AUSTRALIAN LOT FEEDERS' ASSOCIATION

HANDBOOK

UNLOCKING THE BENEFITS OF SHADE IN AUSTRALIAN FEEDLOTS

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PRESIDENT'S FOREWORD

As the peak industry body for the Australian cattle lot feeding sector, we are proud to launch the Australian Lot Feeders' Association (ALFA) shade policy. The policy positions our industry as a proactive, forward-thinking sector that will ultimately assist in the long-term viability and profitability of our industry.

We encourage all Australian feedlots to make a pledge to provide cattle under their care with access to shade by 2026. This will ensure we continue to foster a progressive approach to business operations and demonstrating our collective commitment to the welfare of the cattle in our care.

This handbook has been designed to assist lot feeders in implementing shade, and includes answers to some frequently asked questions, MLA R&D Updates on Animal Welfare and Productivity Benefits of Shade, followed by a Shade Design and Construction Manual.

We understand the challenges that we may face together, however, we must equally understand the impact not enacting this initiative could have for our industry's viability.

There is no denying, this is a big moment for our industry. We are in this together. I personally encourage you to embrace this initiative to improve the welfare of the cattle under our care.

Yours sincerely,

Bryce Camm
President
Australian Lot Feeders' Association

FREQUENTLY ASKED QUESTIONS

SHADE IN FEEDLOTS

What is the ALFA Shade Policy?

ALFA supports that all cattle in feedlots have access to shade.

Why has ALFA developed a shade policy?

ALFA supports cattle in Australian feedlots having access to shade for the following reasons:

- Shade enables feedlot operators to satisfy the five domains of animal welfare which includes cattle displaying natural behaviours and reducing the risk of discomfort through improved self-thermal regulation.
- Shade is a tool that reduces the risk of cattle heatload.
- Shade improves the feedlot industry's resilience to climate variability.
- The installation of shade in all Australian feedlots demonstrates our collective commitment to prioritising and continuously improving the welfare of cattle under our care.

What does the science say about shade in feedlots and the impact it has on cattle welfare?

Research[1] demonstrates that:

- Shade lowers respiration rate, panting score and stress hormones in feedlot cattle.
- Shade alleviates dehydration of cattle.
- Both Bos taurus and Bos indicus cattle positively respond to shade.
- Shade assists in alleviating mortality, fear, and distress during heat wave conditions.

Are productivity gains expected from installing shade?

Research conducted at the Brigalow Research Station, Theodore, Queensland concluded that providing shade to cattle at 3.3 m^2/head resulted in an extra 6 kg of hot carcase weight. This was driven by an extra 36 kg per head of dry matter intake over the feeding period.[2]

The implementation of shade can have positive effects on cattle welfare and productivity and hence can be a valuable driver of business growth and profitability.

[1] Meat & Livestock Australia, 2020. Animal Welfare Benefits Of Shade. MLA Research and Development update.

[2] Gaughan, J. B., S. Bonner, I. Loxton, T. L. Mader, A. Lisle, and R. Lawrence. 2010. Effect of shade on body temperature and performance of feedlot steers. J. Anim. Sci. 88:4056–4067.

FREQUENTLY ASKED QUESTIONS

What financing options are available to feedlots implementing shade?

The Federal Government (and various State Governments) currently offer grants and loans for infrastructure development. The following information can be used to check your eligibility for these grants and loans. Please see ALFA website for links.

FEDERAL

Maximum loan amount: $2 million.

The Regional Investment Corporation (RIC) is a loan suitable for businesses that solely or mainly sell products into supply chains that are interstate or outside Australia, or plan to in the future.

Eligibility for the loan includes:

- Business is in financial need of a loan
- Has the capacity to repay the loan
- Is financially viable in the long term
- Has existing commercial debt
- Is in the agriculture, horticulture, pastoral, apiculture, or aquaculture industry
- Is registered for tax purposes in Australia with an ABN and is registered for GST
- Operates as a sole trader, trust, partnership or private company
- Is not under external administration or bankruptcy

FARM INNOVATION FUND
New South Wales

Maximum loan amount: $1 million

To be eligible for assistance you must demonstrate that:

- You are the owner or operator of a farm business where the work is to be carried out
- Your business operates as a sole trader, partnership, trust or private company and trades agricultural products
- Your business is registered with the Australian Taxation Officer as a primary producer, and has an Australian Business Number (ABN)
- As the owner and operator, you earn more than 50% of your gross income from your primary production enterprise under normal seasonal circumstances;
- You are classified as a “new entrant”, meaning that you have been operating your farm business for between 12 months to three years and more than 50% of your gross income will be derived from the farm business within three years of the date of the application.
- You do not have gross off farm assets exceeding $5,000,000 (excluding funds in a registered superannuation fund)

SUSTAINABILITY LOANS
Queensland

Maximum loan amount: $1.3 million

To be eligible for a Sustainability Loan at least one person in your primary production business needs to be consider a primary producer.

