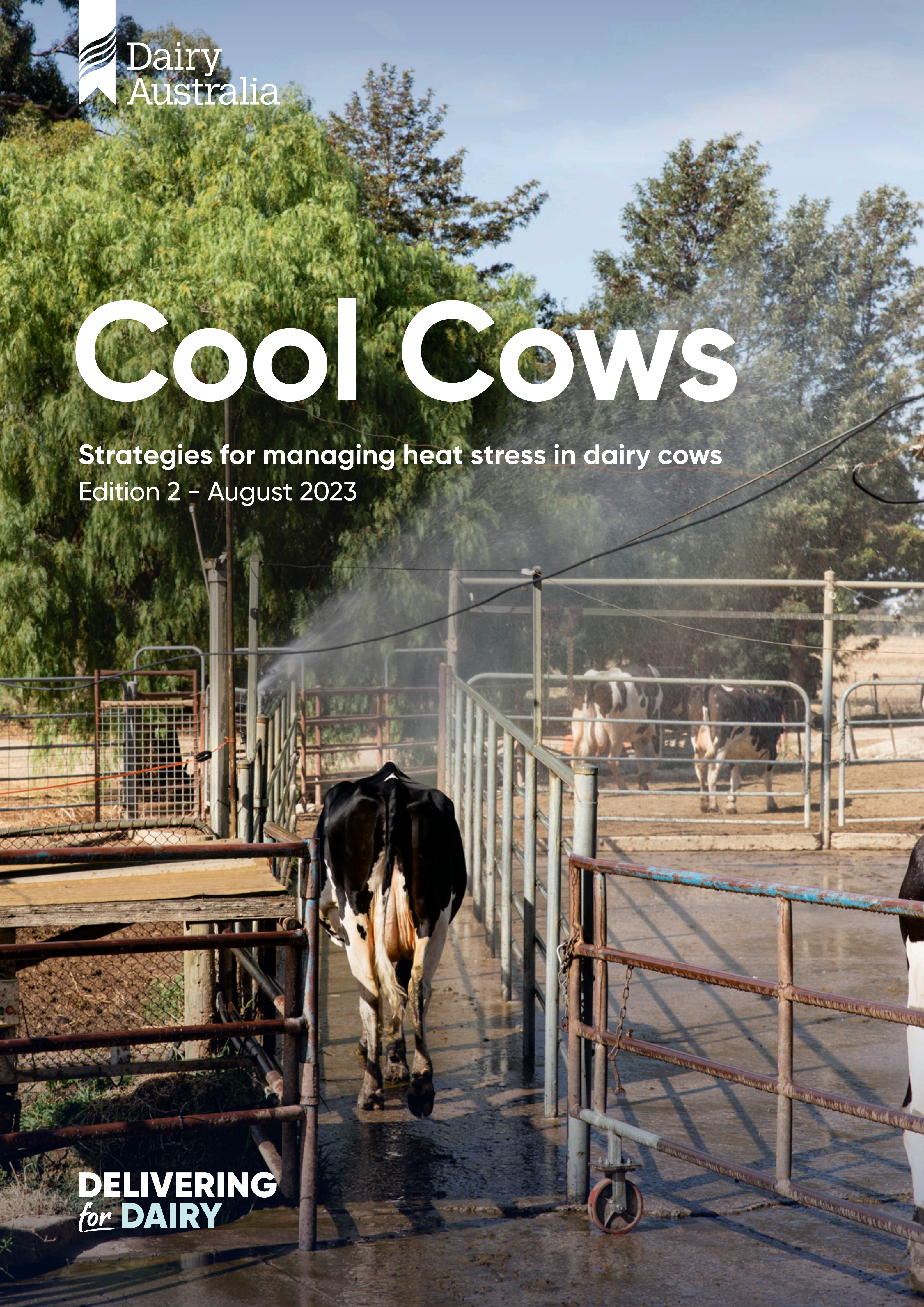
Dairy Australia

Cool Cows

Strategies for managing heat stress in dairy cows

Edition 2 - August 2023



DELIVERING *for* DAIRY

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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.

This newly updated 2023 edition includes new research from the Dairy Feedbase program into nutritional strategies to help keep cows cool, as well as updated information on the Heat Tolerance Australian Breeding Value from Datagene.

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. Install water troughs in all paddocks and along laneways
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. Use the Heat Tolerance ABV when selecting bulls to breed replacement heifers that are more tolerant to heat stress
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.


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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.

