Dairy Australia

COOL COWS

STRATEGIES FOR MANAGING HEAT STRESS IN DAIRY COWS

FOREWORD

Heat stress is a national issue for the Australian dairy industry.

We know that minimising heat stress not only results in happier, healthier cows – it boosts production and profit margins for dairy farmers.

Heat stress can also have major impacts on cow fertility, which means it can continue to be felt well beyond seasonal hot weather.

While high temperatures were once confined to Queensland, New South Wales and northern Victoria, this is no longer the case.

Recent years have seen an increasingly volatile climate and farmers nationwide continue to be affected by the cost and availability of essential farm inputs such as water and feed.

The Cool Cows booklet was developed by Dairy Australia to provide tangible advice that dairy farmers can implement now and into the future to minimise the effects of heat stress.

Tracing their roots back to the mid-1990s, Cool Cows resources continue to be recognised throughout the industry as the go-to source of the latest information and advice based on cutting-edge research and innovation.

This is practical information that equips farmers to take proactive steps to protect cows from heat, through planning and management and investments in infrastructure in both the short and long-term.

Cool Cows is funded by the Australian Government and Dairy Australia.

I encourage you to use these resources to keep your cows cool.

David Nation Managing Director

KEY MESSAGES

Farmers in all dairying regions of Australia must address heat stress.

This booklet will demonstrate:

- Heat stress substantially cuts milk production and income. These financial losses can be doubled by reduced in-calf rates, low milk protein and fat tests, liveweight loss and more cow health problems. The impacts of heat stress last well beyond the hot months.
- Your herd feels the heat more than you realise. Even at 25°C, cows begin to feel uncomfortable and must start actively burning energy to keep cool.
- Heat stress can be effectively managed with a whole-of-year approach.
- Shade is king. Your first priority should be to reduce cows' direct exposure to the sun by providing adequate shade.
- At high temperatures, evaporation is the cow's primary mechanism for heat loss. Every dairy yard in Australia should be fitted with sprinklers.
- You should be alert and monitor how well your cows are coping by counting their breathing rate, keeping a close eye on the weather forecast, and taking action as required.
- If you invest in keeping cows cool you will be rewarded.

Top 10 short term actions to consider during the hot season:

1. Delay afternoon milking until 5pm
2. Wet the dairy yard for an hour before cows arrive
3. Set up a sprinkler system at the dairy yard
4. Install a large water trough on the exit side of the dairy
5. Sprinkle cows for 30–60 minutes while standing in the dairy yard waiting for afternoon milking
6. Increase your cows' grain and concentrate feeding rate, feed high-quality forage fibre and higher-quality protein sources, and increase cows' intakes of potassium, sodium and magnesium
7. If you don't have a shade shed, bring the milking herd back to the dairy yard around midday and use the sprinkler system to cool cows – if possible, give them access to high quality hay or silage
8. Provide cows with the highest quality pasture available to graze overnight when they are cooler
9. Mate more heifers to compensate for lower in-calf rates expected in milkers during the hot season to help maintain your desired calving pattern
10. Implement a tree planting program starting with trees on the western side of the yard.

Top 10 long term actions to consider

1. Review the whole farm for shade
2. Develop a farm plan that incorporates significant tree plantings over time on the northern and western edges of pastures, and plant deciduous trees along laneways
3. Fence off tree lines to protect tree roots from cow treading and reduce the chance of cows lying down in mud and dung
4. Install a shade cloth over the dairy yard to enhance cow cooling prior to milking
5. Install water troughs in all paddocks and along laneways
6. Combine shade and sprinklers at the dairy yard with a feed out system for high quality forage or partial mixed ration close by. Ensure cows can move freely between both areas during hot weather
7. Build a shade shed with a solid roof set over a feed pad integrated with a PMR feeding system
8. Install a sprinkler system set with temperature controls in the shade shed over the feed pad which is integrated with the effluent management system
9. Install fans if air movement through the shade shed is inadequate
10. Assess the impact of withholding insemination during hot weather on herd profitability.

CONTENTS

HEAT STRESS IN COWS

Cows take on heat from the environment and generate metabolic heat from eating and digesting feed. Problems occur if temperature and humidity increase and cows can't balance their metabolic and environmental heat gains.

What causes cows to get hot?

Dairy cows need to maintain their core body temperature between 38.6°C and 39.3°C. Core body temperature changes slightly throughout the day, reaching a peak in the early evening and a low early morning.

In hot environmental conditions, cows off-load heat with a range of physiological and behavioural strategies.

Metabolic heat is being produced all the time. During the day this heat is not as easily dispersed. If night-time conditions are sufficient to allow adequate dispersal of heat, the cow will not suffer ill effects. If this diurnal cycle of heat accumulation during the day and loss during the night is disrupted by high night-time temperatures the effects become more noticeable.

The level of environmental heat a cow is exposed to over time is determined by:

- Air temperature and relative humidity
- Amount of solar radiation
- Degree of night cooling that occurs
- Ventilation and air flow
- Length of the hot conditions.

How do cows keep themselves cool?

In hot environmental conditions, cows offload heat with a range of behavioural and physiological strategies.

Dairy cows may change their behaviours by:

- Looking for areas with greater air movement or standing to increase or exposure to air
- Seeking water and shade
- Changing their orientation to the sun
- Panting or sweating
- Stopping or reducing feed intake which decreases rumen heat production.

As heat load builds the cow's body struggles to cope.

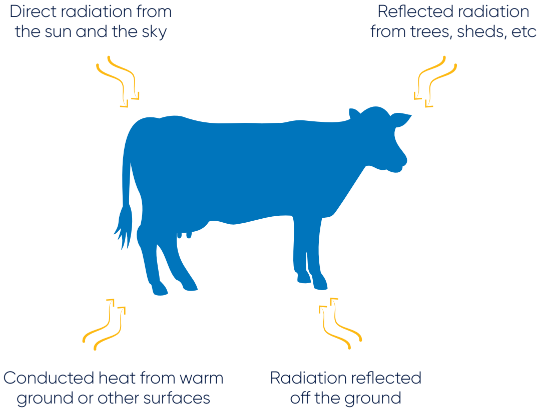
Awareness of the signs will inform your decision-making around the management and response to heat stressed cows.

Looking for subtle changes in behaviour will give you plenty of time to act. If the period of excessive heat load lasts more than a few hours signs of heat stress become more marked.

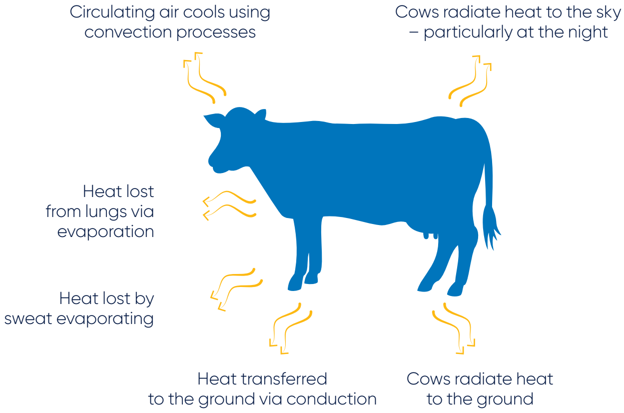
Open mouth breathing, group seeking of shade and excessive drooling are all signs of prolonged heat stress and call for urgent attention.

Recognise the early signs of excessive heat load and allow for early intervention with effective management and mitigation strategies, such as access to shade and cooling infrastructure, water access and feed pad usage.

Sources of heat gain



Heat loss



Unseen responses to excessive heat load

Apart from observable changes in behaviour, there are also unseen physiological changes that occur within the cow:

- Feed intake decreases by 10 per cent to 20 per cent when the air temperature is more than 26°C
- Core body temperature rises
- Blood hormone concentrations are changed
- Blood flow distribution is altered, blood flow to gut, uterus and other internal organs is decreased, blood flow to skin is increased.

The unseen changes can have far-reaching consequences on the productivity, health and welfare of cows.

Temperature and humidity

Increasing air temperature and humidity reduce the cow's ability to cool itself.

Heat exchange between the cow and the environment occurs through radiation, conduction, convection and evaporation processes.

The direction of heat exchange depends on the temperature difference between the cow and the surrounding environment.

When the air temperature is higher than the cow's temperature, heat is absorbed. When the air temperature is lower than the cow's temperature, the cow offloads heat and cools down.

The greater the temperature difference, the faster the flow of heat.

Excessive heat load

A dairy cow manages the body heat load that it carries within itself all the time.

If the sum of metabolic heat produced by the cow and the heat gained from the external environment begins to exceed that lost, the cow's heat load starts to build.

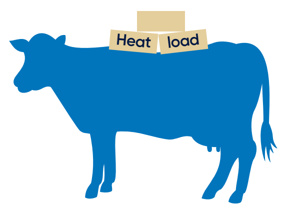
The cow must stay within the optimal range through thermo-regulation. This means balancing the metabolic and the absorbed environmental heat using a range of strategies, such as increased breathing rate and sweating.

It is important for dairy farmers to know the signs of excessive heat load so practical strategies can be implemented to help the cows cope.

Hot zone Cow must use energy to cool down	**Upper critical temperature** 25°C
Thermoneutral zone Cow's comfort zone	As temperatures rise above 25°C, a cow steps outside its 'thermoneutral' zone and has to start actively regulating its body temperature to keep it in the optimal range. At hotter temperatures, the cow begins to feel increasingly uncomfortable.
Cold zone Cow must use energy to warm up	5°C **Lower critical temperature**

Factors impacting on a cows heat load

Heat produced internally by metabolic processes **+** Heat gained from the external environment **-** Heat that is lost to the external environment **=**



Once heat load reaches a critical point changes start to occur in metabolism, hormonal regulation and feed intake. This affects milk production, milk quality, fertility and health.

HEAT TRANSFER AND COW BEHAVIOUR

Off-loading heat

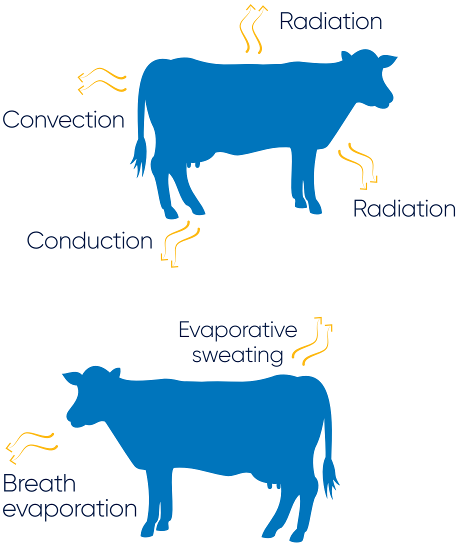
Understanding the heat exchange process can support your decision making around providing shade, water and cooling systems to keep cows cool.

The below table outlines the potential behaviours of cows for each heat transfer process being described.

Heat transfer process	Behaviours
Conduction the transfer of heat through physical contact	Standing in cool drinking water to lose heat through the hooves Standing up to increase air flow around its body
Convection produces cooling if there's high temperature difference	Standing where there is a breeze or under fans Cooling is more effective with higher air speed
Radiation emission of heat to and from the cow and surroundings, directly from the sun or from re-radiation from hot ground, fences, buildings, etc.	Cows positioning themselves away from the sun if there is no shade Shading from direct sunlight reduces the solar radiation it receives by 50% Black coated cows absorb more solar radiation However, black coated cows will re-radiate heat more effectively at night
Evaporation heat loss through sweating and breathing	Standing where there is a breeze or under fans to maximise evaporative sweating (which increases with air movement) Evaporative breathing

Heat loss by conduction, convection and radiation all depend on a temperature difference between the cow and the surrounding environment. The greater the temperature difference, the faster the flow of heat. As the air temperature rises this form of heat loss declines. See figure below.

Air temperature at 30°C



Showing how a greater temperature difference can increase the flow of heat from cows.

Evaporation

This is the most efficient and primary mechanism cows will use to rid themselves of heat loads. Anything you can do to assist the cows evaporative cooling processes is worthwhile.

Evaporation from the cow surface through sweating will increase with air movement. However, evaporation depends on a difference in relative humidity between the cow skin and the air.

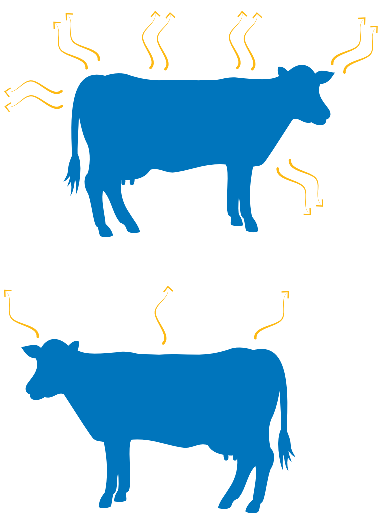
For example, at 30°C you may be able to achieve good evaporative heat loss in low humidity conditions. If the temperature remains at 30°C but the humidity level increases, then the rate of evaporative heat loss will decline (see Figure [2] below). Keep this in mind when making cooling choices for your cows.

Once the air temperature exceeds the cows' body temperature, heat loss can only occur by evaporation.

COOLING BENEFITS OF EVAPORATION

- 70 per cent of total evaporative heat loss is due to sweating
- 30 per cent of total evaporative heat loss is from breathing
- Small evaporative heat losses also occur through loss of water vapour from skin independent of the action of sweat glands, as well as through salivation.

At 30°C, low humidity



Difference in evaporative losses under conditions of low humidity and high humidity

DRY COWS AND HEAT STRESS

Dry cows have received little attention when it comes to managing heat stress.

Autumn and year-round calving farms that dry cows off over the hot months should be doing more to ensure their dry cows stay cool. Heat stress during pregnancy can have consequences on calf health and cause far-reaching health problems later in life.

A growing body of evidence demonstrates that dry herds in heat stress have reduced milk yields during their next lactation, reduced calf weight and a greater risk of health problems.

Reduced milk in next lactation

Cows generate less metabolic heat when dry than when lactating and have a higher upper critical temperature. This may contribute to the belief around heat stress being a lesser concern. However, studies consistently show that when cows experience heat stress during late pregnancy they produce less milk in the next lactation. (See Figure 1).

Researchers believe milk yield reduction is due to impaired blood flow through the dry cow's udder over the last two months of pregnancy. The udder is rapidly growing over this period in preparation for the next lactation. The impaired blood flow stunts udder growth, which means they possess fewer functioning mammary cells with reduced secretory capacity. As a result, they will produce less milk and become disadvantaged while calving.

