

REDUCING HEAT STRESS IN LIVESTOCK WITH SHADE & SHELTER STRUCTURES



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INTRODUCTION

Cattle have an excellent ability to cope with climatic conditions but the combination of high temperature and humidity, with high levels of solar radiation and minimal air movement, can exceed the animal's ability to dissipate body heat.

Excessive heat load in cattle during summer months can result in significant yield losses, cattle welfare issues and under extreme conditions, the death of cattle. Shade structure systems have been used to reduce the impact of heat wave conditions on cattle.

Shade is a thermal radiation shield that reduces heat load on the animal. Shade does not readily affect air temperature but can reduce exposure to solar radiation and enhance minimal air movement for cooling. Major design considerations for shade structures are orientation, space, height and shading material.

DESIGN OBJECTIVES

The design objectives for a shade structure are to

- provide adequate shade for each animal in the pen (square metres per animal) – see technical requirements
- provide a structurally sound and durable structure
- minimise obstructions when cleaning the pen
- maximise air flow under the shade
- maximise pen drying under the shade
- design a structure that suits the geographical location. - shade or shelter

MANDATORY REQUIREMENTS

The Australian Animal Welfare Standards and Guidelines for Cattle (DAFF, 2013) states

S10.4 A person in charge must do a risk assessment each year for the heat load risk at the feedlot and implement appropriate actions to manage ongoing heat load risk.

S10.5 A person in charge must have a documented Excessive Heat Load Action Plan and must implement appropriate actions in the event of a heat load emergency.

TECHNICAL REQUIREMENTS

Shade area per animal

Cattle will use shade when it is available. Lot feeders who have installed shade for cattle have provided between 1.6 m² and 6 m² of shade per head. Shade structures suitable for Australian conditions should ideally provide more than 2 m² of shaded pen floor space per animal, recognising that it is beneficial to spread cattle during excessive heat load events. Overcrowding cattle under shade during normal summer conditions will limit any potential production benefit.

SHADE OPTIONS

Each feedlot has its own distinctive location, topography, climatic conditions, cattle breeds, feeding categories, customers and capital capability. The choice of shade structure and materials for the feedlot will depend on a number of these factors.

Types of shade structure

Four types of shade structure can be used in feedlots

- longitudinal rows – long shade structures that stretch over many different pens
- centre squares – large tent-like structures in the centre of the pen
- separate panels – structures connected in a grid-like pattern and providing alternating shade spots through each pen.
- Fabric structures that provide shade & weatherproof shelter

Spacing in shade structure

Both longitudinal row and centre squares shade structures may have spaces or gaps throughout the structure to encourage the pen floor to dry during the day and to increase air flow. Sunlight reaching different parts of the pen at different times of the day should prevent a build-up of wet manure.

With longitudinal rows, these spaces may run along or across the rows. Spaces within the structure encourage cattle to stand in groups and to move across the pen following the shade areas. This decreases site specific wet spots and promotes airflow.

A disadvantage with centre square structures is that a portion of the pen will always be in the shade and hence will remain wet.

The area of shade provided by the shade structures and the frequency of the spacing in between is important as narrow strips of shade with a high frequency of spacing can result in the cattle bunching and over-heating.

Fabric shelters that provide weather shelter are especially advantageous in higher rainfall areas.

Orientation

Orientation of the structure will determine the pattern of the shade underneath and the amount of shade available to the cattle. The best orientation may depend on the overall design of the feedlot pens, the local climate and the prevailing winds that assist in ventilation and cooling.

The orientation of the longitudinal row shade structure should be north-south, especially if it has no strips to allow for drying, while the orientation of centre square and separate panel structures is unimportant.

Longitudinal row shade structures positioned in the north-south direction with the shade material orientated east-west can have the eastern side of the structure elevated to provide a 10-15° pitch. This encourages better pen floor drying in the morning hours, provides more shade area during the afternoon and increases air flow under the shade structure. A north-south orientation works well with a compacted clay or gravel floor because the sun strikes every part of the pen floor under and on either side of the shade at some time during the day.