Additionally, you are also required to:

- Have operated your Queensland based primary production business for at least two years
- Have sound prospects for commercial viability and the ability to service the loan in the long term
- Should demonstrate the primary production business is not in a financial position to readily support the proposal from cash resources, or a ready capability to service increased commercial lending.

For purposes related to financial sustainability you are required to demonstrate:

- concessional finance is needed to secure sound prospects for success in the long term; and
- the proposal is not simply expanding an already financially sound primary production business, for example, by acquiring more land.

The QRIDA have defined a primary producer as a sole trader who spends the majority of their labour on, and derives the majority of their income from a primary production enterprise; or in relation to a partnership, proprietary company or trust that carries on a primary production enterprise, any partner in the partnership, shareholder in the company or trustee of the trust who spends the majority of their labour on, and derives the majority of their income from, the primary production enterprise.

INSTANT ASSET WRITE-OFF
Federal

Eligibility for the write-off includes businesses with an aggregated turnover of less than $500 million, for assets up to $150,000.

Who does ALFA represent and why have they developed this policy?

The Australian Lot Feeders' Association (ALFA) is the peak industry body representing Australian lot feeders. The body's directly elected representatives to the ALFA Council collectively developed the ALFA Shade Policy on behalf of Australian lot feeders.

How will the shade policy affect me?

ALFA strongly encourages all unshaded facilities to investigate and install shade, ahead of the likelihood that the requirement for shade will be included under NFAS.

If your facility meets the recommended access to shade under the shade policy, there is no additional requirements for your facility to meet.

Are there local planning requirements I need to abide by for the installation of shade?

Local planning requirements vary on a state and local level. Please check with your local council to ensure that any new shade structures meet any planning approval requirements.

What standards do I need to follow for the installation of shade in my feedlot?

ALFA encourages shade to be installed across all feedlot pens, including entry, exit and hospital pens. To ensure consistency with the mitigation options within the Katestone, Risk Analysis Program, shade should be installed at a minimum rate of 1.5m^2 per head of cattle and at minimum 70% UV protection.

The Beef cattle feedlots: design and construction manual can support feedlots in selecting a shade structure suitable to their production system.

The provision of shade in feedlots is also included in the *Animal Health and Welfare Standards and Guidelines for the production of Cattle*[3] which is referenced in NFAS and acknowledged in legislation in a number of Australian States.

What happens if I do not install shade in my feedlot?

A feedlot operator's decision to install shade is currently a commercial decision. ALFA is encouraging all feedlots to consider the benefits of shade to their enterprise and collectively as an Industry. We understand the challenges that individual businesses may face in installing shade, hence ALFA would like to see shade in all feedlots by 2026 which allows sufficient planning and installation time. Whilst shade is not part of the NFAS currently and there is no penalty, ALFA sees this initiative as an opportunity to demonstrate our Industry's leadership and commitment to animal welfare.

Will shade become a requirement of NFAS in the future?

The decision to make shade mandatory is the role of the Feedlot Industry Advisory Committee (FLIAC) who oversee the NFAS Standards. ALFA anticipates that the requirement for cattle in feedlots to have access to shade will be incorporated into the National Feedlot Accreditation Scheme (NFAS) in the future.

I have Bos Indicus cattle in my feedlot that are tolerant to heat, what benefit will shade have in my feedlot?

Research[4] conducted in the US demonstrated significant productivity gains in Bos Indicus cattle when they were provided shade along with reduced mortalities in severe heat events.

Do consumers think about animal welfare in relation to shade in feedlots?

Consumer testing[5] has showed that, when prompted with an image of an Australian feedlot, consumers believe access to shade is a basic requirement for livestock wellbeing.

Australia's red meat customers and consumers, both domestically and overseas, are increasingly seeking reassurance that livestock are cared for humanely and ethically. This initiative will help maintain trust in the Australian feedlot production system.

How do I contact shade manufacturers?

The construction of feedlot shade is a relatively specialised field. Shade manufacturers can support the design of shade to ensure maximum effectiveness of your shade, productivity of your cattle and reduce microclimates occurring.
A list of known shade manufacturers can be found on the ALFA Website: www.feedlots.com.au/shade

My feedlot is located in a cooler climate with typically high rainfall, can I install retractable shade?

Yes. Retractable shade can support improved pen drying times for feedlots located in cooler climates that experience high rainfall.