Smaller, lighter calves

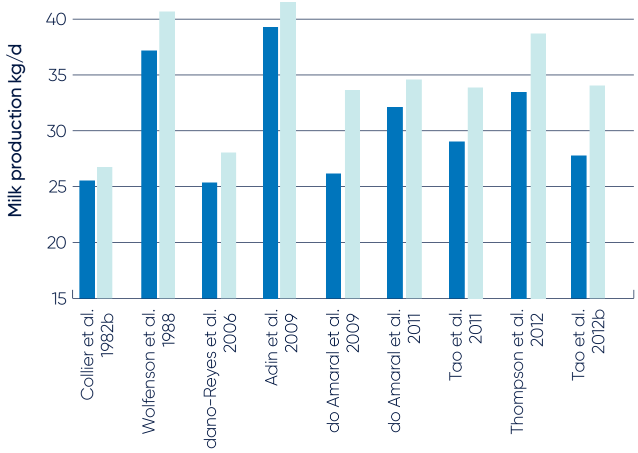
Studies in many species of animals show the conditions that offspring are subjected to while still in the uterus affect their lifetime health and performance. When the foetal calf's body temperature is increased, as it is when its mother experiences heat stress during late pregnancy, it appears that this negatively affects the calf's metabolism and gene expression, pre-programming it for sub-optimal health and performance.

When cows suffer heat stress during their dry period, they have smaller placentas with reduced blood flow through the uterus and umbilical cord. The calves tend to be born several days earlier and a few kilograms lighter than calves of cows that kept cool during their dry period.

When cows experience heat stress during late pregnancy it suppresses their immune system for many weeks. Studies have shown the neutrophils of heat stressed cows become less aggressive against bacteria. Neutrophils are the white blood cells acting as the first line of defence against pathogens.

Cows that experience heat stress during late pregnancy may therefore be at greater risk of health problems such as mastitis and retained foetal membranes around calving when their immune function is already naturally suppressed.

Figure 1 Effect of heat stress and cooling during the dry period on milk production in the following lactation



Source: Tao and Dahl, 2013

Calves less productive and fertile

Calves born to cows heat stressed during the dry period go on to be less healthy, less fertile and less productive in their first lactation. Affected calves have been shown to be less able to absorb maternal antibodies from the first colostrum consumed soon after birth. This results in lower blood maternal antibody levels than in calves from dry cows that don't experience heat stress.

These calves' cell-mediated immune function may also be compromised. This results in them being more susceptible to infections that commonly occur pre-weaning. The ultimate outcome is poor growth rates, higher levels of illness and higher mortality rates.

Researchers have recently found that calves whose dams are heat stressed during pregnancy go on to become maiden heifers that are less fertile. This means a heifer is produced that has both lower production and more difficulty getting in calf.

In the short term, to protect dry cows from heat stress:

- If existing natural shade on the home farm or support block can't provide four square metres of shade per cow at midday, then find alternative paddocks
- Portable paddock shade structures or a permanent shade structure are also options.

In the longer term, the farm plan should be reviewed to:

- Establish more tree belts along dry cow paddocks and springer paddocks
- Adjust the farm's calving system to reduce the number of cows dried off over the hot months of the year.

HEAT STRESS AND PRODUCTIVITY

Milk production drop is usually the most noticeable effect of heat stress events. Other effects are less obvious but will still result in significant productivity losses.

Effects on dairy herds

Heat loads can build when farm infrastructure doesn't provide cooler conditions for the whole herd. Decreased milk production is the clearest cost, but some effects are less obvious and result in significant productivity losses. These include:

- Reduction in fertility and calving rates
- Lower milk components
- Body condition loss
- Increased susceptibility to infection.

Fertility and calving rates

Cows are more likely to have reduced heat expression or shortened heats in hotter seasons. This is a result of reduced activity due to heat as well as alterations in hormonal activity that reduces the expression of oestrus behaviour.

Heat stress has been shown to decrease oestradiol production, a major female sex hormone that regulates oestrous, leading to ovarian inactivity. Alongside this, the hormonal imbalances impair oocyte development. This results in lower conception rates.

Heat stress will affect the endometrium in the uterus. This can result in reduced ability to sustain a pregnancy and increased embryo mortality. Additionally, growth hormones essential to embryo development are affected by heat stress.

A heat stressed dairy herd may experience a decreased six-week and 100-day in-calf rates or increased not-in-calf rates. Higher heat loads affect digestion and nutrient acquisition by lowering feed consumption rates, which in turn can affect calf birth weight and viability. Reduced access to nutrients essential to calf development will have a negative impact on calf weight and viability.

In summary, the risks to calving and fertility presented by heat stress include:

- Reduced intensity and length of oestrus
- Decreased conception rates
- Increased risk of embryo death
- Decreased six-week/100-day in-calf rates or increased not-in-calf rates
- Decreased calf birth weight and reduced viability.

Effects on milk

The metabolic changes associated with dissipating heat loads is energy intensive and responsible for reduced lactation and milk production. Milk from heat stressed cows can have altered milk components with variations in proteins and fat content.[1]

A direct effect on milk quality will be due to the reduction in efficiency of the immune system resulting in increased risk of mastitis.

Care should also be taken when implementing any cooling processes with sprinklers. Wet udders when sitting in potentially contaminated areas and immediately prior to milking can result in increased contamination.

More information at can be found at **dairyaustralia.com.au/mastitis**

In summary, some of the risks to milk production presented by heat stress include:

- Milk production can drop by 10 to 25 per cent during heat stress, or 40 per cent in extremes
- Milk composition is affected with high to severe heat stress, with a decline in total protein
- Increased risk of udder infection, which results in increased somatic cell counts and sediments in milk.

Feed intake and nutrition

Increases in environmental temperature will suppress a cow's appetite. A noticeable difference in cows experiencing heat stress is a reduction in dry matter intake. Dry matter intake drops by 10 to 20 per cent in the short or long term, depending on the length and duration of heat stress. The effort involved with keeping cool can result in 20 to 30 per cent more maintenance energy needed to compensate.

Rumination and cud chewing decreases, along with the cow's ability to digest and absorb nutrients in feed. The cow's body will open blood vessels closer to the skin's surface, so the heat load can dissipate. As a result, blood moves away from the uterus, the gut and other internal organs.

1 Liu Z, Ezermieks V, Wang J et al. Heat stress in dairy cattle alters lipid composition of milk. Scientific Reports 2017;961

Cow health and infections

Hot and humid conditions created after a summer storm or sprinkler use present two main challenges to managing cow health:

- Maintaining the pH of rumen to prevent ruminal acidosis and ketosis
- Suppressed immune function alongside exposure to sources of opportunistic infection.

Large downpours over summer can quickly push up humidity in hot conditions and reduce the effectiveness of sweating as a form of evaporative cooling for cows. As heat loads increase because of this, the cow will increase their breathing rate and begin drooling. Saliva loss reduces the rumen pH because the bicarbonates in cow saliva can't act as a buffer to the rumen's acidity. This can be further impacted by feeding strategies.

Heat stress also reduces the cows' dry matter intake (DMI), grazing during the day and cud chewing. The natural process of rumen buffering through rumination and saliva bicarbonate is impaired. This is a common cause of sub-acute ruminal acidosis (SARA).

In hot weather, cows prefer to eat in blocks in the cooler times of the morning and evening. This will often be when in the dairy being offered high starch bail feed. Cows tend to select against low quality forage/fibre if it is offered to them. They are less likely to use this to aid rumen balance than they would good quality forage. Additionally, a reduction in DMI can push metabolic energy sources from carbohydrates toward fats due to increase body tissue breakdown (ketosis). This will also contribute to metabolic acidosis.

SARA plays a key role in the complex causes and origins of laminitis and associated diseases, such as claw lesions, white line disease, ulcers and lameness. Cows will roll and wallow in mud to alleviate heat loads and this presents a risk of environmental mastitis and other infections.

In summary, some of the risks to cow health presented by heat stress include:

- Decreased rumen buffering capacity
- Decreased rumen pH
- Increased ruminal acidosis and ketosis
- Increased laminitis
- Suppressed immune function, increasing susceptibility to infectious diseases
- Increased mastitis.

HOW SUSCEPTIBLE IS MY HERD?

Before looking at your current farm setup and what strategies you may decide to use to keep cows cool in the hot season, consider how inherently susceptible your herd is to heat stress.

Location

Where you farm within Australia is obviously a major factor. Regions and specific areas within regions vary significantly in terms of:

- Day and night-time air temperatures
- Relative humidity levels
- Amount of solar radiation
- Winds.

These all determine the level of environmental heat that a cow gains or losses over time.

In addition to where you farm, there are three major animal factors which influence your herd's inherent susceptibility to heat stress. These animal factors affect the amount of metabolic heat the cow produces, and/or the ease with which heat is transferred to and from the cow's external environment.

Breed

Tropical cattle breeds such as the Brahman tend to be able to cope better than European breeds. They have better heat regulatory capacities than European breeds, due to differences in metabolic rate, food and water consumption, sweating rate, and coat characteristics and colour.
As European breeds have a higher heat loading at the skin, they must evaporate substantially more sweat than tropical breeds to maintain normal body temperatures.

Of the European breeds, the Brown Swiss and Jersey are least vulnerable to heat stress, followed by the Ayrshire and the Guernsey. The Holstein-Friesian is the most vulnerable.

Age and liveweight

Younger animals are more heat tolerant due to a greater surface area to weight ratio than larger, older animals. This allows more heat per kilogram of liveweight to be unloaded through sweating. Younger animals, however, will absorb more heat from the environment due to this same greater surface area to weight ratio. Generally, younger animals with lower milk yields have lower metabolic heat loads.

Level of milk production

When feed is consumed and digested, metabolic heat is produced and excess amounts must be unloaded to maintain normal body temperature.

High producers eat more feed and generate more metabolic heat yet must still dissipate their heat load from a similar body surface area as lower producing cows. This makes high-producing herds (and higher-producing cows within herds) more susceptible to high environmental heat loads.

Consider the following.

My herd	Lower susceptibility	Moderate susceptibility	Higher susceptibility
What breed are most cows in my herd?	Brown Swiss Jersey	Other European breed or cross-bred	Holstein-Friesian
What proportion of cows are in their first or second lactation?	More than 40%		Less than 40%
What is the herd's average milk production level?	Less than 5,500L or 400kg MS*/cow/year	5,500-8,000L or 400–600kg MS*/cow/year	More than 8,000L or 600kg MS*/cow/year

*MS = milk solids, expressed as fat plus protein

Other factors that increase susceptibility to heat load

There are several other factors that affect the amount of metabolic heat a cow produces and how effectively she transfers heat to and from the external environment.

Coat colour and type	Black-coated cows absorb more solar radiation than cows with lighter coloured coats during the day. At night, black cows will re-radiate heat more effectively. Cows with dense, flat coats like Brahmans resist heat transfer to the skin better than cows with woolly coats (European breeds).
Temperament	Temperament may also play a small role in heat tolerance. Animals that are calmer are more heat tolerant than animals that are more excitable.
Diet	Some feeds produce more metabolic heat than others. Other dietary factors that affect the amount of metabolic heat produced include the amount of fibre versus grain/concentrates in the diet. Any restriction in the availability of fresh, cool drinking water will, of course, increase animals susceptibility to heat stress.
Previous exposure to hot conditions	Cow that have not been preconditioned to hot weather will have a greater stress response (higher breathing rate, higher body temperature). Cows need at least three weeks to acclimatise.
Activity level	Cows that must walk longer distances over hilly terrain each day to and from the dairy generate more metabolic heat.

MONITORING AND EARLY INTERVENTION STRATEGIES

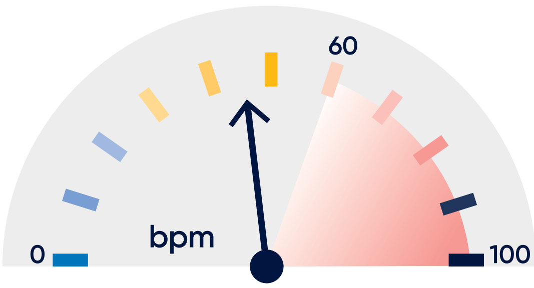
Monitoring cows breathing rate

The most useful and practical way to determine how your cows are coping with conditions and managing their heat load is to check their breathing rate. An increased breathing rate is the first mechanism the cow uses to dissipate heat. It is the first outward sign of heat stress and often precedes an elevated core body temperature. This easy-to-do check of your cows' breathing rates is your real-time indicator of cow heat load.

Consider the following actions as part of your heat stress monitoring program:

- Enter a calendar reminder for a 'go on alert' date – this is the trigger for you to start counting your cows' breathing rates regularly
- On hot days or after an extended period of hot weather, check cows twice daily
- Check using a watch and count the number of breaths in at least 20 cows by observing flank movements over a 20-second interval and then multiply by three
- Check your best-producing cows first – they will be the first to feel the effects because of the extra heat developed in their gut and the higher tissue metabolic rate due to the demands of higher production.

Rate	Comment
40 to 60 breaths per minute	A breathing rate in this range is normal for cows
60 breaths per minute	This rate corresponds to a core body temperature of about 39°C. At this point, you need to take action
70+ breaths per minute	At this rate cows are starting to struggle. If in the 80s, heat stress is severe. If more than 90 to 100, cows may die



Remember, if your cows are at more than 60 breaths per minute, take action!

Anticipating hot weather

In the hot season, one of the key roles a herd manager must play is that of weather forecaster. If you can roughly predict when a heat stress event is likely to occur, you can be prepared – forewarned is forearmed.

The trick is to be constantly aware of the weather you have just experienced and what is likely to be coming. A combination of some or all the following weather conditions increase cows' heat load and should act as a warning.

When we consider hot weather and cow comfort we tend to focus on daily maximum and minimum temperatures, but daily highs and lows only tell part of the heat load story. The length and severity of conditions is also important, as is humidity.

Relative humidity is the 'hidden' heat load factor and must always be considered when assessing cows' heat load. As relative humidity increases, the cow is less able to cool its body using evaporation – a cow's primary mechanism for unloading heat.

Relative humidity is the ratio of water vapour or moisture in the air (at a given temperature) compared to the maximum amount of moisture the air could hold. It is expressed as a percentage.

A simple chart in the back of your paddock book might help you keep track, but get into the habit of using the Bureau of Meteorology website (**bom.gov.au**) and the Cool Cows website (**coolcows.com.au)** to help monitor weather conditions – in the end relying on 'gut feel' may not be good enough to avoid problems.