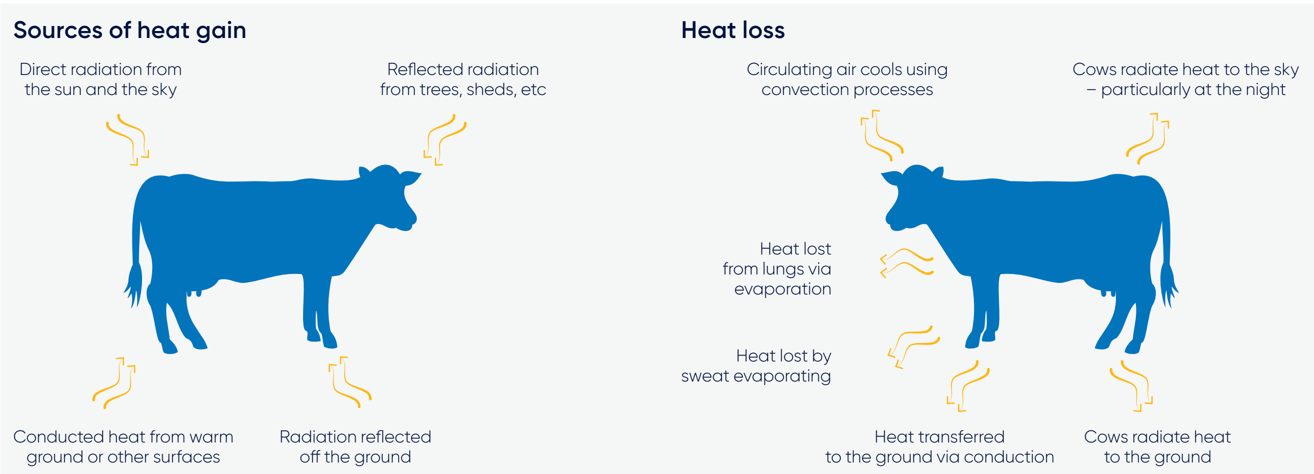
Awareness of the signs will inform your decision-making around the management and response to heat stressed cows.

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.

Figure 1 Sources of heat gain and heat loss in dairy cows



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.

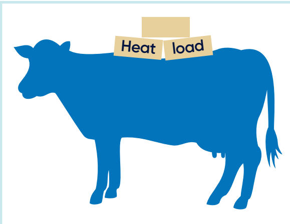
The cow must stay within the optimal range through thermo-regulation. This means balancing the metabolic and the absorbed environmental heat using a range of strategies, such as increased breathing rate and sweating.

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**

Figure 2 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

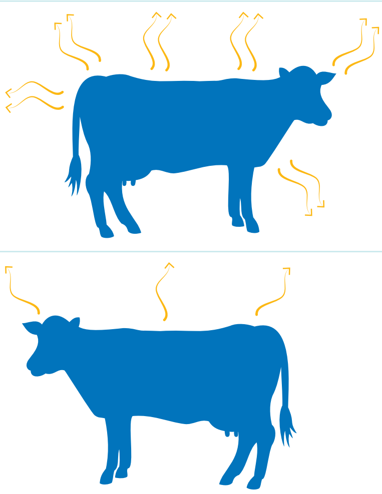
Understanding the heat exchange process can support your decision making around providing shade, water and cooling systems to keep cows cool.

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.

Figure 3 Difference in scale of evaporative losses in cows under conditions of low humidity at 30oC (top) and high humidity at 30°C (bottom)



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.

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

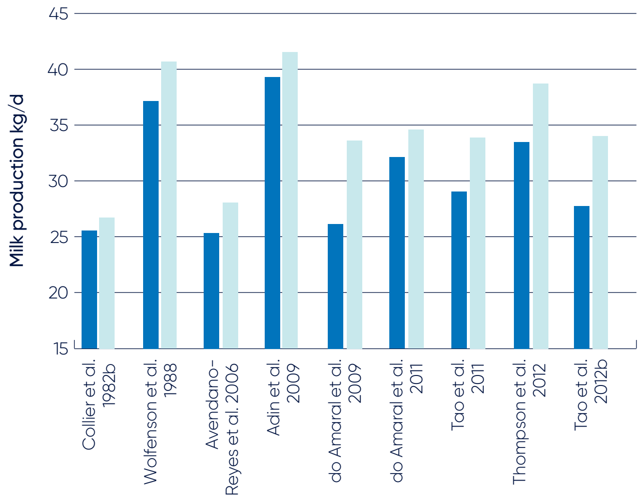
Dry cows generate less metabolic heat than lactating cows and have a higher upper critical temperature. This may contribute to the belief around heat stress being a lesser concern. However, studies consistently show that when cows experience heat stress during late pregnancy they produce less milk in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

Figure 4 Effect of heat stress and cooling during the dry period on milk production in the following lactation



Source: Tao and Dahl, 2013

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.