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[3] Animal Health Australia, 2016. Australian Animal Welfare Standards And Guidelines For Cattle. Turner ACT.
[4] Barajas, R., B. Cervantes, J. Guerra-Liera, and A. Ramos-Suarez. 2018a. Influence of pen-shade area on feedlot performance of finishing bulls in a warm environment. J. Anim. Sci Vol. 96, Suppl. S3:15.
[5] Pollinate 'Grain Fed Beef Website' Research (May 2019)

MLA R&D update

Productivity benefits of shade

Meat & Livestock Australia funded project B.FLT.0345 during the summer of 2007/2008 to examine the effects of shade on feedlot cattle performance in Central Queensland

Location

- Research was conducted at the former Brigalow Research Station, Theodore, Queensland
  - Non-implanted Angus steers (397 kg) were fed a dry-rolled wheat-based diet for 120 days on feed
  - Shade (3.3 m^2/steer) was provided by 80% solar block-out shade cloth aligned in a north-south orientation at 4 m height.
  - A 21-d period of increased heat load (d 71 to 91) induced significant heat load in the cattle. Cattle were exposed to ambient temperatures in excess of 30°C for 8 to 10 h each day during the heat wave.
  - The mean ambient temperature for the 21-d period was 29.7°C between 0800 h and 1800 h, and 23.4°C between 1830 h and 0730 h. Thus, there was only minimal night time cooling.

Treatments

- There were two experimental treatments (main effects compared):
  - **Control** – open feedlot pens with no shade
  - **Shade** – shade provided at 3.3 m^2/steer

Results

Treatment	No Shade	Shade	% Change	*P < 0.05*
Pens, n	10	10	-	-
DOF	120	120	-	-
Initial body weight, kg	396	398	-	-
Final body weight, kg	578	596	+3.1%	*
Dry matter intake, kg/d	10.0	10.3	+3.0%	*
Average daily gain, kg/d	1.51	1.65	+9.3%	*
G:F	0.152	0.160	+ 5.2%	*
Hot carcase weight, kg	315	321	+ 1.9%	*
Water intake	53.1	49.3	-	-

Further Information: Gaughan, J. B., S. Bonner, I. Loxton, T. L. Mader, A. Lisle, and R. Lawrence. 2010. Effect of shade on body temperature and performance of feedlot steers. J. Anim. Sci. 88:4056–4067.

MLA Project B.FLT.0345 https://www.mla.com.au/research-and-development/reports/2009/assessment-of-betaine-and-glycerol-as-ameliorants-of-heat-load-in-feedlo-t-cattle/

Animal Welfare

- Shaded pens had lower body temperatures and mean panting scores during hot conditions.

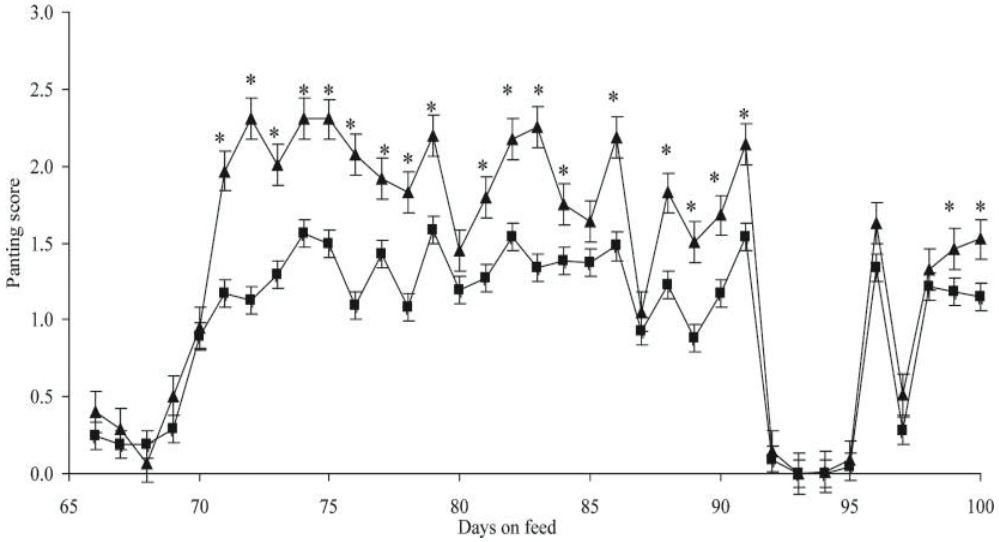

*Figure 1. Panting scores at 1200 h of feedlot steers with (■) and without (▲) access to shade over a 45-d period, which includes a 21-d period (d 71 to 91) of increased heat load. *Indicates a significant difference among treatments within a day (P < 0.05).*