Weather condition	Effect on cows' heat load
High daytime temperatures – two or more days	Back-to-back hot days mean heat load accumulates, gradually rising each day of the heat wave
High overnight temperatures	Limits the amount of heat a cow can off-load overnight (this is of greatest concern in high production herds)
High relative humidity	Limits the effectiveness of a cow's evaporative cooling
Recent rainfall	Increases humidity
Little or no cloud cover	Increases the amount of solar radiation that a cow is exposed to during the day
Little or no air movement	Limits the effectiveness of evaporative cooling
A sudden change from cool, mild weather to hot conditions	If this occurs in late spring/early summer cows with no previous exposure to heat are particularly vulnerable

Temperature Humidity Index (THI)

The Temperature Humidity Index (THI) is a measure that has been used since the early 1990s. It accounts for the combined effects of environmental temperature and relative humidity and is a useful and easy way to assess the risk of heat stress.

- When the THI exceeds 72, cows are likely to begin experiencing heat stress and their in-calf rates will be affected.
- When the THI exceeds 78, milk production is seriously affected.
- When the THI rises above 82, very significant losses in milk production are likely, cows show signs of severe stress and many ultimately die.

A number of important points should be made about the THI:

- A THI of 72 may under-estimate heat load in high-yielding Holstein-Friesian cows – increasing milk yield increases cows' sensitivity to heat stress.
- Recent research shows that increasing milk production from 35 to 45 litres/day reduces the threshold temperature for heat stress by 5°C.
- THI does not account for solar radiation or air movement – those two factors, along with air temperature and relative humidity, determine the heat gained and lost between the cow and the environment.
- THI does not enable you to measure the accumulation of heat load over time, e.g. after several days.

Despite these limitations, THI is still a useful and easy way to assess and predict the risk of heat stress; however, it is wise to be conservative.

If you have a herd of high-producing Holstein-Friesian cows, it is better to overestimate the risks of heat stress using a lower THI than get caught out.

As you can see in Figure 2, a THI of 78 occurs at:

- 31°C and 40% relative humidity; or
- 27°C and 80% relative humidity.

Consider Figure 3, which shows the average and expected range of daily THI values for a particular location, against a background of relative THI bands based on historical weather data.

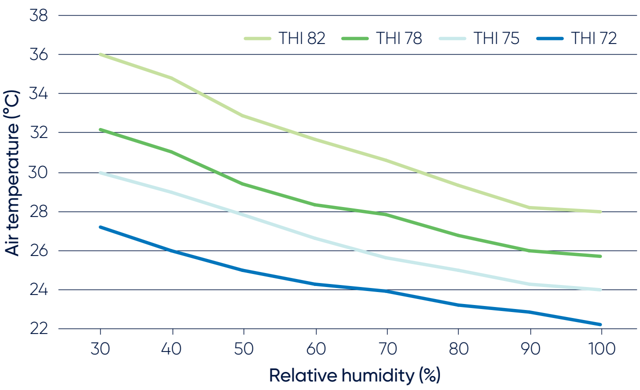
- You can see that for this location, conditions likely to result in periods of moderate heat stress occur commonly from November to March. However, periods of high heat stress do also occur, most often in January and early February. As early as mid-October and as late as March-April, herd milk production and in-calf rates may still be affected if heat load is not actively managed.
- At this location, the appropriate time to go on alert is mid-October.

For further information on your region and area, visit **coolcows.com.au**. You can also access the information via **dairyaustralia.com.au**. You may be surprised just how long your alert period should be!

THI is calculated from air temperature and relative humidity using the following equation:

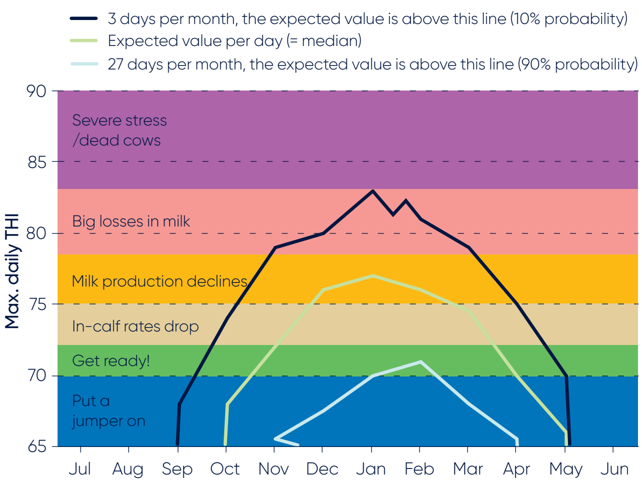
THI = (dry bulb temperature °C) + (0.36 x dew point temperature °C) + 41.2

Figure 2 THI as a factor of air temperature and relative humidity



Even mild heat stress causes physiological changes in the cow that may have an impact on your bottom line.
The temperature can be mild but if humidity is high, cows start feeling the heat.

Figure 3 An example of an annual THI probability graph



Common weather scenarios

It is useful to be able to recognise some of the most common weather scenarios we see in Australia over the hot season. These four scenarios have been provided by the Bureau of Meteorology (BoM). Note the typical THI values associated with each scenario.

Scenario 1 Mid-late summer heatwave in south-eastern Australia

A slow-moving high-pressure system establishes itself in the Tasman Sea, directing a warmer north-west to north-east flow across much of southern Australia. This high pressure system is often referred to as a 'blocking high'.

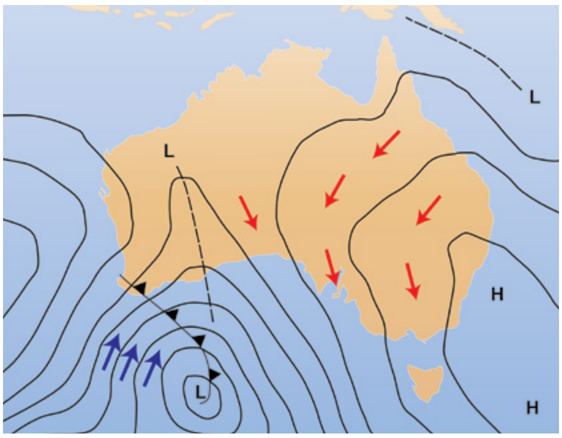
The high-pressure system remains nearly stationary for several days, with warm northerly winds continuing to flow across the affected regions.

Higher-than-average temperatures are experienced, with the daily maximum ranging from the mid-30s to low-40s every day. Night- time temperatures also tend to be higher than average. Winds tend to be light to moderate.

A change to cooler conditions is generally associated with the passage of a cold front. Winds become fresh to strong and gusty as the front moves over the area. Temperatures tend to decrease rapidly once the front has passed.

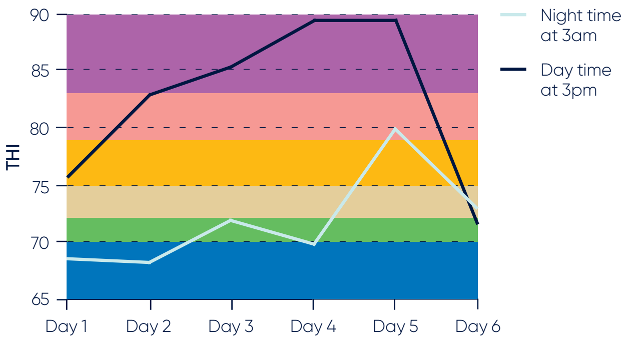
- **Area affected** most of southern Australia, particularly the south-east.
- **When** blocking highs can occur at any time of year, however temperatures only tend to reach the mid-30s and higher during the mid-late summer and early autumn period.
- **Duration** hot spells can last from a few days to a few weeks (extreme end of the scale).

Scenario 1



Source: BoM

Typical THI values for northern Victoria



Source: BoM

Scenario 2 Wet season storm in northern Australia

During the northern wet season (October to April) the temperatures increase, and humidity rises.

The monsoon trough moves into the southern hemisphere and its movement dictates the nature of the monsoon at any time.

During 'active' periods of the monsoon (the monsoon trough is over land across northern Australia), there are sustained periods of rainfall, increasing the humidity, but decreasing the temperature.

In contrast, when the monsoon trough is in the southern hemisphere, but to the north of the continent, humidity increases and temperatures remain high. This is termed a 'break' period of the monsoon. Localised storms characterise the monsoon's break periods.

During break periods, and before the onset of the monsoon, a moist east to north-east flow is directed onto the north Queensland coast.

This onshore flow interacts with the region's topography and there are often isolated storms during the afternoon.

At this time of year, the temperature usually reaches the low to mid-30s, and the humidity is moderately high. When a storm passes overhead, the rainfall increases the moisture available in the region.

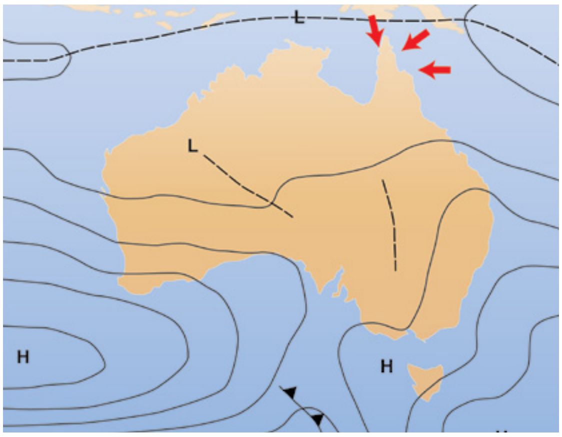
The temperature drops slightly while it is raining, however the storms are short in duration, and the temperature is quick to increase again once the storm has passed.

After the storm has moved away, temperatures return to close to their former level, in the low to mid-30s. However, the extra moisture available dramatically increases the region's humidity, causing an increase in the THI.

Winds before the storm tend to be moderate to fresh, becoming strong and gusty during the storm, before returning to a moderate to fresh flow.

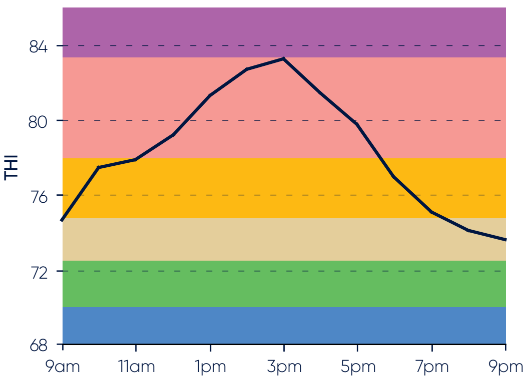
- **Area affected** Most of tropical northern Australia.
- **When** Wet season storms generally occur between October and April.
- **Duration** Storm events are short-lived, lasting a couple of hours at the most, however it may take several hours after a storm's passing for the increased humidity to moderate.

Scenario 2



Source: BoM

Typical THI values for tropical Queensland



Source: BoM

Scenario 3 Early warm period in southern Australia

This is similar to Scenario 1 – a slow-moving moving high-pressure system establishes itself in the Tasman Sea, directing a warm north-west to north-east flow across much of southern Australia.

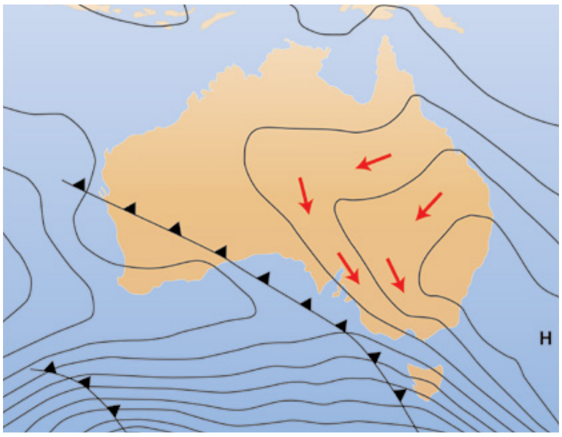
When this situation occurs during spring or early summer, it can lead to an early warm spell across southern Australia.

Maximum temperatures can reach the high 20s to low 30s, while the minimum temperatures remain in the low teens.

The winds tend to be light to moderate, increasing to fresh to strong and gusty as the cold front approaches.

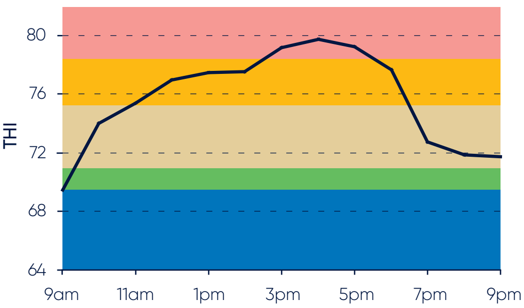
- **Area affected** Most of southern Australia, particularly the south-east.
- **When** Blocking highs can occur at any time of year, however early warm spells occur during spring and early summer.
- **Duration** Warm spells can last from between a few days to a few weeks (extreme end of the scale).

Scenario 3



Source: BoM

Typical THI values for northern Victoria



Source: BoM

Scenario 4 West coast trough (mid-spring to mid-autumn)

The west coast trough is a semi-permanent feature of the surface pressure pattern near the west coast of Australia during the warmer months and is the dominant influence on west coast weather conditions at this time.

The trough is a zone of low pressure that develops at the boundary between warm continental easterly winds and cooler maritime air from the Indian Ocean.

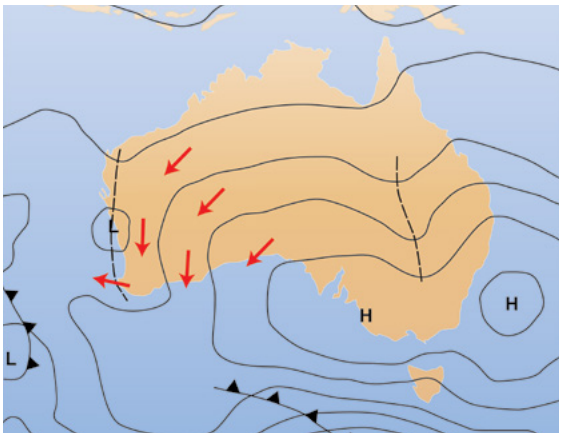
Initially, the trough tends to lie near the west coast of Australia and will remain there over a period of several days.

Areas to the east of the trough are under the influence of warm north-easterly winds. These areas can experience hot days with maximum temperatures in excess of 40 degrees, and the possibility of thunderstorms. Winds near the trough tend to be light to moderate.