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 are energy intensive and responsible for reduced 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. Less saliva entering the rumen results in reduced rumen pH as there are less saliva bicarbonates added to buffer the rumens 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 they are in the dairy being offered high starch bail feed. Cows also tend to select against low quality forage/fibre if it is offered to them, increasing the risk of SARA. 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

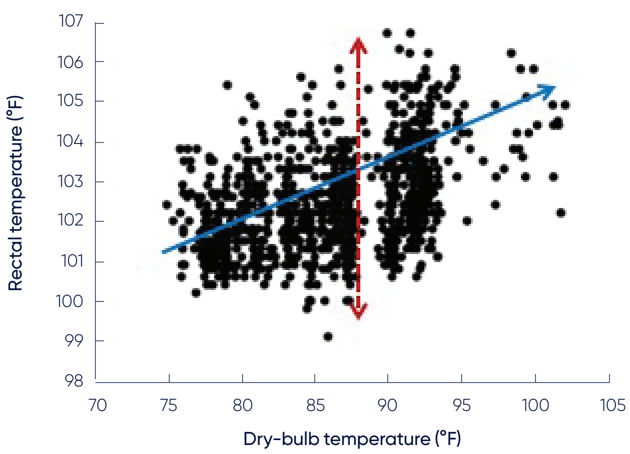
There are several other factors that affect the amount of metabolic heat a cow produces and how effectively she transfers heat to and from the external environment.

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.

Genetic selection for more heat tolerant cows

As the graph below shows, some cows are better at regulating their body temperatures than others (much the same as some cows are more efficient at converting feed into milk than other cows).

Figure 5 Body temperatures for 1,016 lactating dairy cows in Florida during the afternoon (3-5pm)



Note: As it gets hotter, cow rectal temperature tends to increase (see blue line). The rectal temperature of cows exposed to the same ambient temperature varies widely (see dotted red line).

Source: Hansen 2013

13 to 17 per cent of the variation in rectal temperature in cows during heat stress has been found by researchers to be due to genetic differences. This heritability (0.13 to 0.17) is lower than the heritability of milk yield (0.30), but is high enough to allow selection for lower rectal temperature under heat stress.

Breeding for more heat tolerant cows

One of the newest tools in the toolkit for Australian farmers managing and preventing heat stress is the Heat Tolerance Australian Breeding Value (ABV), developed by Datagene. It allows farmers to breed animals with greater ability to tolerate hot conditions with less impact on milk production. Within a herd, some cows demonstrate an increased tolerance for hot and humid conditions than others. Genomic technology (DNA testing) enables us to identify these animals.

The Heat Tolerance ABV is expressed as a percentage, with a base of 100. An animal with a Heat Tolerance ABV of 105 is 5% more tolerant to hot, humid conditions and her fall in milk production will be 5% less than the average of animals sired by that particular breed. By contrast, an animal with a Heat Tolerance ABV of 95 is 5% less tolerant to hot, humid conditions than average and her fall in milk production will be 5% more than average.

Heat tolerance is favourably linked with fertility and unfavourably with production. This means a strong focus on heat tolerant bulls and replacement heifers may improve gains in herd fertility but compromise gains in production. To combat this, farmers should select animals that are both high in the Balanced Performance Index (BPI) and Heat Tolerance ABV. Additionally, the reliability of the Heat Tolerance ABV is less than conventional production traits (i.e. milk production) but is in line with other genomic only traits. Work is being undertaken to improve the reliability of this trait through the collection and analysis of more data.

The Australian Heat Tolerance ABV is a world-leading trait and is one of a new generation of breeding values that are difficult to measure but made possible due to advances in genomic technology. Like all new ABVs, the reliability of the Heat Tolerance ABV will improve with time. However, in the meantime, if placing a high priority on selecting for heat tolerance, aim to use a larger team of high BPI, high Heat Tolerance ABV bulls to allow for lower reliability for heat tolerance. A combination of best-practice management, improved diets and genetic selection should halve the economic losses currently observed in the dairy industry from heat-affected cattle.