Position in the pen

Shade structures are typically erected towards the centre of the pens so that cattle can follow the shaded area as it moves across the pen during the day.

Shade positioning should take advantage of the morning sun for drying while maximising the shaded area in the afternoon summer sun.

Shade only type structures should not be positioned over water troughs or near a fence line; water troughs and feed bunks should be kept outside the shaded area (particularly in the hottest time of the day). Ideally, strips of shade should be constructed parallel to the feed bunk but not close to it. Shade over the troughs or bunks encourages cattle to congregate around them, limiting access for extensive periods while increasing pen surface pitting in these already high traffic areas.

Support posts and cables

Obstructions in the pen should be minimised to allow easy cleaning and less risk of animal injury. Clear span structures are preferred with few or no support posts in pens. Separate panel shade structures do not require any posts in the pen to hold them up as a cable network is constructed with posts on the fence line. However, fewer support structures means that they will need to be engineered to support the shading material and withstand the force of high winds, and hence are more costly. Support posts should preferably be in line with the perimeter fences.

Centre square and longitudinal row shade structure often need support posts within the pen, and this can create areas which are extremely difficult to clean.

Columns are commonly made from steel, but the base should be encased in concrete to prevent corrosion, to provide better protection from equipment damage during pen cleaning operations and to reduce injury to cattle that bump into them.

Roofing material is often supported on cable strung between supports that are determined by calculated engineering load. Cables should be storm rated for the feedlot site but should be at least 11mm cable to ensure good tension and long life. The thread should be high density, low shrinkage, abrasion resistant and unaffected by cleaning agents, acid rain, mildew, chlorine, saltwater and industrial pollutants. End assembly strainers should be outside the pen.

Shade material

The most commonly used shading materials are shade cloth, waterproof fabrics and galvanised iron sheet.

Shade cloth is available in many densities and strengths. It is generally manufactured from lightweight knitted or woven polyethylene fabric that is resistant to rot and mildew, does not become brittle and is water permeable. It provides a good shade, reflects heat, diffuses light, has long life and is easily supported with adequate assemblies.

Knitted shade cloth is heavy duty with a longer life expectancy. Shade netting is slightly cheaper, has a considerably shorter life expectancy and tends to unravel and fall apart if not taped. Woven synthetic shade materials are available in varying degrees of strength and texture. However, woven shade netting can accumulate dust & so become impermeable to rain & hail while also harbouring birds & rodents.

Table 1. Advantages of shade cloth and iron sheeting for shade

Shade materials and structures		
	Shade cloth	Iron Sheeting
Suitability	May be retractable allowing pens to dry out in winter months.	Typically permanent fixed shade structures.
UV radiation protection (UPF)	UPF varies with colour, fabric density and degree of stretch (from <50% to >90% UPF). A shade rating of 90% will give a UPF of only 10.	Excellent protection with UPF 50+.
Light transmission	Lighter colours allow more light but reflect and scatter more UV radiation.	None.
Solar heat gain	Barrier to direct solar radiation while allowing ventilation. Darker colours are hotter and reflect less UV radiation	Better thermal performance if painted white topside
Structural implications	Minimal down or uplift force as material is porous (if clean). Shade cloth can be damaged by wind unless sufficiently tensioned.	Requires well-engineered support structures fixed to manufacturers specification and designed to wind codes and potential loads.
Permeability	Mainly permeable unless sealed with dust. Pen maintenance problems if the area beneath shade becomes permanently wet.	Not permeable but can concentrate heavy runoff leading to pen maintenance issues
Ease of replacement	Readily available. Re-fitting is generally easy and low cost.	Material readily available and easily fitted.
Maintenance Requirements	Keep clear of tree debris. Dust can reduce porosity, increase tension and concentrate heavy rainfall on the down slope machinery and vehicles access to the pen. Retractable shade cloth can allow pens to dry out in winter.	Requires minimal maintenance to the structure itself. Remove all metal shards after installation to prevent staining and corrosion under moisture. Water runoff on down slope side under heavy rainfall can create wet patches, increasing pen maintenance. Wet shaded areas may cause dags on cattle, increasing Maintenance requirements.
Life span	About five years depending on location, less in windy locations. Retractable shades generally last longer if stored appropriately.	Long life if well maintained. Fixings and flashing materials should have a lifetime similar to that of the roof covering material.