Eventually an approaching cold front will push the trough inland, bringing with it a welcome cool change.

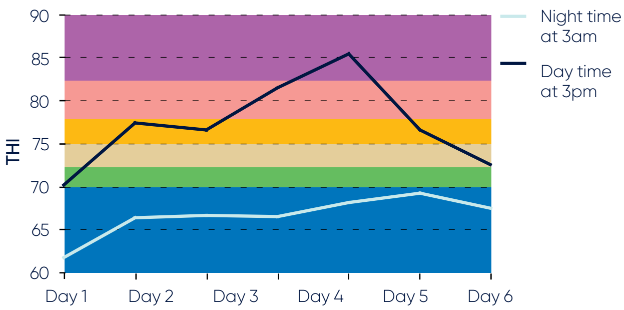
- **Area affected** South-western Australia.
- **When** West coast troughs occur during the warmer months, from mid-spring through to mid-autumn.
- **Duration** Each development cycle of the west coast trough lasts for a few days to a week.

Scenario 4



Source: BoM

Typical THI values for south-west Western Australia



Source: BoM

PLANNING AND MANAGEMENT

Short and long term tips for heat stress management

Whether you want to make small or big changes, these to 10 short-term and long-term changes to farm infrastructure provide options for heat stress management.

Top 10 short-term actions to consider

1. Delay afternoon milking until 5pm during the hot season
2. On hot days, wet the dairy yard for an hour before cows arrive
3. Set up a sprinkler system at the dairy yard.
4. Install a large water trough on the exit side of the dairy
5. Sprinkle cows for 30 to 60 minutes while standing in the dairy yard waiting for afternoon milking on hot days or when cows breathing rate exceeds 60 breaths per minute or the temperature heat index (THI) is above 78
6. Increase your cows' grain and concentrate feeding rate, feed high-quality forage fibre and higher-quality protein sources, and increase cows' intakes of potassium, sodium and magnesium
7. On very hot days, if you don't have a shade shed, bring the milking herd back to the dairy yard around midday and use the sprinkler system to cool cows – if possible, give them access to high quality hay or silage
8. In hot weather, provide cows with the highest quality pasture available to graze overnight when they are cooler
9. Mate more heifers to compensate for lower in-calf rates expected in milkers during the hot season to help maintain your desired calving pattern
10. Implement a tree planting program starting with trees on the western side of the yard.

MORE INFORMATION

Further detail on the above options has been provided on the following pages.

Top 10 long-term actions to consider

1. Review the whole farm for shade
2. Develop a farm plan that incorporates significant tree plantings over time on the northern and western edges of pastures, and plant deciduous trees along laneways
3. Fence off tree lines to protect tree roots from cow treading and reduce the chance of cows lying down in mud and dung
4. Install a shade cloth over the dairy yard to enhance cow cooling prior to milking
5. Install water troughs in all paddocks and along laneways
6. Combine shade and sprinklers at the dairy yard with a feed out system for high quality forage or partial mixed ration close by. Ensure cows can move freely between both areas during hot weather
7. Build a shade shed with a solid roof set over a feed pad integrated with a PMR feeding system
8. Install a sprinkler system set with temperature controls in the shade shed over the feed pad which is integrated with the effluent management system
9. Install fans if air movement through the shade shed is inadequate
10. Assess the impact of withholding insemination during hot weather on herd profitability.

Hot weather management

In cooler climates, hot weather events are not as common, but they do happen.

When hot weather events happen, they are usually forecast five to seven days in advance. There are some simple management steps that can be taken to minimise the effects of these events on herd production.

Access to cool drinking water

Allow for 200 to 250 litres per cow per day of drinking water in hot weather – double what cows usually need each day. Make sure cows have access to plenty of cool drinking water wherever they are during the day.

A large water trough on the exit side of the dairy allows cows to consume water at their leisure.

Water troughs in every paddock will keep cows grazing longer in hot weather. Shorter distances to water reduce the chance of cows stopping grazing due to the heat. Large volume concrete troughs help keep drinking water cool.

High flow rates are essential. Water pipes should be 75mm in diameter. There needs to be sufficient pressure to provide 20 litres per cow per hour.

Avoid running black polyethylene pipe along the ground as water will become very hot.

Milking times

Walking cows to the dairy during the hottest part of the day (about 3pm) adds to their heat loads.

Delaying afternoon milking until 5pm may increase milk yield by up to 1.5 litres per day, regardless of whether the cows are sprinkled with water while in the dairy.

Be sure to milk and feed cows before 10am on hot days. Have it done by 9am on heat wave days. Look for ways to offer feed to cows as soon as they exit the dairy. Have the paddock or feed-out area ready and ensure that every cow has adequate access.

Paddock rotation

It is useful to have a rating for all paddocks based on distance from the dairy and amount of shade available. When high heat and humidity periods are forecast the paddock rotation can be adjusted to minimise walking and maximise available shade.

During summer when there is minimal paddock feed available consideration needs to be given to whether the cows need to go to the paddock during the day. The use of sacrifice paddocks and feed pads will help to minimise heat exposure.

Care needs to be taken to avoid excess paddock contamination in sacrifice paddocks. This will increase the risk of mastitis and milk quality issues. Ensure any stand-off areas have plenty of access to water with high flow rates into the trough.

Mating and heat stress

Increased heat loads during periods of continuously hot humid weather can impact severely on conception rates and in-calf rates, particularly in higher producing cows.

Mating management

When considering the timing of your calving pattern, remember mating during hot summer months will have an adverse effect on fertility outcomes.

When considering calving strategies, allow for the following impacts in hot season mating periods:

- Oocyte quality will be reduced, resulting in lower conception rates (This will be less of an issue in heifers than in older cows)
- Cows are less likely to express oestrus behaviour in hot weather and heat detection techniques will need to be intensified
- Bulls will be less inclined to be active and increasing the number of bulls might be necessary.

During hot conditions, reduced fertility can be avoided by:

- Minimising the time cows are standing around in hot yards waiting to be inseminated
- Providing a shaded area for these cows
- Increasing the use of heat detection aids.

Heat detection

Cows are more likely to have silent heats or shortened heats in the hot season. Accurate heat detection is critical to achieving high submission rates. Expect cows calved in summer to take longer to start cycling than cows calved in winter.

The key is to increase your heat detection efforts over the summer months and manage cows not detected on heat.

Access InCalf resources for more information at **dairyaustralia.com.au/incalf**

Artificial insemination practices for heat stressed cows

Increased heat loads during periods of continuously hot, humid weather can be severe on conception rates particularly in higher producing cows. It would be prudent to lower fertility expectations for mating carried out during hot periods.

Make sure you are not blaming the hot weather for problems caused by poor procedures. Ensure that all AI practices are up to scratch including general preparation and cow handling, semen storage and handling, insemination techniques and timing.

Assess your herd using the InCalf AI practices tool at **dairyaustralia.com.au/incalf**

Calving pattern decisions

Altering calving patterns to avoid extreme heat will only partially address the effects of heat stress on mating performance, conception or calving rates.

The extra cost of cooling infrastructure may deliver better outcomes in herd fertility performance than delaying or changing calving patterns. Extreme heat events should be a just one of the many factors considered when deciding the best management approach.

Access the InCalf herd assessment tools and book for more information at **dairyaustralia.com.au/incalf**

Nutrition and heat stress

Fats and proteins for heat stress

Higher producing cows and those under greater metabolic stress respond well to this nutritional strategy.

Supplementary fat sources like vegetable oil and commercial 'bypass fat' supplements are regularly used, while proteins provide a good source of amino acids.

How much fat during warmer periods?

Feeding fat has an added advantage in hot conditions – it is digested and used by the cow more efficiently than starches and fibre and produces less metabolic heat.

Too much fat interferes with microbial digestion in the rumen and depresses feed intake. Aim for a maximum of six to seven per cent total fat in the diet (DM basis). Dietary supplementation with extra fat is a good way to help increase the energy density of the cow's diet and maintain the daily energy intake.

Higher producing cows and those under greater metabolic stress respond well to this nutritional strategy. Supplementary fat sources like vegetable oil and commercial 'bypass fat' supplements are regularly used. It is important to manage the ratio of saturated versus unsaturated fats being fed in the diet.

In the US, diets used in hot conditions contain three per cent fat from the main feeds in the diet, two to three per cent fat from added vegetable oil and one to two per cent fat as supplementary bypass fat.

How much protein during warmer periods?

In hot conditions cows still need enough protein in their diet to maintain rumen microbial function and supply good flows of amino acids to the intestine. They are faced with three challenges:

- Their daily feed intake is reduced
- Their rumen microbial function is compromised
- Summer pastures are lower in protein.

Feed higher quality protein sources in the diet during the hot season. Higher 'bypass' or 'escape' protein sources that are readily digested in the cows' small intestine can help offset lower yields of microbial protein from the rumen during hot weather.

Fibre and starches for heat stress

With daily dry matter intake (DMI) reduced over summer, the quality and amount of fibre and starches can assist heat stress management.

Breakdown of fibre and starch during warmer conditions

High quality fibre will maintain rumen stability and increase nutrient density without producing excessive metabolic heat. Low-quality forage (high NDF) gives too much dietary bulk and makes it difficult to reach the daily nutrient intakes needed for milk production.

Higher fibre intakes add safety and help cows return to good health after an excessive heat event has passed.

Mixer wagons that allow for the feeding of fibre with other feeds in a partial mixed ration (PMR) give much more flexibility. It is best to feed the PMR under shade between the morning and afternoon milking and allow cows to graze best-quality pastures overnight.

Ensure all cows get equal access when feeding out quantities of forage fibre to your herd. Heifers and less-dominant cows may be more at risk of acidosis than others.

Starches as a source of glucose

Heat stressed cows have a greater need for glucose. Provide a form of starch that will slowly ferment so the cow has a steady supply of glucose across the whole body. Corn (maize) is the most readily available slow-fermenting starch source of all the grains.

A slowly fermenting starch source will assist feed digestion in two main ways. Firstly, it takes some of the starch fermentation away from the rumen. This reduces the rumen energy yield and allows for greater glucose formation in the liver. It also reduces the risk of ruminal acidosis through excessive starch fermentation. A quickly fermenting starch releases energy too fast and rapid fermentation pushes rumen pH down.

The starch that is not digested in the rumen will normally be digested in the small intestine. At this site of digestion, it produces glucose for use by the gut tissue.

Heat stress affects grain digestion, so manure screening is a good indicator of grain digestion efficiency and informing choices around dietary management.

Feed additives for heat stress

Feed additives assist cows in hot conditions in many ways. Some include:

- Rumen modifiers
- Yeast and yeast metabolites
- Betaine
- Niacin.

Rumen modifiers such as monensin, tylosin, virginiamycin, lasalocid and bambermycin may assist by altering the balance between the different populations of microbes in the rumen and the proportions of volatile fatty acids (VFAs) they produce.

Yeast and yeast metabolites increase fibre digestibility. They use-up lactic acid and break down rumen contents into glucose from propionate, a VFA commonly produced by gut bacteria. There is some evidence that suggests increasing glucose can assist cows in managing their metabolic heat loads during heat stress.

Betaine helps to maintain feed intake and reduce the amount of energy used to stay cool and continue normal metabolic processes. It can provide effective relief in heat stress situations, but only if the dosage is correct.

The dose rate for heat stress is 15 to 20 grams per cow per day, but a nutritional advisor should be consulted to get the balance right. There are some situations where betaine would not be advised. Excessive dose rates can be counterproductive.

Vitamin B3, or niacin, has been shown to play a role in energy metabolism, so additional niacin supplementation may be helpful in the warm seasons.

The most important thing with your summer nutrition program is to provide a diet which includes high quality forage fibre, adequate protein, slowly fermenting starch sources, fats, buffers and minerals.

Consult your nutrition adviser for more information on what place these or other feed additives may have in your summer nutrition program.

Essential salts provide potassium, sodium and magnesium

Electrolytes are essential salts that all mammals need to balance water intake and keep hydrated. Cows lose electrolytes through sweating and urination, so their feed intake may require supplements.

Cows lose large amounts of potassium (K+) in hot conditions through sweating. **Potassium bicarbonates** provide a good source of dietary potassium for dairy herds. Between 1.3 and 1.6 per cent potassium in the diet (DM basis) is recommended during the hotter seasons.

Cows urinate in response to increased water intake and excrete more sodium (Na+). **Sodium bicarbonate** is the preferred source of dietary sodium, but sodium chloride works as well and is cheap. Approximately 0.45 to 0.6 per cent sodium in the diet (DM basis) is recommended during the hot season.

Magnesium inputs should also be increased during the hot season because it's an essential co-factor for many metabolic processes, particularly when extra fat supplementation is occuring. Approximately 0.35 per cent magnesium in the diet (DM basis) is recommended.

A nutritional advisor will have a solid knowledge around the existing salt and electrolyte content of your current feedstocks and provide advice on adjustments during warmer months..

Are buffers necessary?

Cows normally produce more than 2.5 kilograms of bicarbonate-rich saliva every day. Bicarbonates act as an effective buffer against changing stomach acidity and keeps rumen pH within an optimal range. A stable pH range supports the cow's gut bacteria, an essential component in breaking down the rumen contents.

Hot conditions make cows drool from their mouth instead of letting saliva flow into the rumen. On top of that, heat-stressed cows will have lower concentrations of bicarbonates in their saliva.

A drop in the flow and the concentration of bicarbonate means the natural buffering activity is reduced. At the same time, the cow may be consuming less effective fibre and more grain or feed concentrate. This also increases the risk of a fall in rumen pH and ruminal acidosis problems.

Therefore, dietary supplementation with a buffer is good insurance during the hot season. Recommended daily feed rates vary depending on what is fed and how it is fed.

Consult your nutrition adviser for more specialised advice.

INFRASTRUCTURE TO MANAGE HEAT STRESS

Shade, water supply and access are the most important considerations for reduction of heat stress. Sprinklers and fans can improve heat load reduction further. It is worth considering how these can be integrated into existing infrastructure.

The right combination of cooling methods based on how the farm operates is the key to reducing heat stress. Consider the following factors:

Herd condition considerations

- Your herd's susceptibility to heat stress (low, moderate or high) based on location, breed, milk production level and age profile of herd.
- Walking distances for cows between paddocks and the dairy, as well as between the dairy and the feedpad (if you have one).