For more information visit the **DataGene Fact Sheet on Heat Tolerance ABV**.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Monitoring and early intervention strategies

Monitoring cows breathing rate

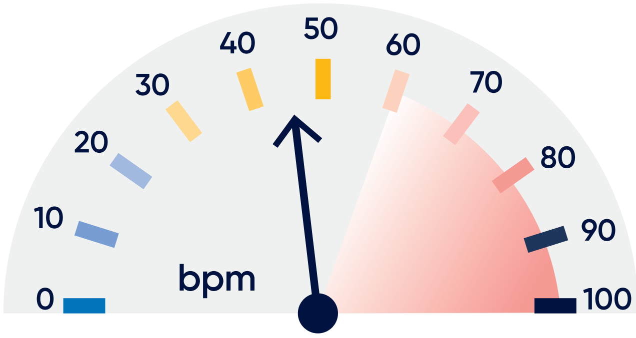
The most useful and practical way to determine how your cows are coping with conditions and managing their heat load is to check their breathing rate. An increased breathing rate is the first mechanism the cow uses to dissipate heat. It is the first outward sign of heat stress and often precedes an elevated 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.

Breathing rate in cattle

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!

Panting Score is a useful visual observation tool that can also be used to assess the respiration rate of the cows, in addition to breaths per minute. It is slightly easier to measure than breaths per minute and will still provide a good indication of whether a group of cows is under duress from heat stress conditions.

Panting score in cattle

Score	Description
0	Normal breathing
1	Respiratory rate increased slightly
2	Moderate panting and/or presence of small amount of drool or saliva
3	Saliva usually present, panting hard with mouth open
4	Severe panting with open mouth, protruding tongue, excessive drooling, and generally extended neck

Source: Based on Mader et al, 2006 – Journal of Animal Science.

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.

WHAT IS RELATIVE HUMIDITY?

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**) 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 6, 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.

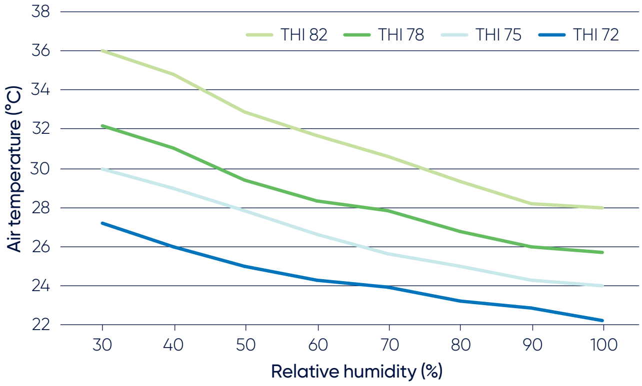
- You can see that for this location, conditions likely to result in periods of moderate heat stress occur commonly from November to March. However, periods of high heat stress do also occur, most often in January and early February. As early as mid-October and as late as March-April, herd milk production 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.

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

Based on Bohmanova et al 2007, Temperature Humidity Indices as Indicators of Milk Production Losses due to Heat Stress. J. Dairy Sci.

Figure 6 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 7 An example of an annual THI probability graph

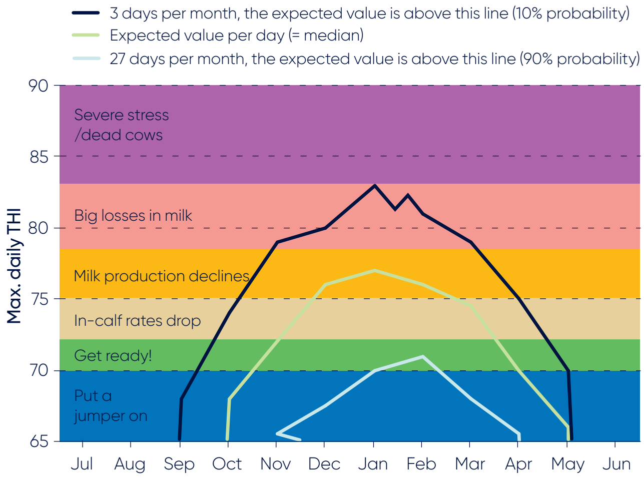


Figure 8 Matrix of THI's at varying combinations of Temperature and Relative Humidity