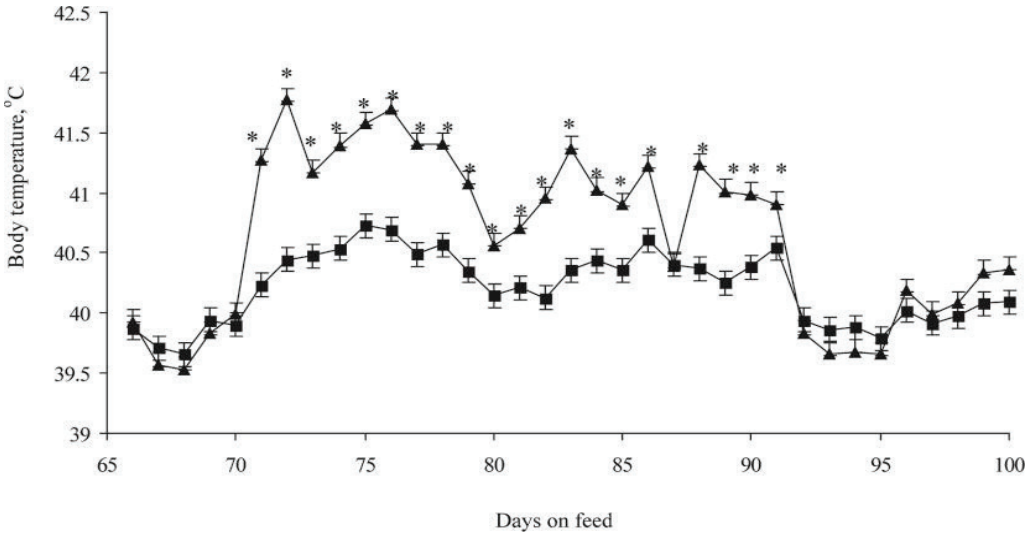

*Figure 2. Maximum body temperature of feedlot steers with (■) and without (▲) access to shade over a 45-d period, which includes a 21-d period (d 71 to 91) of increased heat load. *Indicates a significant difference among treatments within a day (P < 0.01).*

Conclusions

- Shade is beneficial for animal performance and welfare.
- Cattle in shaded pens have lower panting scores and body temperature.
- Providing shade to cattle at 3.3 m^2/head resulted in an extra 6 kg of hot carcase weight revenue. This was driven by an extra 36 kg per head of dry matter intake over the feeding period.
- Lot feeders should apply site-specific values to determine economic feasibility, including advice from your consultant veterinarian on shade's effect on morbidity and mortality.

MLA R&D update

Animal welfare benefits of shade

Meat & Livestock Australia funded project B.FLT.4014 to review the animal welfare benefits of shade.

Optimising welfare of feedlot cattle

Livestock care is fundamental to the success and sustainability of every feedlot. Australia's red meat customers and consumers, both domestically and overseas, seek reassurance that livestock are cared for humanely and ethically. A characterisation of what constitutes animal welfare is required before discussing the effect of shade on animal welfare.

Animal welfare is often described through the Five Freedoms. It defines that for appropriate animal welfare during an animal's life it is as free as possible from hunger, thirst and malnutrition; thermal and physical discomfort; pain, injury and disease; expresses normal behaviour; and is free from fear and distress. The five freedoms are an outcome-based system. The provisions outline the husbandry necessary to promote the outcomes. As such, the concept is easy to convey to cattle producers. In addition to the five freedoms, any outcome-based working protocol for the evaluation of animal welfare must include chronic indices of failure to cope with physical and emotional challenge (Webster, 2016).

Table 1: Five Freedoms of animal welfare

Freedom	Provisions
Freedom from thirst, hunger and malnutrition	By ready access to a diet to maintain full health and vigour
Freedom from thermal and physical discomfort	By providing a suitable environment including shelter and a comfortable resting area
Freedom from pain, injury and disease	By prevention or rapid diagnosis and treatment
Freedom from fear and distress	By ensuring conditions which avoid mental suffering
Freedom to express normal behaviour	By providing sufficient space, proper facilities and the company of the animal's own kind

Based on the Five Freedoms, and consideration of the peer reviewed literature in this review it can be advocated that providing shade to feedlot cattle during periods of excessive heat load:

- Improves freedom of choice for normal shade seeking behaviour of feedlot cattle
- Alleviates possible thirst and dehydration
- Mitigates possible thermal discomfort
- Reduces possible pain and disease
- Decreases possible fear and distress

Promotion of best-practice design shade adoption will lead to the above improvements, relative to the five freedoms, independent of breed and geographical location.

Understanding thermal regulation and shade seeking behaviour

On hotter days cattle in a field will seek shade as a natural behaviour. This does not mean that they will necessarily get 'heat stressed' if there is no shade as they can use other strategies to reduce their body's 'heat load', such as panting or reducing their feed intake. However, these alternative strategies come at a cost as they divert energy away from growth and maintaining good health.