Existing infrastructure considerations

- The amount of tree shade already present in the paddocks and laneways.
- Whether you are willing to wait long enough for shade trees to grow.
- Whether it is feasible to provide adequate tree shade in paddocks to all your cows each day.
- What irrigation infrastructure and water is available.
- Whether there is a shady loafing paddock available near the dairy.

Feeding system

- What feeding infrastructure and equipment is currently available? Is the feedpad surface concrete?
- Which feeding system is used? A hybrid system or a TMR system? Does the herd graze over summer?

Daily schedule

- How many hours do the cows spend in the dairy yard before each milking?
- How many times a day do you milk?

Step-by-step development of a dairy holding yard's cooling capacity

Developing the cooling capacity of a dairy holding yard can be considered as a series of steps in which items of cow cooling infrastructure or equipment are progressively installed depending on budgets. The aim is to start simple, and then add cooling capacity over time as necessary, depending on how susceptible the herd is to heat stress. (See prior section of this booklet that describes the factors that determine a herd's susceptibility to heat stress: location, breed, genetics, age and liveweight, and level of milk production).

For each of the above infrastructure options, further detail is provided in the following pages. This includes its strengths, limitations and keys to success. The information is intended to help with decision-making around the best placement of resources, time and effort into improving infrastructure in paddocks and laneways, the dairy yard and feedpads.

Stepped approach to increasing cooling capacity on your dairy yard

1 Install more water troughs > **2** Install sprinkler system > **3** Install shade structure > **4** Install fan > **5** Automate sprinklers and fans

Water supply and access

Changes to farm infrastructure could improve water security or efficiency – for example, upgrading leaky systems or investing in larger water troughs.

Drinking water for warm weather

In hot weather, cows will drink up to 250 litres each day – double their consumption on a cooler day. Make sure cows have access to plenty of cool drinking water wherever they are during the day. This is a combination of trough access and flow rate into the trough.

It is estimated that 30–40 per cent of daily water intake can be consumed at the exit side of the dairy. A large water trough on the exit side of the dairy allows cows to consume water at their leisure. Water troughs in every paddock will keep cows grazing longer in hot weather. Less distance to water reduces the chance of them stopping grazing due to the heat. Large volume concrete troughs help keep drinking water cool.

High flow rates are essential. Water pipes should be 75mm in diameter. There needs to be enough pressure to provide 20 litres per cow per hour. A cow can drink 20 litres per minute so flow rates are critical. Large volume troughs will help to maintain supply during high demand.

Avoid running black poly pipe along the ground as water will become very hot.

Water quality tips

- Water salinity can affect animal health and affect the effluent management system. Stock water supplies should be analysed regularly to check the salinity levels.
- Install troughs adjacent to feed alleys and dairy yards so cows must place their head through the fence to access water.
- Make sure you can get access to troughs for cleaning.
- Use a bung to drain the trough into the effluent management system. Plumb troughs so water can drain back into concrete feed alley or yards after cleaning.
- Rectangular water troughs are easier to drain and clean.
- Ensure manure does not build-up around the base of troughs.
- Stock water points should be cleaned at least weekly to remove any feed residue or other contaminants.
- Water supplies should be tested for chemical and bacterial contamination. Information on water quality and water testing is available from government agencies.

Watering points in housed environments

According to the Victorian Department of Primary Industries, each watering point should be able to hold 200 to 300 litres of water, with a minimum flow rate of 10 litres per minute.

The volume can be reduced to approximately 100 litres if the flow rate is increased to 20 litres per minute. At least 50mm of water point space should be provided per cow in systems where cattle are confined for 24 hours per day.

The optimal water point height is between 600 to 900mm (cow feet level to top of water point).

Water points should be:

- Surrounded by plenty of passage space and preferably on the outside of the traffic curve
- Easily accessible as soon as cows leave the dairy and also within 15m of the feeding table
- Easily accessible for cleaning. A bung should be provided to drain the system completely

The drainage water for earthen pads should be piped directly from the water point to the manure management system.

KEY TO SUCCESS

AVOID RUNNING black poly pipe along the ground, as water will become hot before reaching the watering point.

LARGE VOLUME concrete troughs help keep drinking water cool.

LOCATE TROUGHS in shaded areas where possible.

USE HIGH-PRESSURE flow systems that allow rapid refilling of water troughs.

DESIGN TO cater for increased demand in hot weather.

CONSIDER FUTURE increases in herd size or changes to farm layout.

LOCATE SO that water is not contaminated by feed.

DESIGN AND locate to allow easy, frequent cleaning.

MANAGE MANURE build up around troughs.

Water point location	Guidance
Paddocks and laneways	Provide watering points in every paddock, as this will keep cows grazing longer in hot weather. If they leave the paddock to get a drink they often do not return to graze.
Dairy exit	A large water trough on the exit side of the dairy is a must. Locate a wide passage, preferably on the outside of cow traffic curve.
Dairy holding yard	Install troughs along sides of dairy yard so cows must place their heads through the fence to drink.
Earthen feedpad	Place troughs away from the feed source on the down-slope side, so water can drain into the effluent management system. This helps to minimise the formation of wet patches throughout the feedpad.
Concrete feedpad	Place water troughs within about 15m of the feeding table. Locate away from the feed alley to prevent feed contaminating the water. Locate within the feedpad complex, so that spillage and flushing can be directed into the effluent management system.
Freestall shed	Provide at least 5cm of trough space per cow in systems where cattle are confined for 24 hours/day with at least two points for every group of cows. Locate water troughs at the crossovers to prevent feed contaminating the water and to reduce the incidence of cattle blocking each other in the alleys.

While cows prefer drinking warm water, providing cool water will help them manage heat load

Water troughs in each paddock will keep cows grazing longer in hot weather

Sprinklers and fans

Sprinklers

Sprinklers encourage heat loss through evaporative cooling and are an effective method of cooling a large number of cows quickly.

Dairy yard sprinklers assist cooling in a few different ways. Sprinkling cows before milking can lower breathing rates and increase milk yields. If cows are cool when leaving the dairy in the afternoon, they will eat more overnight.

Sprinkled concrete loses heat via evaporation and conduction through contact with the cooler water. This reduces its ability to re-radiate heat to the cows standing on its surface. A small amount of heat is also off-loaded via conduction from hoof contact with the cooler concrete surface.

Sprinklers can also be used to wet cows so they can off-load heat via evaporation with the assistance of fans.

Dairy yard sprinklers

Sprinkler systems are relatively easy to install and can be built from irrigation or garden sprinklers and poly pipe.

Droplets must be medium large to allow water to penetrate the hair coat and wet the cow's skin.

Sprinklers should be spaced at intervals of 1.5 to 2 times their wetted radius so there is a slight overlap of wetted areas.

Piping must suit the length and area to be sprinkled, the number of sprinklers and their flow rate. Piping can be PVC or polythene and any exposed pipe should be painted white to keep water cool. The ideal water temperature is 15 to 20°C.

For more information, see design considerations for sprinklers later in this booklet.

Spray curtains

Spray curtains are a relatively cheap cooling option that has the added benefit of keeping flies out of the dairy.

Spray curtains can be used in dairy yards but are normally attached to the underside of the dairy shed roof between the yard and the platform.

The example shown was constructed for less than $100 using 19mm black polyethylene attached to the roof with garden sprinkler sprays inserted into the pipe every metre. It is about 2.5m above the cows' feet level.

Strengths

- Low capital outlay.
- Can be easily fitted to any dairy yard (or feedpad) with a concrete floor.
- Effective method of cooling a number of cows quickly.

The sprinklers generate a semi-circle spray pattern that is directed towards the yard side of the shed

Polyethylene pipe attached to the dairy shed roof for the spray curtain

Spray curtain water supply and filter

Spray curtain in operation

Limitations

- If droplet size is too small cooling will not be effective.
- Use in high humidity conditions increases heat load on cows.
- Without adequate air movement, cooling using sprinklers is not effective.
- Need access to a reliable water supply.

The spray curtain not only keeps the dairy shed cool for cows and milkers, but it also reduces fly numbers in the dairy by washing flies off cows on entry and providing a wall of mist that prevents flies from entering the shed.

REMEMBER

For evaporative cooling to be effective, the cows' skin needs to be wet but not so wet that water dribbles down the udder.

Sprinklers in dairy yards

- **Aim for medium-size droplets** on a high-volume sprinkler to avoid a fine mist.
- **Cover the entire dairy yard** so that all cows are wet in the first 10 minutes.
- **Conserve water** by installing a timer and running sprinklers on an on-off cycle. For example, sprinkle cows for one to three minutes every 15 minutes.
- **Don't pack cows too tightly**, as sufficient air movement is needed to allow evaporative cooling to work. Poor ventilation results in high humidity and health problems.
- **Position sprinklers** along the sides of a dairy yard, mounting them high enough to project water up and over cows, so it falls from above (ideally 2m). This will minimise wetting of udders and the risk of mastitis. It will also prevent water being thrown directly into cows' ears.
- **Dry cows' teats** if they get wet and allow time to dry, or dry them with a paper towel before putting cups on.
- **Avoid wetting cows after milking** to prevent teat disinfectant from being replaced with contaminated water while teat orifices are still open.
- **Pre-wet the dairy yard** by hosing, flood washing or sprinkling for the hour before cows arrive for afternoon milking. This helps dissipate the heat stored in the concrete.

Fans and sprinklers in dairy yards

Fans complement sprinklers, especially on days when there is little to no wind. Fans only help cool cows when:

- Air temperature is lower than the cows body temperature (39C).
- The cow is wet.

For more information, see design considerations for fans.

KEY TO SUCCESS

In a dairy yard, fans should be mounted above sprinklers.

Space out fans evenly, using a sufficient number of correctly spaced fans with suitable airflow capacity for the area.

Orientate fans to work with the prevailing winds

Mount fans above sprinklers.

Tilt fans down so they blow air between and underneath cows to enhance whole body cooling.

Operate on a temperature threshold to reduce unnecessary power use and machine wear and tear.

Fans being used in dairy yard (above and below picture)

Paddock sprinklers

If cows have accumulated heat load, systems that promote evaporative cooling will help to reduce this. Paddock sprays and sprinklers will wet the cow's hair and skin in low humidity conditions and provide evaporative cooling.

The cows will position themselves into the evaporative cooling zone and as the water evaporates, heat is offloaded from the cow to the surrounding environment. Sprays and sprinklers work best in low humidity conditions.

The evaporative cooling effect from paddock sprinklers increases with air movement, so if breezes and wind direction change, cooling systems require relocation to an optimal position.

The sprinkler cooling system's location should be changed daily to avoid the formation of muddy areas and pugging. This lowers the risks of environmental mastitis by preventing cows from wallowing in mud to stay cool.

A cooling system using paddock sprays and sprinklers has a low capital outlay but requires access to a reliable water source and dry conditions to work best.

Strengths

- Lower capital outlay.
- Effective method of cooling a large number of cows.

Limitations

- Requires access to reliable water supply.
- Needs to be shifted daily.
- Effective in low humidity areas only.

Centre pivots and travelling irrigators

Centre pivots and travelling irrigators provide cows with evaporative cooling on warm to hot days.

The centre image was taken in South Australia on a 40°C day with strong northerly winds.

KEY TO SUCCESS

Shift paddock sprinkler daily to avoid pugging and cows sitting in wet/muddy patches and so reduce the risk of mastitis.

A close, reliable water source.

Cow cooler water jet sprinkler

A 40°C day in South Australia with strong northerly winds.

The pivot was orientated east-west. Note that the majority of the 700-cow herd is standing in the 'evaporative zone' south of the sprinklers rather than directly under the sprinklers.

Soft-roof shade structures

Minimising heat gain using shade should be the first priority for farmers hoping to keep their cows cool.

There are two main options for providing shade in the dairy yard and feed pads. The cheapest is shade cloth, which if well-constructed and maintained can have a lifespan of at least 10 years.

On the other hand, solid-roofed shade structures are more expensive to build, but last much longer. If paired with sprinklers and air movement at milking time, shade at the dairy yard is particularly effective in cooling cows.

If the cow's skin is wet, air movement enhances cooling. It also allows for faster milk let down and more incentive for the herd to walk to the dairy. Shade at feeding areas will help to maintain dry matter intake during hot periods.

Strengths

- Shade cloth is porous, so heat evaporated from cows can vent through it.
- The small amount of radiation that penetrates through the shade cloth ensures the concrete surface regularly dries out, which prevents mould or bacteria from establishing on the concrete and reduces risk of the cows slipping.
- Can be manufactured off-site then installed in a day.
- Can be removed in cooler months.
- In most council areas no planning permit is required, as shade cloth is not considered a solid roof structure.

Limitations

- Can be affected by hail damage and machinery exhausts.
- Shorter lifespan compared to a solid-roofed structure.
- If not well-designed and constructed, shade cloth can rip in high wind.

KEY TO SUCCESS

Seek professional advice from a registered engineer and/or builder.

Use quality shade cloth with a minimum solar rating of 80 per cent, minimum 300 GSM (gram per square metre) and at least a 10–year warranty against UV degradation. Green or black material is preferred

Apply sufficient tension. Sufficient enough to shade cloth in order to prevent damage during windy conditions. Monitor tension regularly, especially after strong winds.

Allow sufficient height to provide adequate airflow under the structure, effective use of sprinklers and fans and good machinery access (minimum 3.6m and ideally 4m high).

A pitched roof is better than a flat roof as it enhances convective air movement.

Support posts used should be structural grade steel. They should be located outside the dairy yard to prevent contact with manure and water and so that they don't interfere with yard washing.

Cure deep footings for an extended period (at least two to three weeks) before bearing any load.

Damage to shade cloth caused by tractor exhaust. This shade cloth structure is only 3.5m high. Shade structures should be ideally at least 4m

Damage to shade cloth caused by poor maintenance. Ensure that springs that become detached are re-attached as soon as possible

Feedpad shade structures

Permanent shade structures over feedpads can reduce the impact of heat stress on overall farm productivity.

Permanent shade sheds are an investment that provide excellent protection from solar radiation, but they must be well designed and constructed. A well-considered orientation for the site will shift the shaded area across the pads during the day. This spreads manure deposits over a larger area as the cows move with the shade.

The sun will strike each part of the pad at some point over the day. This allows the feed pad to dry out evenly after rainfall. Whether the pad is earthen or concrete, pads and drive alleys must consider run-off into farm effluent systems. The drainage system should control and direct all run-off away from the pads.

Raised floors and pitched roofs allow storm water to be effectively managed and not end on the pad floor, so there are no wet patches for cows to lie in. They also enhance convective air movement from under the roofs. A structural engineer will be able to advise on the best design for the location.