Temperature		Relative Humidity (%)																				
ºF	ºC	0	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100
75	24.0	66	66	67	67	68	68	68	69	69	70	70	71	71	72	72	73	74	74	74	75	75
76	24.5	66	67	67	68	68	69	69	70	70	71	71	72	72	73	73	74	75	75	75	76	76
77	25.0	67	67	68	68	69	69	70	70	71	71	72	72	73	73	74	74	76	75	76	76	77
78	25.5	67	68	68	69	69	70	70	71	71	72	73	73	74	74	75	75	77	76	77	77	77
79	26.0	67	68	69	69	70	70	71	71	72	73	73	74	74	75	76	76	78	77	78	78	79
80	26.5	69	69	69	70	70	71	72	72	73	73	74	75	75	76	76	77	78	78	79	79	80
81	27.0	68	69	70	70	71	72	72	73	73	74	75	75	76	77	77	78	79	79	80	80	81
82	28.0	69	69	70	71	71	72	73	73	74	75	75	76	77	77	78	79	80	80	81	81	82
83	28.5	69	70	71	71	72	73	73	74	75	75	76	77	78	78	79	80	81	81	82	82	83
84	29.0	70	70	71	72	73	73	74	75	75	76	77	78	78	79	80	80	82	82	83	83	84
85	29.5	70	71	72	72	73	74	75	75	76	77	78	78	79	80	81	81	82	83	83	84	85
86	30.0	71	71	72	73	74	74	75	76	77	78	78	79	80	81	81	82	83	84	83	85	86
87	30.5	71	72	73	73	74	75	76	77	77	78	79	80	81	81	82	83	84	85	84	86	87
88	31.0	72	72	73	74	75	76	76	77	78	79	80	81	81	82	83	84	85	86	85	87	88
89	31.5	72	73	74	75	75	76	77	78	79	80	80	81	82	83	84	85	86	86	86	89	89
90	32.0	72	73	74	75	76	77	78	79	79	80	81	82	83	84	85	86	86	87	87	89	90
91	33.0	73	74	75	76	76	77	78	79	80	81	82	83	84	85	86	86	87	88	88	90	91
92	33.5	73	74	75	76	77	78	79	80	81	82	83	84	85	85	86	87	88	89	90	91	92
93	34.0	74	75	76	77	78	79	80	80	81	82	83	85	85	86	87	88	89	90	90	92	93
94	34.5	74	75	76	77	78	79	80	81	82	83	84	86	86	87	88	89	90	91	91	93	94
95	35.0	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	92	94	95
96	35.5	75	76	77	78	79	80	81	82	83	85	86	87	88	89	90	91	92	93	93	95	96
97	36.0	76	77	78	79	80	81	82	83	84	85	86	87	88	89	91	92	93	94	94	96	97
98	36.5	76	77	78	80	80	82	83	83	85	86	87	88	89	90	91	92	93	94	95	97	98
99	37.0	76	78	79	80	81	82	83	84	85	87	88	89	90	91	92	93	94	95	95	98	99
100	38.0	77	78	79	81	82	83	84	85	86	87	88	90	91	92	93	94	95	96	96	99	100
101	38.5	77	79	80	81	82	83	84	86	87	88	89	90	92	93	94	95	96	98	98	100	101
102	39.0	78	79	80	82	83	84	85	86	87	89	90	91	92	94	95	96	97	98	99	101	102
103	39.5	78	79	81	82	83	84	86	87	88	89	91	92	93	94	96	97	98	99	100	102	103
104	40.0	79	80	81	83	84	85	86	88	89	90	91	93	94	95	96	98	99	100	101	103	104
105	40.5	80	80	82	83	84	86	87	88	89	91	92	93	95	96	97	99	100	101	102	104	105
106	41.0	80	81	82	84	85	87	88	89	90	91	93	94	95	97	98	99	101	102	103	105	106
107	41.5	80	81	83	84	85	87	88	89	91	92	94	95	96	98	99	100	102	103	104	106	107

Source: Adapted from University of Arizona

- No heat stress
- Mild heat stress
- Moderate heat stress
- Moderate severe heat stress
- Very severe heat stress
- Dead cattle

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'.

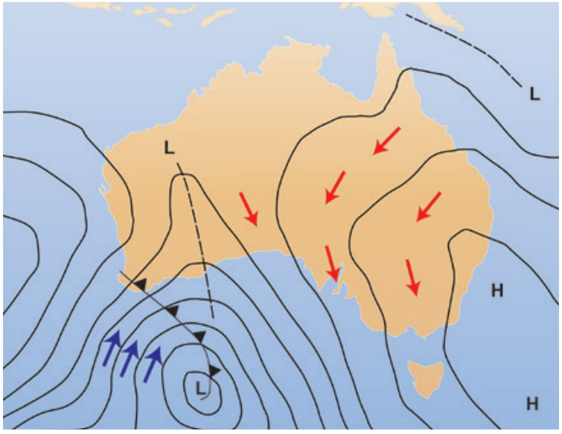
The high-pressure system remains nearly stationary for several days, with warm northerly winds continuing to flow across the affected regions.