Animals are often subject to variation in environmental temperature and respond through thermoregulatory mechanisms. Thermal regulation balances heat gain/production with heat losses to the surrounding environment in an attempt to maintain thermal neutrality. Thermal regulation can occur through either changes in their physiology (eg. panting, reducing feed intake) or behavioural mechanisms (eg. seeking shade). In contrast to physiological thermoregulation, behavioural thermoregulation offers an effective means of controlling body temperature while minimising water loss through panting and maximising time allocated to activities such as feeding.

The easiest method for determining if cattle are experiencing heat stress is by observing their panting. Cattle that breathe with their mouths open are heat stressed. A simple panting scoring system can be used. When cattle are at rest in their pens, the first sign of heat stress is open mouth breathing followed by tongue extension. The further the tongue is extended, the greater the heat load of the animal.

Excessive heat load 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 it 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.

Some cattle breeds are genetically more heat tolerant than others. However, heat tolerance is also behavioural. Cattle may deal with lack of shade by grazing and walking in the cool of the day or at night, and by utilising good airflow to help evaporation.

Cattle will seek shade when it is available regardless of whether they are breeds adapted to hotter climates (*Bos indicus*) or southern breeds (*Bos taurus*), and even in mild climatic conditions (Rovira and Velazco, 2010; Daly 1984; Bennett *et al*. 1985; Blackshaw *et al*. 1987). Shade helps reduce heat loading from the sun, especially for dark-coloured animals that readily absorb heat. In the absence of adequate shade, animals will try to find any form of shade they can — it could be from a fencepost or another animal's shadow.

Responses to shade

The provision of shade in feedlot pens can provide cattle with an option to escape extreme heat events, or even just to regulate their physiology to minimise their body's thermal regulation effort.

Studies have shown that, in beef and dairy cattle in natural grazing environments, shade utilisation increases with increasing air temperature, solar radiation or temperature humidity index (Rovira and Velazco, 2010; Kendall et al. 2006; Tucker et al. 2008). Dairy cattle provided with increased shade allocation under pasture situations during summer spent twice as much time under shade (25% vs 50%) and showed less aggressive interactions (Schulz et al. 2010).

For feedlot steers provided with 100% solar block polyvinyl shade cloth (21.6 m^2 per head; 50% of pen area) spent from 80% to 96% of their time under shade for normal and emergency thresholds of the temperature-humidity index, respectively (Brown-Brandl et al. 2005). Whilst another study found that under non-heat wave conditions on average 50% of feedlot steers were at any time point under 70% solar block shade cloth (2.0 to 4.7 m^2/head) in a summer feedlot experiment in South East Queensland. Under heat wave conditions, on average 90% of cattle accessed shade at any time point (Sullivan et al. 2011).

The above literature demonstrates the strong biological drive of *Bos taurus* cattle to seek shade, and escape thermal discomfort.

Bos indicus cattle also benefit from shade for productivity and animal welfare. Studies with Brahman cross cattle with access to 3.3 to 4.0 m2/hd of roofed shade had reduced stress hormones, reduced respiration rate, improved hydration and had greater feed intake, gain and efficiency (Barajas et al. 2013, Barajas et al. 2018a; Barajas et al. 2018b, Ramos-Saurez et al. 2018).

Numerous scientific papers have reported the benefit of shade for decreasing respiration rate, panting score or productivity in *Bos taurus* cattle (Brown-Brandl et al. 2005; Gaughan et al. 2009; Gaughan et al. 2010; Mitlohner et al. 2001; Mitlohner et al. 2002; Sullivan et al. 2011; Hagenmaier et al. 2016).

Mortality has been prevented in severe heat waves through provision of shade. A survey in the USA of 36 farmer-feeders (9,830 head) in Iowa reported that 35 pens with shade had a mortality of 0.2% whereas 46 pens without shade had a mortality of 4.8% (Busby and Loy, 1996). Similar observations have been made in the Australian feedlot industry.

Observational evidence from Australian lot feeders indicates that cattle that experience bouts of excessive heat load, are more susceptible to bovine respiratory disease post a heat stress event as well as feed intake variation. Feed intakes of severely affected lots of cattle may never recover.

We now have good evidence that:

- Shade lowers respiration rate, panting score and stress hormones in feedlot cattle
- Shade alleviates de-hydration of cattle
- Both *Bos taurus* and *Bos indicus* cattle can respond to shade
- Shade alleviates mortality, fear and distress during heat wave conditions
- Shade improves feedlot performance

Management strategies to optimise welfare with shade

Moisture accumulation under shade can occur as shade seeking is normal behaviour for feedlot cattle as reported above.