Feedpads that encourage the cows to sit in cleaner areas of the floorspace can reduce the incidence of mastitis. Alongside daily scraping, farmers can change the locations of the feed and water trough to encourage the cows to rest in cleaner areas of the feedpad.

An effectively designed and built shade shed provides

- Enough room for resting and standing
- Comfortable, hygienic lying surfaces
- Clean, dry surfaces for standing and feed placement
- A safe environment to minimise injury
- Smooth, quiet stock movement.
- Note that the orientation and roof design of the shade structure will influence the amount of solar radiation that it can block.

Strengths

- Has a long useful life of at least 25 years.
- Doubles as a feedout facility.
- Can be used to protect pastures and prevent soil pugging during prolonged periods of rainfall.
- Can be used to break the growth cycle of parasites such as cattle tick and reduce the need for chemicals.
- Can be fitted with evaporative cooling systems such as sprinklers and fans.
- Can be converted into a freestall or integrated with loafing pads if well designed.

Limitations

- Location on farm is not always ideal for paddock rotation.
- High capital cost to provide shade. Cost depends on amount of concrete, type of roof, strength of structure required to support the roof, and the effluent management system.
- Must have an effective system for handling effluent and run-off, otherwise cow comfort and production may be compromised.
- Needs to comply with regulatory authorities (e.g. local council building permit for solids roof structures).

KEY TO SUCCESS

Shade structures located closer to the dairy will make management easier, as staff can monitor the herd while preparing for milking or post-milking clean-up.

Consider prevailing winds, radiation from the sun and rainfall. Structures need to be able to withstand extreme weather conditions

Daily scraping of earthen feedpad surfaces helps manage the risk of mastitis.

An effective effluent system for handling effluent and run-off.

Cows feeding under permanent shade structure

Compost bedded-pack structures

While compost bedded-pack structures call for different uses of time and money, they provide many benefits for dairy farmers in dryer and warmer climates.

In more recent years, composted bedding packs as a loafing area surface have become more common on Australian dairy farms.

The basis for these shelters is the use of bedding that can promote the composting of cow manure into the bedding of the shed. This is achieved by using a deep bedding that can be aerated daily.

Building or modifying a bedded pack structure may be in response to changes in farming systems, such as feeding rations, paddock rotations or a bigger herd. Considerations of potential heat stress impacts from the composting process should inform the decision-making around bedded pack structure design and maintenance.

While compost bedded pack structures can be a significant investment, they provide some benefits for dairy farmers in dryer and warmer climates.

From a heat stress management perspective, a compost shed will be able to handle high levels of animal traffic better than a few shaded paddocks over the summer.

Many farmers report using a few sacrifice paddocks over the summer to provide some shade. The paddocks are used until mastitis levels start to increase then another paddock is found. A compost barn is an alternative to sacrifice paddocks.

It is still unclear how effective compost bedding pack systems will be in hot humid areas of Australia, such as coastal Queensland, especially if using dry manure solids as compost bedding. It is important that the bedding pack does not get too wet as this will kill the composting bacteria. In humid climates this is a challenge.

A recent investigation into the experiences of eleven Australian dairy farmers showed that heat stress issues had decreased on most of the compost bedding pack shelter farms visited. However, some farms have cows that are still experiencing some heat stress (in Victoria and Queensland) and some farmers are considering using fans in hot periods (Chamberlain, 2018).

It is unclear if the heat generated from microbial activity causes more heat stress when cows are lying down, but it is assumed that some heat transfer will occur from the pack to the cow. It is possible that this could add to heat stress or willingness of cows to lay down during periods of higher environmental temperatures.

Strengths

- Flexibility in use if appropriately designed and managed to support higher levels of cow comfort, and include appropriate space allocation for a hospital herd, breeding and calving.
- Potential to mitigate risks to high-producing herds from seasonal weather variability and long-term changes in climate systems.
- Low capital outlay and maintenance costs, although they present new management challenges, such as staff training and changes in labour use.
- In some cases, can allow for better pasture use and dry matter production.
- Range of low-cost options available; many of these facilities have used plastic greenhouse type structures for the shelter rather than solid sheds.

Limitations

- Larger herds can become difficult to accommodate if using compost bedded packs.
- Excellent management of mastitis is required. The cows should be properly prepared and teat preparations applied after milking.
- Poorly ventilated structures resulting in high bed moisture content can increase the risk of environmental mastitis in humid conditions.
- Bedding materials can fluctuate in price through changes in availability.
- Summer storms in warmer months with higher than normal rainfall can wet the bedding.

KEY TO SUCCESS

Make sure staff are well trained in identifying issues and understanding the processes of bedded structures, such as monitoring moisture and bedded pack tilling, along with extra steps (if required) in milking management, teat preparation and spraying.

Reduce water or mud splashing on return to feed bunk to reduce mastitis or compost bedding contamination. Keeping cows standing for one hour following milking is advised

For a broader look at the benefits of compost pack structures, limitations and design considerations, visit **dairyinfrastructure.com.au**

Portable shade structures

Portable shade structures can be located in paddocks or laneways or near portable feeding troughs and hay rings.

Portable paddock shade structures may incorporate shade cloth or corrugated iron roofing. Some shade cloth materials are now heat resistant and reflective and designed for harsh conditions. This means they can last longer, but still require some maintenance.

Due to its high heat capacity, an iron-roof will re-radiate heat down on to the cows. Make sure the roof is high enough to allow for convective cooling of the structure.

The structures are towed on wheels or skids with a tractor or four-wheel motorbike. These are very effective when no other cooling is available in paddocks, such as overhead sprinklers (e.g. lateral move and centre-pivot irrigators).

Strengths

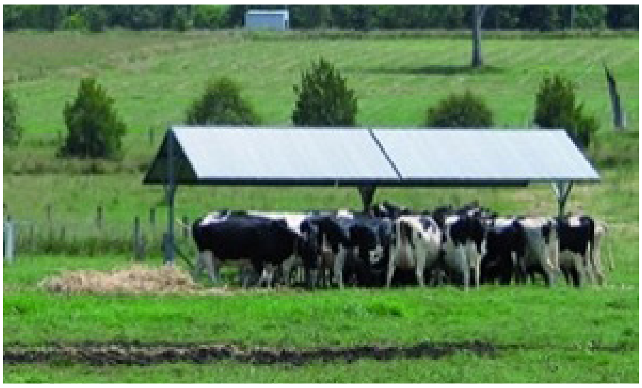
- Enables you to bring the shade to the cows, as opposed to cows to the shade.
- Best suited to smaller herds.
- Can be readily moved withanimals, or moved to cleaner, drier locations close to feed and water when necessary.

Limitations

- May need several structures to provide enough shade for all animals.
- May lead to localised pugging, nutrient build-up or compaction if not shifted regularly.
- Time cost to be allocated to shifting shade structures.
- Shorter useful life than a permanent shade structure.
- Vulnerable to high winds.

Portable paddock shade structure

A simple, low-cost design, but one that might not be suitable in windy conditions. (Note some shade cloth tears along the edges.)



An iron-roofed structure will re-radiate heat on the cows underneath, so where possible create a larger gap between the cows and roof

KEY TO SUCCESS

Use existing tree shade. If located near property boundaries, shade structures should be positioned to take advantage of additional shade from neighbouring vegetation on road reserves.

Re-locate structures if manure builds up or the ground underneath is muddy. This reduces the risk of mastitis around calving time.

Install properly under tension, so it is not damaged by winds. Wind load will increase with roof height and therefore the base needs to be heavier and wider to prevent the structure from tipping over.

Ensure adequate protection. Shade structures should block at least 80 per cent of sunlight.

Wind load will increase with roof height and therefore the base needs to be heavier and wider to prevent the wind from tipping the structure over.

Ensure there is a gap between the portable sections of the roof (when raised), so that heat can be vented through the top of the structure. This is especially important for iron roofed structures.

Ensure wide footings and that the base of the structure is wide enough to support the roof spans – this needs to be worked out for the specific individual structure.

Trees for shade

Maintaining or establishing shade and shelter belts can be a useful infrastructure adaptation for the long-term management of heat stress in Australian dairy herds.

Tree shade belts for managing heat

Shade from trees can form part of a long-term strategy for managing climate variability in dairy farming regions. The shade and shelter provided by trees in paddocks and laneways can reduce the radiant heat load by more than 50 per cent. Tree belts provide shade and protection from winds. This allows cows different options for cooling and better control over their heat loads. This also makes farms a more comfortable workplace or home for people.

Tree shelter belts that act as windbreaks will protect buildings from exposure to the elements, such as direct sun, high winds and hail. This reduces damage risk from storms to nearby farm infrastructure or buildings, such as hay or silage sheds.

To learn more about establishing and maintaining shelter belts visit Dairy Australia's Climate Toolkit at dairyclimatetoolkit.com.au

Branch out – benefits of planting trees

Trees and shade belts have less obvious, but long-lasting effects on land use and land values.

Trees will attenuate noise from machinery and shield cows from loud or unfamiliar sounds, such as a tractor backfire in lane ways. Trees also support native wildlife that prey upon pasture and crop insect pests. This can reduce costs and reliance on pesticides.

Function aside, trees have an aesthetic value. A farm with enhanced aesthetic values is more appealing to buyers. This can influence yearly valuation and capital value.

Strengths

- Trees are the cheapest method of providing shade.
- Trees absorb CO_2 and don't require electricity to establish or maintain.
- Trees enhance local biodiversity.
- Trees assist with erosion management and salinity control.
- Opportunity exists for supplementary income from timber sales.
- Trees provide protection from grass fires.

Limitations

- It takes many years to establish plantings.
- It can be difficult to provide adequate shade every day during paddock rotation.
- Trees along laneways can be a risk in severe wind conditions.
- Supplementary irrigation may be needed to establish or speed up tree growth.

Falling branches can compromise fencing. Regular clean-ups are necessary depending on the type of trees used.

Cows resting in the shade

KEY TO SUCCESS

Consider orienting north-south along the long axis of paddocks to help maximise shade and shelter if you're looking into redesigning paddock layout and rotation.

Aim for 4m² of shade per cow at midday.

Seek recommendations on tree and shrub species from an advisor such as Greening Australia or regional natural resource management bodies.

Strategically plant species based on natural traits. For example west Australian swampy yate can minimise grass growth beneath its canopy through the secretion of a toxin.

Deciduous trees will allow solar radiation to penetrate through canopies and allow laneways to dry out quicker in the winter.

Fence outside the perimeter of the tree root systems to protect trees from excessive compaction and manure that may kill some species.

Locate feed and drinking water 20 to 30 metres away from trees so that cows don't defecate excessively in the shaded areas.

Consult an arborist for the best practice approaches toward tree management.

Tree planting resources

Landcare provides a free search-based tool for finding networks in your area. These groups have some familiarity with local species, alongside being a network of volunteers willing to assist.

Find a group on the Landcare National Directory at **landcareaustralia.org.au/landcare-get-involved/findagroup/**

Organisation	Phone number	Website
Landcare	1800 151 105	**landcare.org.au**
Greening Australia	1300 886 589	**greeningaustralia.org.au**
Ausralian Government's National Landcare Program	1800 552 008	**nrm.gov.au**
NRM Regional Australia	**Visit contact page**	**nrmregionsaustralia.org.au**
Department of Agriculture Victoria V.R.O (by region)	**Visit VRO contact page**	**agriculture.vic.gov.au/home**
NSW Catchment Management Authority	1300 361 964	**environment.nsw.gov.au**
Victorian Catchment Management Authority	**Visit key contacts page**	**Catchment Management Framework**
Tasmanian Department of Primary Industries, Parks, Water and Environment	1300 368 550	**farmpoint.tas.gov.au/farmpoint** View **Re-vegetating your farm** (pdf)
Natural Resources South Australia	(08) 8204 1910	naturalresources.sa.gov.au

It's said that the best time to plant trees was 20 years ago. The next best time is now! These photos show what can be achieved in a short time.

Willowgrove 2004

Willowgrove 2007

INFRASTRUCTURE DESIGN CONSIDERATIONS

Wherever you choose to focus your cooling and infrastructure efforts, there are many aspects to consider before you invest.

The following design considerations provide information about the construction, maintenance and daily operation of cooling systems.

These design considerations could mean the difference between a shade structure or evaporative cooling system that works extremely well for you for a long-time and one that disappoints.

Design considerations for compost bedded-packs

Compost Pack Bedding (CPB) relies on an aerobic process to decompose cow waste in the bedding, producing heat, water and carbon dioxide from the pack. The composting process relies on pack bacteria being kept in an active phase, where the pack heat and adequate ventilation are essential to allow for water loss from the pack as evaporation. Design and construction of barns must focus on adequate natural and forced ventilation and keeping solar radiation and exogenous water off the pack. Packs are generally removed and replaced annually. (Source: Chamberlain, 2018)

See below tables for how to manage barn temperature and bedding pack variables to ensure bacterial growth and composting activity does not impact on cow hygiene scores or heat stress. Note that in warmer environments bacterial growth in CPB may be more difficult to manage.

Recommended bedded pack variables

Variable	Recommendation	Practical assessment of variable
Temperature	Surface bed: Ambient Deep bedding: 45-65°C	The pack temperature is used as a guide to the level of microbial activity and the speed of organic matter breakdown. It is ideally kept between 45°C and 66°C below the surface, while surface temperatures should remain close to ambient. If the pack temperature is lower than 40°C, the composting process is too slow, while pack temperatures above 66°C will result in bacterial death. Both situations result in the pack becoming inactive which leads to excessive moisture from urine and faeces not being broken down.
Moisture	Surface bed: 15% Deep bedding: 50-60%	The moisture content is easily estimated by squeezing a handful of bedding in the hand. If water can be squeezed out, the pack is too wet, but if you can't form a ball that stays in shape the pack is too dry. Upper layer moisture content of <15% is required to maintain cow cleanliness, low cell counts and cow health. To maintain this environment, additional bedding is required, ranging from 4.5kg to 15.9kg (up to 18kg) per cow per day
pH	6.5–8.0	Lower pH levels can be maintained with good pack management
Ratio	25:1–30:1	If you can smell ammonia, the C:N ratio is likely below 25:1

Mastitis-causing bacteria in compost bedding

Cause	Observations
Coliforms	CPB temperature, CPB moisture, space per cow and C:N ration had no effect on coliform counts
Escherichia	Reaches a peak concentration when the C:N ratio is between 30:1 and 35:1 (ideal C:N ratio is between 25:1 to 30:1)
Staphylococcus	Counts increase mainly as ambient temperature increases
Streptococci	Counts decrease with decreasing stocking rate and increasing composite temperature. Counts increase with increasing ambient temperature and moisture. Counts peak at a C:N ratio ranging from 16:1 to 18:1.
Bacillus	Counts decrease with increasing moisture, C/N ratio, and ambient temperature

Bed materials selection

Some materials will be more suitable than others, but in some instances, a combinations of materials has been trialled with varying success.

