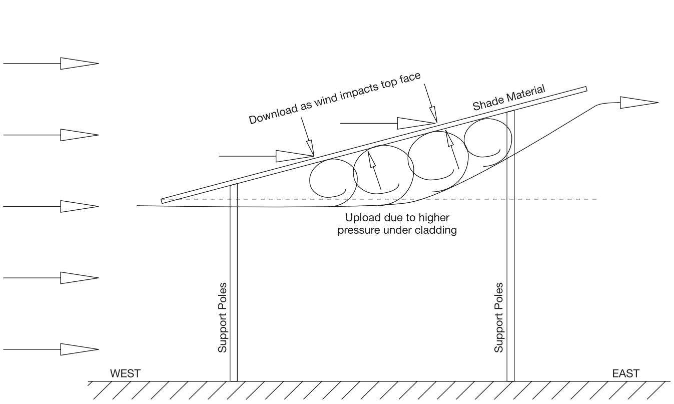

Figure 4: Static direction loads for wind

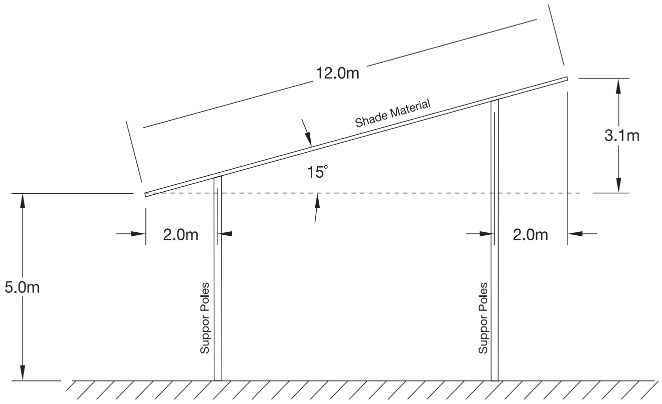

Figure 6: Conceptual shade design

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.

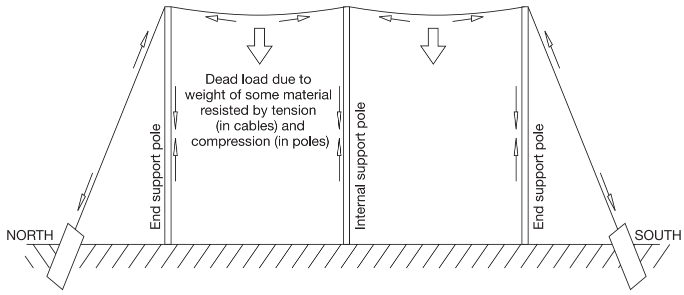

Figure 5: Tension cables

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°.

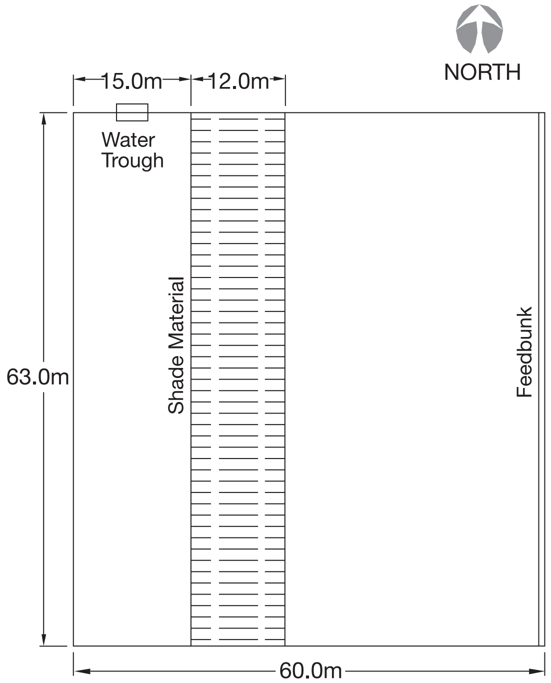

Figure 7: Conceptual shade location within a feedlot pen

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 675 717 or email publications@mla.com.au

Key contact

Des Rinehart, MLA
Ph: 07 3620 5236
Email: drinehart@mla.com.au

MEAT & LIVESTOCK AUSTRALIA

Level 1, 165 Walker Street,
North Sydney NSW 2060
Ph: +61 2 9463 9333
Fax: +61 2 9463 9393
www.mla.com.au

Reprinted October 2006
ISBN: 1 74036 505 4

ABN 39 081 678 364