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.

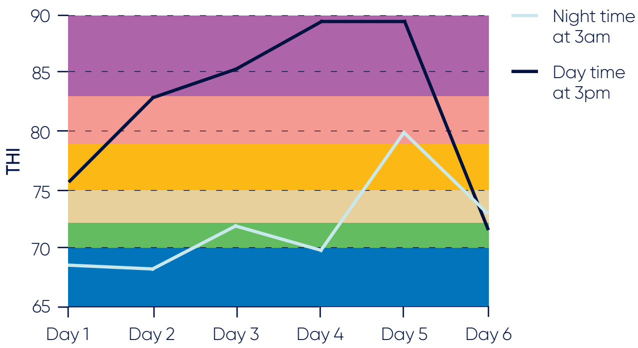
- **Area affected** most of southern Australia, particularly the south-east.
- **When** blocking highs can occur at any time of year, however temperatures only tend to reach the mid-30s and higher during the mid-late summer and early autumn period.
- **Duration** hot spells can last from a few days to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

Scenario 1



Source: BoM

Figure 9 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.

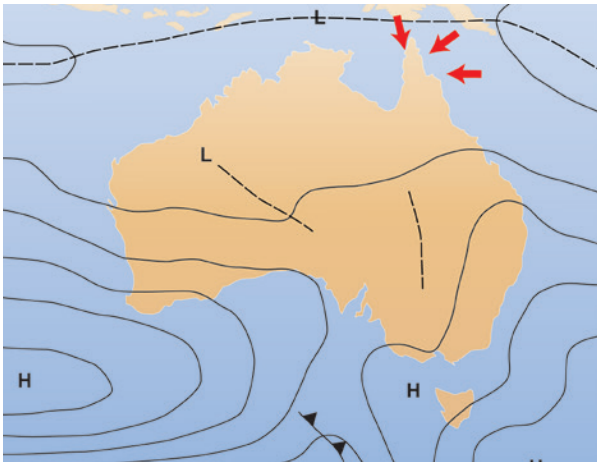
The temperature drops slightly while it is raining, however the storms are short in duration, and the temperature is quick to increase again once the storm has passed.

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.

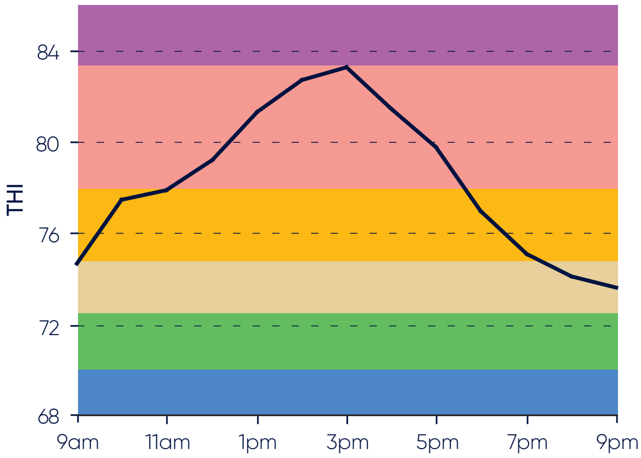
- **Area affected** Most of tropical northern Australia.
- **When** Wet season storms generally occur between October and April.
- **Duration** Storm events are short-lived, lasting a couple of hours at the most, however it may take several hours after a storm's passing for the increased humidity to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

Scenario 2



Source: BoM

Figure 10 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.

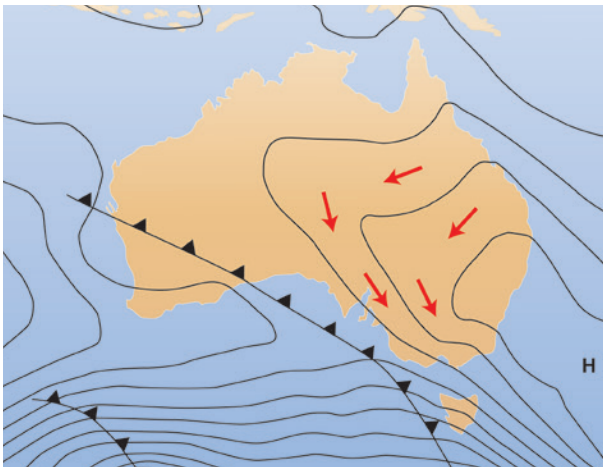
When this situation occurs during spring or early summer, it can lead to an early warm spell across southern Australia.