Suitable bedding materials

Materials	Reasoning
Kiln-dried sawdust	Performs well if the moisture content is less than 18% on entry.
Chopped straw	Ensure straw is chopped very short, is absorbent and non-waxy. Ideal straw length is <2cm.
Straw	Low surface area to volume ratio, may not be appropriate for compost beds.
Recycled manure solid	Unsuitable in moister environments, maybe successful in drier conditions.
Soil	Might not provide enough carbon or moisture absorbing capacity and could potentially be too moist.
Chipped wood	Less effective than sawdust and shavings due to low surface area to volume ratio. Sharp and cause injury.
Wood shavings	Mixed with sawdust to improve tillability and aeration. Supports microbial breakdown of manure and urine and prevents excessive compaction.

Unsuitable bedding materials

Materials	Reasoning
Coarse hay	Uneven tillage and patchy pack performance.
Cereal grain straw	Clumps during cultivation, decreasing the effectiveness as bedding material.
Oily and fragrant woods like cedar, black walnut and cherry	Antimicrobial properties that interfere with the composting process.
Green sawdust	May contain Klebsiella bacteria (mastitis pathogen), too wet.
Long corn stalk and waste hay as well as oaten, barley, and wheat straw	Less absorption and dries slowly.

Design and construction

Site selection and preparation

- Barns or feedpads with compost packs require excellent ventilation.
- Work with prevailing winds to dry out the compost pack.
- If an internal concrete alleyway is constructed, approximately 25 to 30 per cent of manure and urine is collected. A handling facility for slurry manure, such as a lagoon, must be constructed. Otherwise, daily manure hauling is needed.

Orientation and sunlight

An east to west orientation is preferred. This prevents the sun from drying the compost and encourages the cows to congregate into shaded areas. Avoid compacting and excess moisture in the shaded areas and over-drying in the pack areas that get more sun.

Structure

- Roof supports need to be 4m to 5m in height of 3m open wall space around all sides, starting at cow resting height.
- Sidewall open area target is 0.093m^2/cow in roof pitch of barns of less than 4:12 will limit the natural ventilation rate per cow.
- Continuous ridge vent opening of at least 7.6 cm for every 3m of roof width, with a minimum opening width of 30.5cm.

Bedding pack area and stocking density

- The recommended bedding area requirements can be 7 to 30 m^2/cow .
- High-producing herds will require more space because they will produce more urine and faeces. Minimum 1m^2 for each 11kg/day of increased milk production above 22kg/day.
- Cows producing more than 40 litres/day require an area of more than 14 m^2/cow for efficient composting to occur.

Sidewall curtains

Curtains should be fully raised in the summer to increase air flow and care should be taken in winter, to ensure that any restriction of air flow is not sufficient to create condensation, ammonia build up and a humid environment.

Additional ventilation and cooling

Without circulation fans in the barn, cows may tend to congregate in areas where natural air flow is higher, especially during heat stress conditions. Congregation of animals in one area leads to excessive manure and urine accumulation and ineffective composting from too high moisture in that pack region.

Consider installing box fans or high-volume low-speed fans that provide appropriate ventilation. This can drastically reduce bedding costs, with fan speeds of 9.6km/h having the potential to increase the length of time bedding will last in a barn.

For more information on compost pack facilities, visit the Dairy Infrastructure **website**.

Fan system design

Considerations for maximum effectiveness and useful life

Ventilation should always be considered a priority in any infrastructure planning. A pitched roof and open ridge vent should be considered before fans. Good facility design will create the most effective air movement. Fans will then help to increase this. Fans are designed to move warm air away from the cow as well as create air movement over the cow's skin to enhance evaporative cooling through sweating.

Fan sizing, type and placement	
Fan cost	**$550–2,000 each**
Recommendations • Costs will depend on size, capacity, design and installation • Energy consumption and efficiency of the entire cooling system should be considered • Fans should be mounted above sprinklers so they remain dry • Only use fans with sealed motors	
Fan flow rate	**285 to 840 cubic metres per minute**
Recommendations Spacing is determined based on the fan's operating flow rate. As a guide: • 900mm blade, 285 m^3/min with a 0.45 kW motor spaced every 6m • 1,300mm blade, 840 m^3/min with a 1 kW motor spaced every 12m • The base of the fan blade should be at least 2.3m from the ground	

Design considerations

- Ensure that fans used have the capacity to move the volume of air required at >2.0m/second. If cows are tightly packed, airflow will need to be greater. When used in open spaces, larger-capacity fans are required because they are operating against static pressure, so their efficiency is lower.
- Doubling the operating capacity of the fan does not double the distance covered by the fan, but it will increase costs. Be prepared to modify the placement of fans and add additional or larger-capacity fans if required.

Examples of fans in dairy sheds

Fan orientation and pitch	
Fan orientation	**Work with prevailing wind (e.g. westerlies)**
Recommendations • To minimise operating costs, locate fans to take advantage of prevailing winds at the site	
Fan pitch	**20 to 30 degrees**
Recommendations • The fans should be tilted 20° to 30° down from the vertical so they blow down to the floor, to ensure air is forced down around and beneath the cows. This will enhance evaporative and convective cooling. Tilting the fans towards the ground also reduces interaction between groups of fans that are located in series with each other, improving operating efficiency	

Operational considerations

- When operated in conjunction with sprinklers, fans will usually be initiated first (i.e. start to operate at a lower temperature than sprinklers).
- Sprinkler on/off cycles can then be stepped up at different temperature trigger levels.
- If fans are in the dairy they should run continuously when the temperature humidity index (THI) is more than 72.
- Keep the safety grill around each fan free of cobwebs and dust to maintain their maximum efficiency and effectiveness.

Fan design considerations for compost bedded - pack structures

High-volume, low speed (HVLS) fans are used to circulate the incoming fresh air through all areas of the barn and ensure sufficient barn air exchange is achieved. These fans are named due to their large size (2.5 to 7.3m diameter) and slow-moving speeds (45 revolutions per minute for a 7.3m fan). For a 7.3m HVLS (helicopter) fan, there should be a minimum of 20 meters between each fan.

If used correctly, moisture, heat and odour can all be greatly reduced. However, these fans often need the assistance of smaller fans, closer to the pack, to establish enough airspeed to dry the pack and cool the cows.

Box fans are smaller than HVLS fans and provide improved air movement at cow and pack level, to dry the pack and cool the cow.

Commonly these fans, can range from 0.9m to 1.3m, should be spaced 10m apart for 0.9m fans and 15m apart for 1.3m fans. They should also be positioned at an angle that is below the downstream of the preceding fan. These fans may also oscillate. The larger the fan, the more space can be placed between them. Fan placement should be concentrated over the cow beds and feed lanes.

Shade-cloth structure design

Several forms of shade cloth structures are available including span structures, peaked sail structures, cantilever structures and tent-like structures with large central supports.

If you intend to install a shade structure, consult a registered builder or structural engineer.

Alternatively, if you are buying a pre-fabricated shade cloth structure ensure that structural computations are supplied, the installers are experienced and local building regulations are met.

Stresses on shade cloth structures	
Loading problem	**Design solution**
Wind loads	
Ripples or waves may lead to premature failure	Ensure the shade cloth is adequately tensioned
Horizontal winds generating lift (like an aeroplane	Flatten to between 10 and 14° or install it with an inclination in excess of 20°. Roof angles of 15 to 18° should be avoided
Poor material selection, proneness to ripping in high wind loads	Choose adequate fabric strength. Lack of structural reinforcement and excessive spans can lead to billowing
Dead loads	
Gravity	Brace frames or cables supporting shade cloth are usually used to "stay" or brace posts
Poorly distributed loads	Angled posts provide tension to evenly distribute dead loads, but this can also contribute to instability when the cable support is removed
Cloth impregnated with dust or accumulated leaves, twigs, hail, ponded water or being wet from beneath	Regular cleaning and maintenance to remove any debris. Install structural reinforcement, such as cabling support, if debris is an ongoing issue.
Live loads	
Hailstones or rainfall cascading down a roof, water pooling on the canopy or being shed through or from shade cloth	Regular cleaning and maintenance. included in farm maintenance and operational schedules
Human traffic on roof	Prohibited under OHS regulations for shade cloth roof structures

Design considerations for maximum effectiveness and useful life

Materials selection

Cloth performance requirements to consider:

- Blocks at least 80% of sunlight
- Minimum 300 grams per square metre (GSM)
- Green or black coloured material
- 10 years lifespan
- Higher quality and tighter weave fabrics will last longer.

Stressors to consider:

- Exposure to sunlight
- Dust
- Accumulated debris
- Water
- Flexing
- Failure or loosening connections.

Design notes

- Cows resist being moved from bright areas to dark areas and prefer dappled shaded spaces so they tend to get used to a shade cloth structure more quickly than a solid roofed structure, provided the cloth is not billowing or flapping noisily.
- Shade cloth is also prone to bird, insect and rodent attack and areas not able to be hosed down or easily inspected for maintenance are particularly prone.

Tension system and maintenance considerations	
Load-carrying straps	Regular checks for durability or damage due to loading
Chains and U-bolts	Chain connections should be avoided. In the event of over-stress, breakage of a link can lead to the launch of a projectile whereas a cable will fray or unravel, allowing time for repair, replacement or escape from injury
Adjustable cables and turnbuckles	Turnbuckles for tensioning cable - supported shade cloth structures are prone to loosening or failure through repetitive loading so they should be inspected regularly and tightened or replaced as required.

Support posts and foundations

When installing footings, they should be:

- Deep and concreted into the ground
- Left to cure for two weeks before bearing any load
- Free from potential collisions by animals and vehicles
- Rigidly attached to a wide steel plate which is mounted on the foundation using bolted connections.

Design notes

- Galvanised and threaded starter bars extending from the footing reinforcement are better for holding the plate than dynabolts.
- Apart from central supports these posts usually lean against the applied horizontal load to maintain the tension rather than being vertically upright. They need to be free standing in a farm situation. Guy cables must be avoided.
- If possible, position posts outside the animal traffic area so they are not in contact with manure and water and don't interfere with washing. If located in the yard, place a raised concrete or PVC sleeve around the pipe to reduce corrosion potential.

Fastening fabric to posts

Prevent cloth damage by:

- Applying enough tension using flexible and adjustable connections to prevent tearing in the wind.
- Reinforcing cables and seams to distribute the point load at the stanchion to the fabric. This reduces the chance of rips and damage.

If shade cloth fastening is too loose:

- Flapping causes excessive flexing and can generate noise during wind events which can disturb cows and irritate people.

If shade cloth fastening is too tight:

- A cable or cable connector could fail due to over-tensioning. This can cause instantaneous and catastrophic structural failure.
- Shade cloth structures can become a hazard if damaged by storms. Blown cladding can provide serious injuries whilst broken cables and unsecured shade cloth can whip.

Design notes

Height

A minimum height of 4m is recommended.

If too low:

- Cows might hesitate when entering the area
- Effectiveness and installation of sprinklers and fans is reduced
- Machinery access can be restricted. This increases the chance of exhaust damage from machinery.

If too high:

- Area of shaded footprint is limited
- Maintenance becomes difficult, especially if you are running machinery under the shade cloth, which can lead to damage from the exhaust.

Location

The height of the structure, the angle of winter and summer sun and the required area of shaded footprint govern the orientation of the shade structure north-south or east-west.

If the structure is aligned east west the passage of the sun will generally ensure that the northern side of the structure is more exposed to sunlight than the southern.

If the paving is earthen and subject to animal traffic, drainage should be directed to formed drains.

If well designed, installed and maintained there is no greater risk of failure of these structures compared with other farm buildings.

Different fastening methods

WEAKNESSES IN SHADE CLOTH STRUCTURES ARE USUALLY ASSOCIATED WITH
Lack of fabric strength
Inadequate fabric reinforcement or degradation at connections
Poor choice of connection
Loose posts and failure in footings
Billowing in spans
Corrosion
Rain, hail or debris accumulating on top of the shade cloth

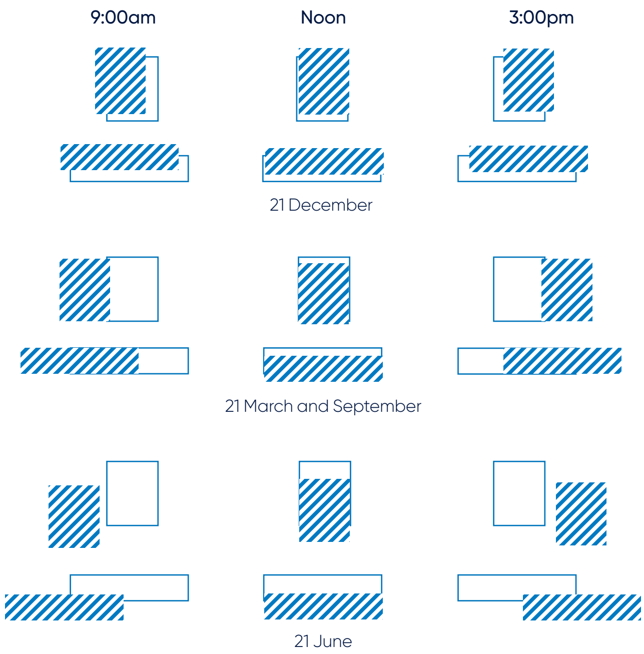
ADVANTAGES OF A SHADE CLOTH STRUCTURE OVER A SOLID-ROOFED SHADE STRUCTURE
More than 50% cheaper than solid-roofed structures
Easy to remove if not needed in cooler months or during a storm (store it away from vermin)
Easy to upgrade and maintain in responses to farm's changing needs
If well made, the posts and foundations are long lasting
Has fewer drainage considerations

Orientation – east-west or north-south?

With an east-west orientation, and an area of 2.5 to 3m^2 per cow, part of the floor area under the roof will be in shade all day. Extending the floor approximately one third its length on both the east and west to 3 to 4m^2 per cow will place feed and water troughs under shade at all times, which will encourage intakes. More dung will be dropped in the shaded area, which will need frequent cleaning to avoid the risk of mastitis. East-west orientation, therefore, works best for concrete floors.