To limit this accumulation and optimise welfare a variety of shade and/or engineering designs are recommended in the MLA Beef cattle feedlots: design and construction manual. These include:

- Retractable shade designs
- Separate panel designs
- Corrugated iron strip design with spaces to encourage drying
- Centre square designs with gaps to encourage drying
- Longitudinal shade rows in the North to South direction
- Correct inclination of shade to encourage drying in morning sun
- Covered housing systems.
- Increased shade allocation to allow the cattle the space to spread out.
- Correct shade height
- Correct positioning of water troughs away from shade

Providing shade at an appropriate density for the class of cattle allows animals to spread out, and for wind movement to encourage convection cooling and pen floor drying. Lot feeders should maintain appropriate pen cleaning intervals and surface maintenance in shaded pens.

Ongoing Research

MLA is supporting ongoing research on the animal welfare benefits of shade in southern regions of Australia. This includes determining the year-round animal welfare and production effects of conventional shade systems. Novel designs are also being explored including dual purpose shade-shelter structures that may offer some beneficial protection during rain events. Results of these projects will be made available in 2021.

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16. Shade

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Shade structures – longitudinal rows

Introduction

Cattle have a remarkable ability to cope with environmental stress but a 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 (EHL) in feedlot cattle during summer months can result in significant production losses, animal welfare problems and under extreme conditions, the death of cattle. Shade structures are one strategy that has 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 also enhance minimal air movement for cooling. Major design considerations for shade structures are orientation, space, height and shading material.

Shade structures – central square

Design objectives

The design objectives for a shade structure are to

- provide adequate shade for each animal in the pen (square metres per animal)
- 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.

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.

Shade structures – separate panels

Technical requirements

Any shade should be designed and constructed in accordance with the Australian Standards for Wind Loads – AS 1170.2.

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 m^2 and 6 m^2 of shade per head. Shade structures suitable for Australian conditions should ideally provide more than 2 m^2 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

Three types of shade structure can be used in feedlots

- longitudinal rows – long thin 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.

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 buildup 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 also 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.

Orientation

Orientation of the structure will determine the pattern of the shade underneath and also 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.

Insufficient shade area can result in cattle bunching and over-heating

Orientation of longitudinal row – shade area at midday (above) and during the afternoon (below)

Clear-span structures minimise columns within the pens. Columns are best positioned in the subdivision fence lines.

Too many support posts make pen cleaning more complicated; fewer structures would need to be strengthened. Encasing posts in concrete protects them from corrosion, damage during pen cleaning and reduces injury to cattle.

Shading material is often supported on cable suspended between columns, posts or supports. Infrastructure must be engineered for rain, hail and wind loadings.

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 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 and galvanised iron sheet (Table 1).

Shade cloth is available in many densities and strengths. It is generally manufactured from lightweight knitted or woven polypropylene 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. Polypropylene woven shade cloth is slightly cheaper, has a considerably shorter life expectancy and has a tendency to unravel and fall apart if not taped. Woven synthetic shade materials are available in varying degrees of strength and texture. However,

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 on 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 manufacturer's 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.	Requires minimal maintenance to the structure itself. Remove all metal shards after installation to prevent staining and corrosion under moisture.
	Needs to be at an appropriate height to allow machinery and vehicles access to the pen.	Water runoff on down slope side under heavy rainfall can create wet patches, increasing pen maintenance.
	Retractable shade cloth can allow pens to dry out in winter.	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.

woven shade cloth can accumulate dust and so become impermeable to rain and hail while also harbouring birds and rodents.

A reinforcing tape border around the shade panels prevents the cloth from unravelling, and must be used when grommets are inserted to allow cables to be used to secure the shade cloth to the support posts. For shade cloth without grommets, shade clips can be used to attach the shade cloth to structures or wire supports. No tools are required and the clips simply snap into place.

Corrugated roofing iron requires more support through the structure but has the advantage of being self-cleaning in rain, sheds heavy rain and hail, provides increased rigidity in high winds, is resistant to birds and rodents and has 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.

Shade structures should be high enough for machinery. Higher shade structures offer better ventilation but limit the area of shaded footprint and have higher wind loading.

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.

With galvanised iron sheets in hotter climates a pitch of 1:3 increases air movement and shade coverage in the afternoon.

Retractable shade improves drying of pen surface during winter months in high rainfall areas.

This shade can be retracted using a pulley system connected to the PTO shaft of a tractor.

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 rain water.

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 much 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 can concentrate runoff resulting in ponding on the pen surface. The pen floor beneath the shade must be given the opportunity to dry when the sun is shining.

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 results 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 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.

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 figures are 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 (azimuth) of the sun (Figure 1) at the feedlot site for three or more times during the day e.g. 9 am, 12 noon and 3 pm (Figure 2). 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. The shadow length is calculated by multiplying the height of the structure by the shadow cast length (Figure 3).
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. Figure 4 steps lot feeders through the process of preparing a shadow diagram.