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.

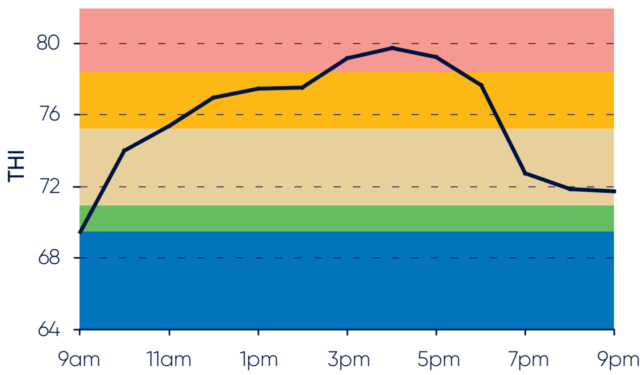
- **Area affected** Most of southern Australia, particularly the south-east.
- **When** Blocking highs can occur at any time of year, however early warm spells occur during spring and early summer.
- **Duration** Warm spells can last from between a few days to a few weeks (extreme end of the scale).

Scenario 3



Source: BoM

Figure 11 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.

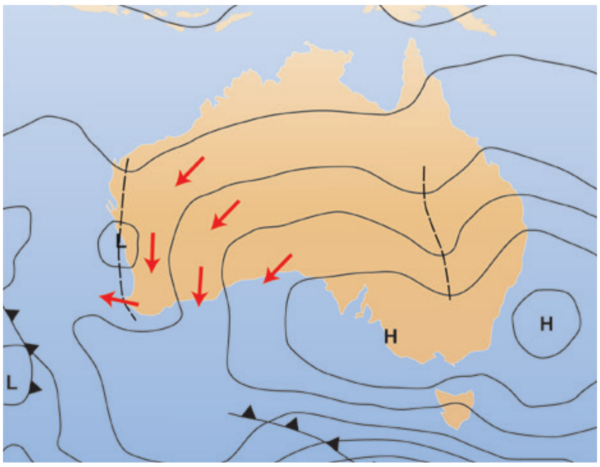
Initially, the trough tends to lie near the west coast of Australia and will remain there over a period of several days.

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.

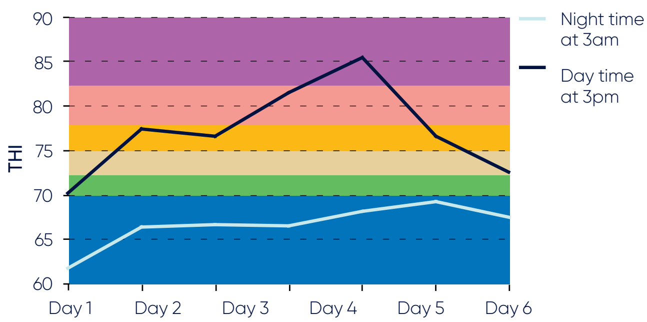
- **Area affected** South-western Australia.
- **When** West coast troughs occur during the warmer months, from mid-spring through to mid-autumn.
- **Duration** Each development cycle of the west coast trough lasts for a few days to a week.

Scenario 4



Source: BoM

Figure 12 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 during the hot season:

1. Delay afternoon milking until 5:00pm
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. Install water troughs in all paddocks and along laneways
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. Use the Heat Tolerance ABV when selecting bulls to breed replacement heifers that are more tolerant to heat stress
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

MORE INFORMATION

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

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 3:00pm) 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 10:00am on hot days. Have it done by 9:00am 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

The most important thing with your summer nutrition program when it comes to heat events is to provide a balanced diet which includes high quality forage fibre, adequate protein, slowly fermenting starch sources, fats, buffers and minerals. Compared to providing shade and keeping cows cool, the relative impact of nutritional interventions on heat stress outcomes is likely to be less impactful. However, there is still good evidence that certain nutritional strategies are beneficial during heat events in terms of maintaining rumen and metabolic function, which assists in reducing the negative impact of heat stress on Dry Matter Intake (DMI) and milk yield.