Reinforcing webbing around the shade panels supports the cloth so that it can be tensioned to minimise wind flap. The use of eyelets, grommets &/or clips are not recommended if a more permanent shade structure is required

Corrugated roofing iron requires more support through the structure but provides increased rigidity in high winds, is resistant to birds and rodents and can have a longer life span than shade cloth.

Iron sheeting can also reflect solar radiation; a silver or white coating on the surface can significantly reduce radiant heat.

Height of shade structure

Higher structures will allow better ventilation but result in increased wind loads and costs. As low shade cloth structures may discourage cattle from entering an area the minimum height is 4 m, but 5 m will reduce the risk of pen cleaning machinery tearing cloth with an extended loader bucket or tipping tray or burning holes in it with an exhaust pipe.

Shade height also determines the area of shade cast at different times of the day.

Inclination of shade structure

Inclined shade structures may increase the sunlit area in the morning and extend shade coverage in the afternoon sun, thereby increasing the shadow area accessible by cattle. Sloping fabric will shed more rainwater.

Shapes that have little curvature and tension will deform under load and become unstable and move about. Outside the agricultural industry, the best shade designs from a structural stability perspective are thought to be shade sails that have a significant difference in height of posts, where one corner is higher than the other. The shade sail is essentially pulled taut and twisted so one axis is convex and the other axis concave.

With suspended iron sheeting, a lower pitched roof (1:4 pitch or less) can result in lower air movement whereas a steeper roof pitch results in greater air movement (e.g. 1:3 pitch is suggested for a hotter climate).

Retractable shade structures

Shade can be retractable so that it can be removed during the winter when not required, especially in winter rainfall regions.

Retracted shades help to keep the pen surface dry when evapo-transpiration is low. Retracting shade cloth helps prolong its life.

Other shade cloth structures can be removed for winter periods but need to be stored correctly to maintain life expectancy.

Rainfall zone

Rainfall zone can influence the type of shade to be used. Feedlots located in winter-dominant rainfall areas would favour north-south orientation with retractable shade cloth, as this would allow for optimum pen drying.

In high rainfall areas, solid shade covering needs adequate draining to prevent ponding on the pen surface.

Structural design

Shade cloth needs to be structurally sound in order to withstand wind loads. The impact of excessive wind load at the feedlot site should be considered in the design of an appropriate shade structure and accompanying strengthening assemblies.

The movement of wind against a solid structure result in directional loads on the structure. Wind moving against a wall causes a static side load. As wind moves up and over an inclined surface roof structure, it causes a download on the front face of the roof and an upload on the leeward face as a result of an induced area of low pressure. These forces must be considered 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.