Corrugated iron sheets can concentrate rainfall runoff to localised areas; ponding will damage the pen surface.

Altitude and Azimuth of the sun in mid-summer – 21st December	
Latitude	27°23
Longitude	151°32
Sunrise	4.58 am
Sunset	6.48 pm

The sun is shown in the noon position

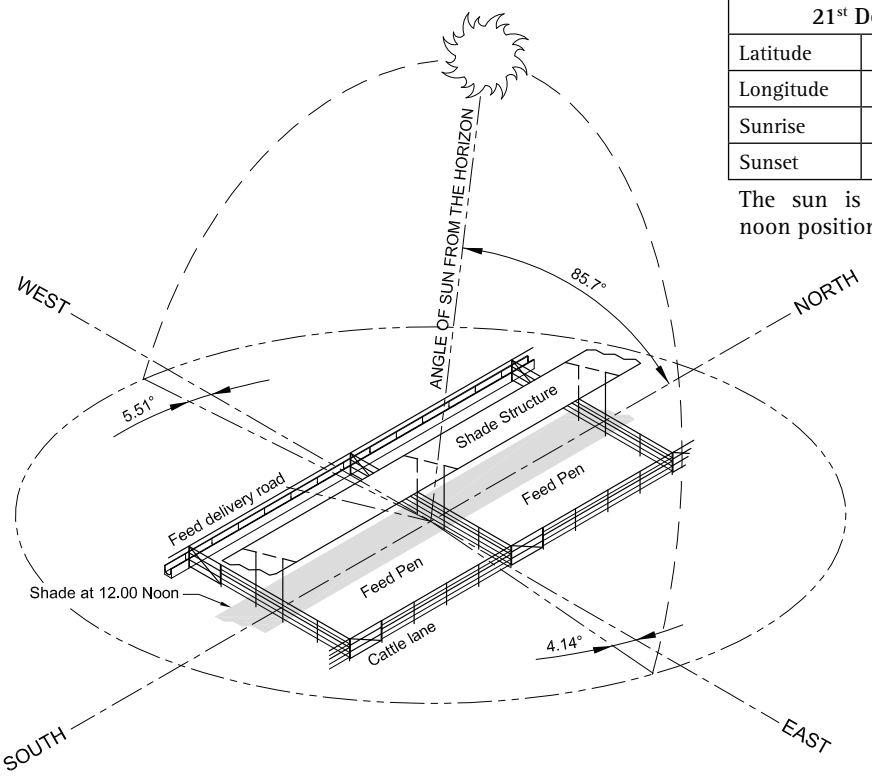
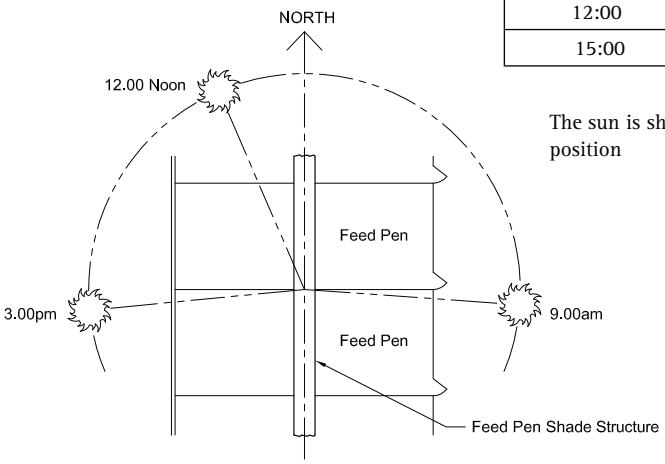


Figure 1. Altitude and azimuth of sun in mid-summer

Shade sails should be pulled taut and twisted so one axis is convex and the other axis concave. Shapes with little curvature and tension will deform under load and become unstable. Sloping fabric will ensure good shedding of water and hail.

Time	Angle (°) (azimuth)
09:00	94
12:00	337
15:00	264

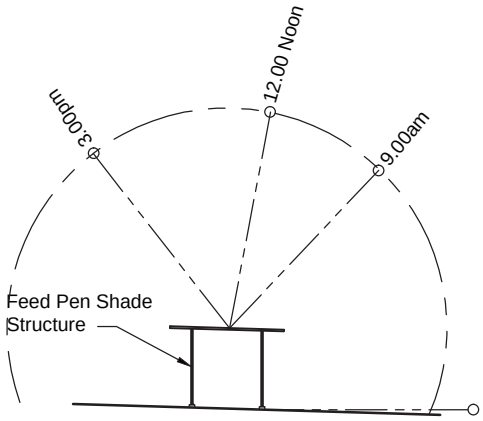
The sun is shown in the noon position



ANGLE OF SUN FROM TRUE NORTH ON 21st DECEMBER (AZIMUTH)

Figure 2. Azimuth of sun in mid-summer at three times during day

A taut peaked shade cloth structure. Sloping fabric will ensure good shedding of water and hail.