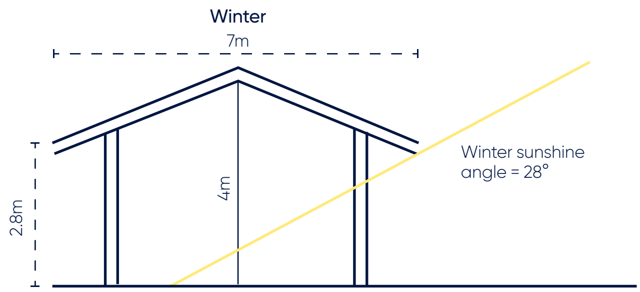
If concrete is too costly, the north-south orientation works best. It works well for a compacted clay or gravel floor because the sun strikes every part of the floor area under and on either side of the roof at some time during the day. This helps to keep the floored area dry and restricts pathogen build up. A shaded area of 2.5 to 3m^2 per cow is adequate if feed and water troughs are placed away from the shaded area. In regions where temperatures average 30°C or more for up to five hours per day during some period of the year, the east-west orientation is deemed more suitable.

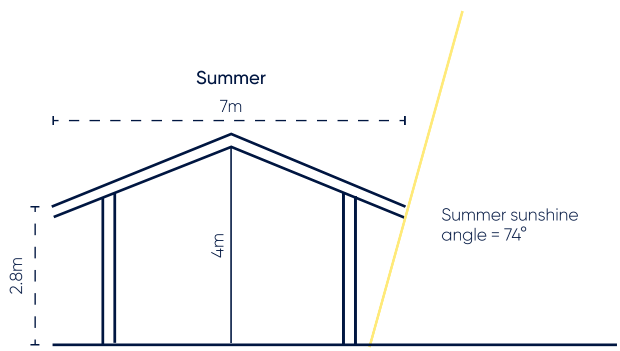
Shed profiles at 9am, noon and 3pm at different times of the year



Winter and summer sunshine angles

Winter and summer sunshine angles determine how much of the floor area receives sunshine at some time during the day, given a shed is roof height and width, as below.





Solid-roof shade structure design

Design note on roof pitch

Lower roof pitch results in slower air movement (e.g. 1:4 pitch or less). Steeper roof pitch results in greater air movement (e.g. 1:3 pitch is suggested for warmer climates).

Enclosing a shelter using sheeting, a blind or even a furled shade cloth can contribute to significant horizontal wind loads which could cause structural failure. If the angle of inclination of a roof or shade cloth is 15° or so, it will generate lift. Like an aircraft wing.

Minimise lift by either flattening the inclination of the roof to between 10 and 14° or installing it with an inclination in excess of 20°. Roof angles of 15 to 18° should be avoided.

Design note on orientation

With an east-west orientation, and an area of 2.5 to 3m^2/cow, part of the floor area under the roof will be in shade all day. Extending the floor about one third its length on both the east and west to 3 to 4m^2/cow will place feed and water troughs under shade at all times, which will encourage intakes. More dung will be dropped in the shaded area, which will need frequent cleaning to avoid the risk of mastitis.

East-west orientation, therefore, works best for concrete floors. If concrete is too costly, the north-south orientation works best.

It works well for a compacted clay or gravel floor because the sun strikes every part of the floor area under and on either side of the roof at some time during the day. This helps to keep the floored area dry and restricts pathogen build up.

A shaded area of 2.5 to 3 m^2/cow is adequate if feed and water troughs are placed away from the shaded area. In regions where temperatures average 30°C or more for up to 5 hours per day during some period of the year, the east-west orientation is deemed more suitable.

This roof slope is 18° with a 500mm vent at the apex. Eaves are 4.3 m high, and 6.9m at apex. The shed runs north-south with 3% slope on patterned cement floor. Feed troughs are 1.2m wide inside, 400mm high and 100mm thick.

Design considerations for maximum effectiveness and useful life

Element	Recommendations
Roofing material	Roof material may be aluminium or white galvanised iron sheets to increase the rate of solar reflection. This should last at least 25 years.
Roof height	For good machinery access, the roof height should be at least 3.7m
Roof pitch	Lower roof pitch results in slower air movement (e.g. 1:4 pitch or less). Steeper roof pitch results in greater air movement (e.g. 1:3 pitch is suggested for warmer climates).
Roof pitch	Provide a continuous open ridge to promote air movement (i.e. convective heat dissipation via the stack effect). Recommendations for open ridge space: • 50–75mm/3m of shed width. • 300mm + 50mm per 3m width for sheds greater than 6m wide for northern Australia.
Eave overhang	The recommended overhang for open-sided sheds is 900mm. Eave overhang is dependent on feedpad/freestall configuration as well as on eave height and required degree of protection.
Orientation	East-west or north-south
Gutter and downpipe design	As per state plumbing code (engage a qualified design engineer). The **Roof and Gutter Design Calculator** has both free and paid resource for the design and construction of guttering and roof design. Visit **roof-gutter-design.com.au**

Effluent management systems

An effective system for handling effluent and run-off is essential, otherwise cow comfort, health and production may be compromised. Refer to section 8.0 of the **Guidelines for Victorian Dairy Feedpads and Freestalls** (Department of Primary Industries, Victoria 2009). The following is a list of reference material and resources specific to your state/territory.

Regulatory body	Resource
Federal Department of Agriculture	**Effluent Management Guidelines for Dairy Sheds in Australia**
Agriculture Victoria	**Managing Dairy Shed Effluent**
Water NSW	**Onsite Waste Water Systems**
Tasmanian Department of Primary Industries, Parks, Water and Environment	**Farmpoint Dairy Effluent Guidelines**
Queensland Department of Agriculture and Fisheries	**Dairy Effluent Management Systems**
SA Environmental Protection Agency	**Wastewater for Dairy Farmers**
WA Department of Water and Environment Regulation	**Dairy Effluent Management Programs**

Note the position of water trough, grooving to help prevent cows slipping, water runoff from the roof to lane, high eaves and pitched roof to facilitate ventilation. The shed run north to south to use sunlight to dry cow standing areas

Note the poor drainage due to the lack of slope. The freestall shed has fans and sprinklers but is not linked to good drainage – a recipe for high mastitis levels

Regulatory requirements for solid roof structures

Solid roof structures need to comply with regulatory authorities, e.g. a local council building permit is required.

Victoria	
The **Victorian Building Authority** (VBA) has recently announced new categorisation and regulations for shade structures	
Regulations on farm structures	**VBA Regulations** (new farm structure changes)
Plumbing in Victoria	**VBA Plumbing Standards**
New South Wales	
The NSW Planning Portal provides all advice and guidance on shade structures	
Regulations for farm structures	**NSW Planning Portal** Shade Structure and Guidance Notes
Plumbing in New South Wales	**NSW Fair Trading Plumbing Code**
Queensland	
Department of Housing and Public Works (HPW). HPW is a central resource for plumbing and construction in this state	
Regulations for farm structures	**Building farm structures** in Queensland
Plumbing in Queensland	**Queensland Plumbing Codes**
Tasmania	
Tasmania's Consumer, Building and Occupational Services (CBOS)	
Regulations for farm structures	**CBOS Sheds and Structures Fact Sheet**
Plumbing	**CBOS Technical Regulations**
South Australia	
SA's EPA is the regulatory body for farming structures	
Regulations	**EPA Shelter Regulations**
Western Australia	
The Department of Primary Industries and Regional Development is responsible for regulation shade structure constructions in WA	
Regulations	**A guide for construction and developments on land holdings** in Western Australia

FOR MORE INFORMATION

Sustainability aspects of Dairy Effluent Management can be found on the Dairying for Tomorrow website - **dairyingfortomorrow.com.au**

Sprinkler system design

Sprinkler nozzles

Sprinklers can be effective in boosting evaporative cooling. Their effectiveness will be lost when humidity is high and airflow is low.

Combined with good infrastructure to maintain airflow, the use of on-off timing to allow humidity to drop will maximise the effectiveness of sprinklers.

There are several sprinkler nozzle types that will adapt to your desired use, location, area and droplet size.

Type	Benefit	Limitation
Large irrigation sprinklers	Can wet a large area	High water use
Overhead wobbler sprinklers	Use less water	Do not throw water as far
Garden sprinklers	Use less water, also suitable for overhead use	Can be ineffective in windy conditions

Design tips

- Droplet size must be medium-large to allow water to penetrate the hair coat and wet the cow's skin
- Best position depends on type and capability of selected sprinkler and pumping system
- However, as a guide, sprinklers should be spaced at intervals of 1.5 to 2 times their wetted radius, so there is a slight overlap
- Sprinklers should be set at least 2m above the floor of the dairy yard.
- A roof over any area were sprinklers are used will minimise radiant heat and improve effectiveness. Concrete flooring will minimise mud build up and reduce pathogen loads.

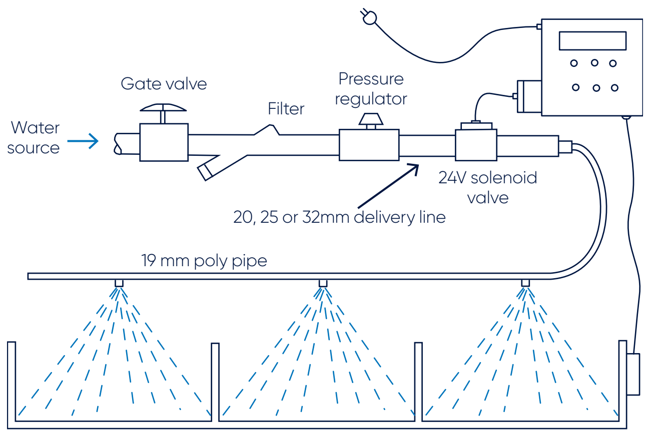
Pipes

Sizes must suit the length and area to be sprinkled, the number of sprinklers and their flow rates.

Shed length	Diameter of main delivery line
Up to 40m	20mm
40–60m	25mm
60–100m	32mm
More than 100m	2 x 50m runs of 20mm

Design tips

- PVC piping does not twist, but polyethylene (PE) is cheaper
- To maintain low water temperatures, all exposed pipe should be painted white and header tanks should also be shrouded, insulated and painted white
- There are also some newly developed paints that have reflective properties that are worth investigating.



Ideal state	Consideration
Water temperature	
Temperature range: 15–20°C	Providing cows with chilled water at the dairy to help reduce heat load may reduce water intake and therefore be counter-productive.
Temperature sensors: Automatic	If an automated system is installed, ensure you can manually override it if necessary.
Water quality	
Total dissolved solids (TDS): No more than 1000mg/L TDS	High dissolved solids used in reticulation systems are corrosive and dissolve concrete.
Water output rate: 0.5–1L/head/hr	Excess water use will create waste management issues.
	Design note: For more complex or larger installations it is necessary to properly design the system taking into account friction losses, flow rates and component selection
Pressure range	
Low pressure: 0.70kg/cm^2	Produces larger droplets, less mist and drift of spray.
Operating pressure: 14 to 20m (140–200 kPa)	A main pressure regulator can be installed at the beginning of the pipeline or smaller regulators on each sprinkler nozzle can be used.
	Design note: Large droplets penetrate the coat better. Smaller droplets can create an insulating layer of water on the cow's coat that can make the cow hotter instead of cooler. Droplets are required as opposed to mist.

Filters and rates	
Drip cooling system	
Filter: 80 micron Rate: 0.8L/second	Sand or dirt may clog the sprinkler nozzles, so a filter is required between the water supply and solenoid valves that control the water flow to the spray nozzles or drip outlets.
Spray cooling system	
Filter: 200 micron Rate: 1.6L/second	A common filter type is a plastic filter with a grooved disc filter element
Timers	A 15–minute adjustable type timer, attached to a remote control valve (solenoid) will enable you to apply sufficient water on cows while minimising wastage. Aim to sprinkle cows for one to three minutes, which should be enough to wet them effectively. Then shut off for the remainder of each 15–minute cycle to allow water to evaporate before the next cycle. A remote sensor can be used to shut off sprinklers and fans when ambient temperature falls below 26°C. This is especially important when high air movements exist as chilling can occur. Young stock are particularly susceptible.

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Dairy Australia

Dairy Australia Limited ABN 60 105 227 987
Level 3, HWT Tower
40 City Road, Southbank Vic 3006 Australia
T +61 3 9694 3777 F +61 3 9694 3701
E enquiries@dairyaustralia.com.au
dairyaustralia.com.au

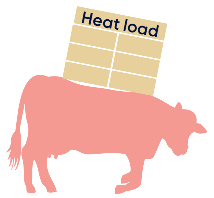
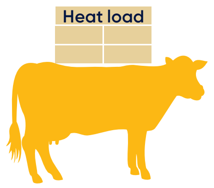
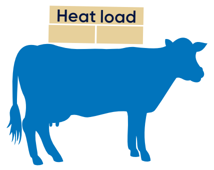
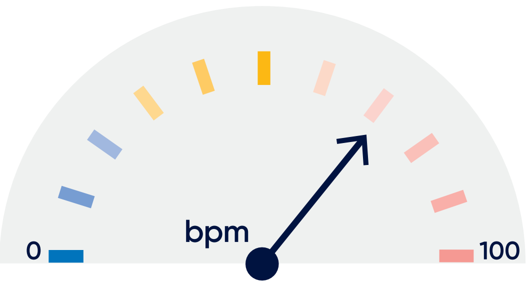
1899 | Sep 2019

Dairy Australia

OUR FARM'S COOL COW ACTION PLAN

Managing heat stress helps us maintain our summer milk production and maximise cow comfort.

We use Cool Cows' daily Temp. Humidity Index (THI) forecasts* to determine actions to help keep cows cool. We record our cows' breathing rate daily** to check these actions are helping cows manage their heat load.

Heat stress risk level	Actions	Who is responsible?	Notes
Severe (THI 82+) 			
High (THI 78) 			
Moderate (THI 75) 			
Low–mild (THI <75)			
	At 80+, cow heat load is severe At 70, cows are starting to struggle 40–60 breaths / minute is normal	* For daily max. THI forecasts for your local area, visit **coolcows.com.au** and click on **'Weather Forecaster'**. ** For a guide to counting your cows' average breathing rate, visit **coolcows.com.au** and click on **'Managing in the heat'**.	

Month: ______________________

Day of month	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
Max. THI																															
Breaths/minute																															
Acceptable ✓ / X																															

COOL COWS

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