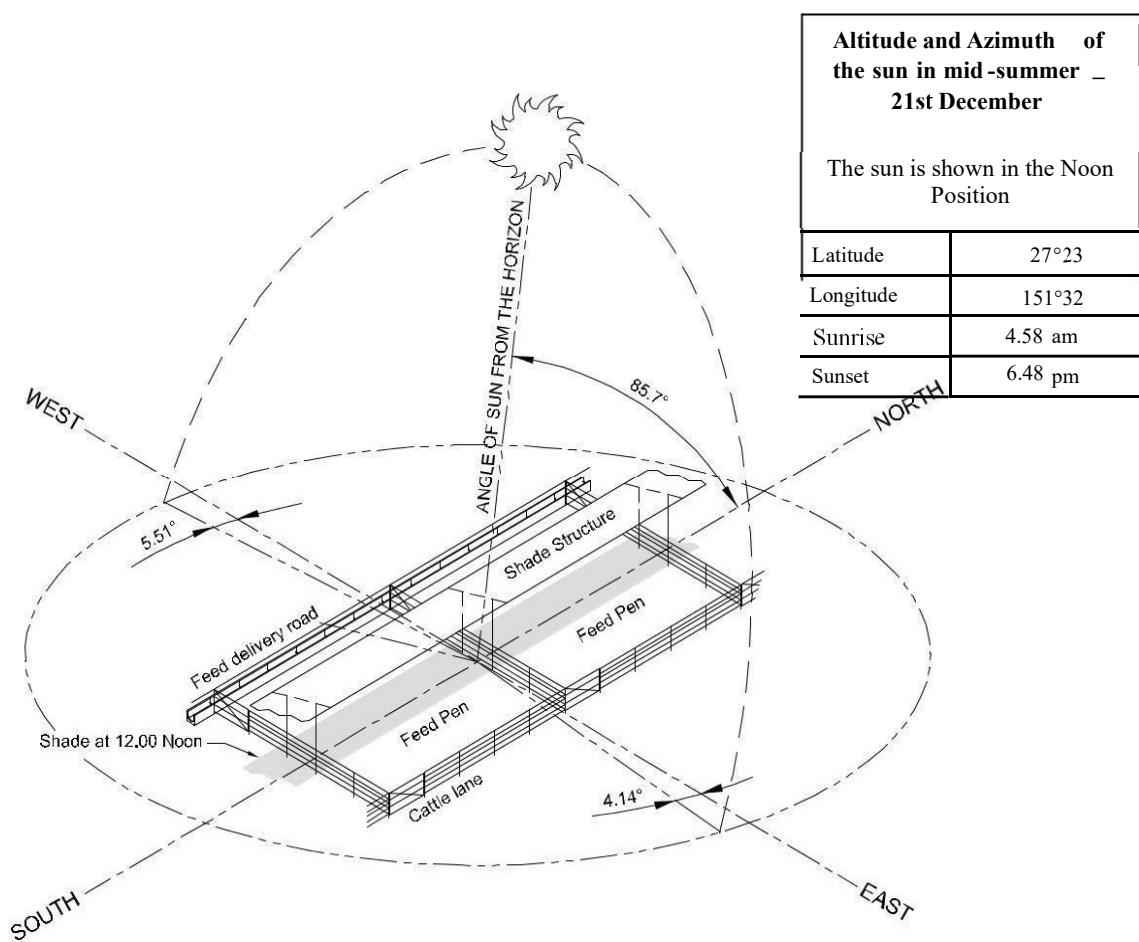
Structural design should be undertaken by a suitability qualified, licensed and experienced structural engineer.

Preparing a shadow diagram

A shadow diagram should be prepared to ascertain how a shade structure is likely to affect the shadows cast.

The following diagram is provided to illustrate the preparation of a shadow diagram for a feedlot site.

1. Place the north point on the plan.
2. Determine the angle of the sun at the feedlot site for three or more times during the day e.g. 9 am, 12 noon and 3 pm. Solar azimuth and elevation calculations can be obtained from the internet.
3. Determine the shadow cast by a structure of unit height at each time of day.
4. Project the shadow cast onto the site layout. The effect of width and height of shade structure on the amount of shade cast can be analysed by varying the parameters of the shade structure.



QUICK TIPS

- Seek professional advice from a structural engineer when designing shade structures.
- Use shade cloth with a minimum solar rating of 78%, minimum 270 GSM +/- (gram per square metre) and at least a 10-year warranty against UV degradation. Green or black material is recommended.
- Apply sufficient tension to shade cloth to prevent damage during windy conditions. Monitor tension regularly, especially after strong winds.
- A greater pitch is better than a low pitch on waterproof structures as it enhances convective air movement, encourages dust/rainfall run-off and enhances drying during sunlight periods.
- Support posts used should be graded structural steel with the base encased in concrete to prevent corrosion and damage by pen cleaning machinery. Minimise the number of posts located in the pens.
- Galvanised iron sheets reflect more solar radiation.
- A maximum height of 4.5m at the highest point of the shade to promote airflow and provide adequate clearance for pen cleaning machinery.

Further reading

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