ANGLE OF SUN FROM THE HORIZON ON 21st DECEMBER (ALTITUDE)

Time	Angle (altitude)	Length of shadow cast by a 1m pole on flat land (m) (shadow length – Multiplier)
09:00	51	0.81
12:00	86	0.08
15:00	48	0.91

Figure 3. Length of shadow cast

STEPS IN PREPARING A SHADOW DIAGRAM

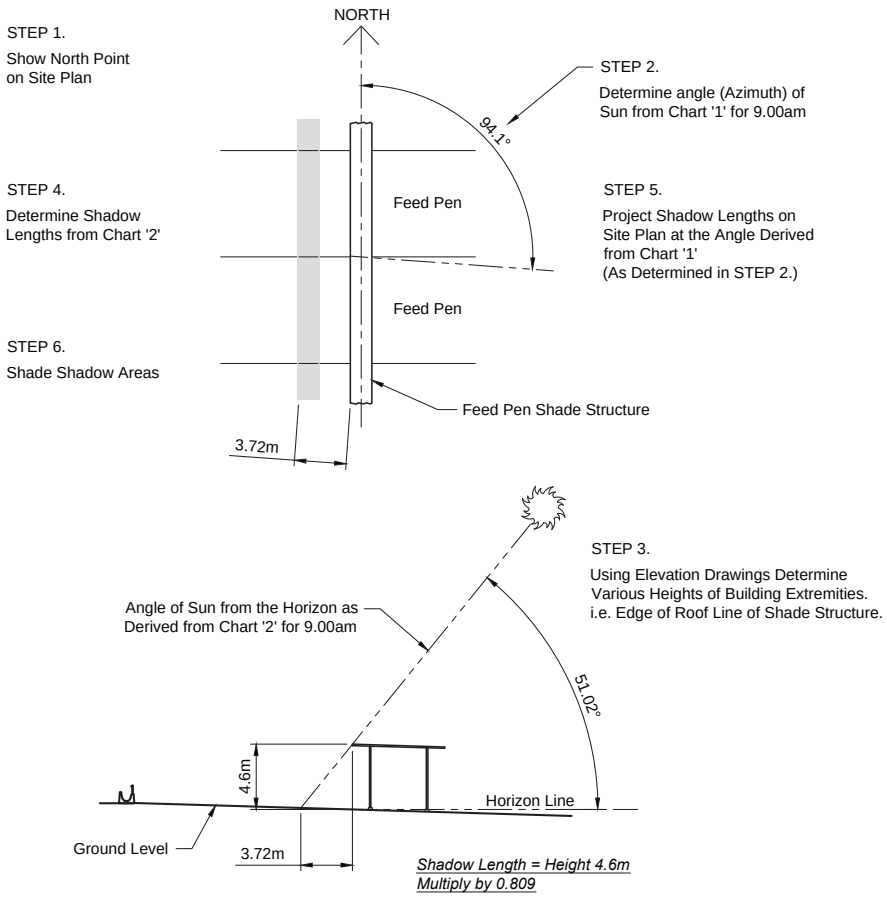
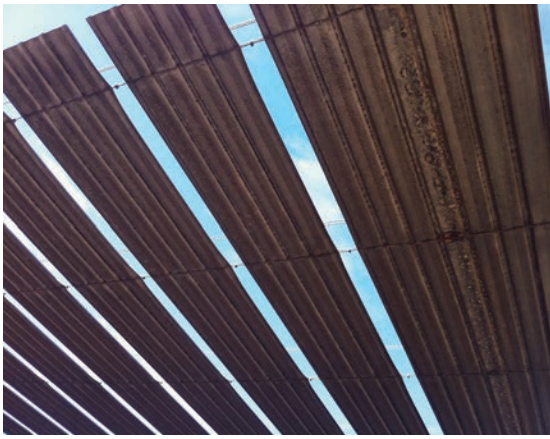


Figure 4. Determining shadow length

Cattle bunching under limited afternoon shade.

The advantages of using either shade cloth or corrugated iron sheeting are listed in Table 1.



Quick tips

- Seek professional advice from a structural engineer when designing shade structures.
- Use shade cloth with a minimum solar rating of 80%, minimum 300 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 structure 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 minimum height of 5.0 m at the lower side of the shade should promote airflow and provide adequate clearance for pen cleaning machinery.

Further reading

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