Fibre and protein for heat stress

With daily DMI generally reduced during periods of extreme heat where the Temperature Humidity Index (THI) is greater than 75, modulating the quality and amount of fibre (neutral detergent fibre or NDF) and protein in the diet can be beneficial for heat stress management.

Breakdown of fibre during warmer conditions

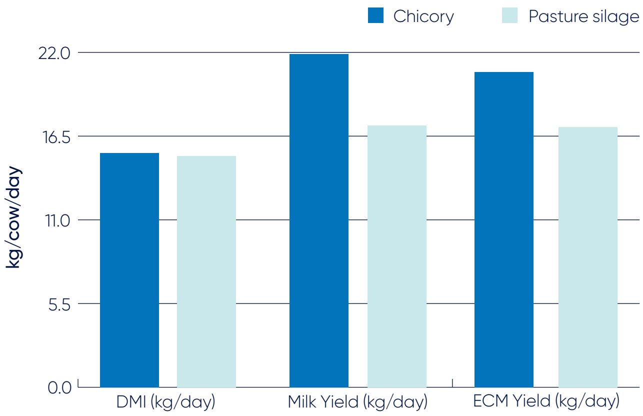
High quality forage (moderate-low NDF) will promote DMI, maintain rumen stability and in-crease nutrient density without producing excessive metabolic heat. By contrast, low-quality forage (high NDF) gives too much dietary bulk (limiting DMI), resulting in slower fermentation rates in the rumen and a greater amount of indigestible fibre passing through the rumen, there-fore making it difficult to achieve the daily nutrient intakes needed to sustain high milk production.

WHAT IS HIGH QUALITY FIBRE?

The amount of fibre, defined as Neutral Detergent fibre (NDF) in forages varies significantly. The quality of this NDF component is a function of the total amount of NDF in the forage, as well as the digestibility of that NDF. The lignin and Acid Detergent Fibre (ADF) components of the feed are both a part of the total NDF content in any given forage and provide an insight into the quality of the fibre in that feed. Forages with relatively high lignin and ADF components will have a lower NDF digestibility. In practice this means that a larger portion of the NDF is indigestible (lignin) or takes longer to digest (ADF). However, the absolute amount of NDF in a forage is also a major factor in assessing forage quality. For example, a forage with 40% NDF will generally be nutritionally superior to one with 60% NDF. Factors such as plant maturity, plant genetics and the growth environment all influence the amount and composition of NDF in a forage and can be hugely variable within the same species of forage, hence the importance of regular feed testing of forages to establish this.

An experiment as part of the DairyFeedbase Feeding Cool Cows project showed that providing a low NDF forage (fresh chicory; 34% NDF) resulted in lower body temperatures and greater milk production than cows fed a diet containing a higher NDF forage (pasture silage; 48% NDF). This is because less work is required from microbes in the rumen to break down a low fibre forage which means a lower amount of metabolic heat is produced during digestion in the rumen. This keeps the cows internal body temperature lower than cows fed a forage with comparatively high levels of NDF and helps the cow to maintain feed intake and milk production during periods of heat stress.

Figure 13 Effect of low (chicory) vs high (pasture silage) NDF forage on DMI and milk yield during a heat challenge



Even small increases in cow body temperature can have negative impacts that reach beyond the easily observed reduction in feed intake and milk yield, such as reduced immune function and fertility. Therefore, feeding cows a high-quality, low NDF forage during summer, and helping cows stay cooler from the inside, will not only improve summer milk yield, but may also have wider reaching benefits.

The target level of NDF in the total diet of lactating cows ranges from 28-34%. Use of a ration formulation software such as Rumen8 is useful to monitor the levels of specific nutrients in the total diet. The aim should be to provide a ration with a forage source that contains more digestible fibre and doesn't allow the overall dietary NDF level to exceed 34%.

Feeding of fibre sources to the herd during heat events

As with any supplementary feed, try to 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 if their access is restricted. Mixer wagons that allow for the feeding of fibre with other feeds in a partial mixed ration (PMR) can be a good option for controlling the level of fibre and forage in the total diet, if feeding infrastructure on the farm allows this strategy to be implemented. There are nutritional benefits to using a PMR in terms of allowing even and uniform chop length of supplementary fibre if it is supplied as part of a PMR. Another non-nutritional benefit of a PMR is that it can be fed under shade between the morning and after-noon milking and then cows can graze the best-quality pastures overnight when temperatures are cooler.

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 generally lower in crude protein than winter or early spring.

The target concentration of crude protein in a lactating dairy cow diet ranges from approximately 15-17 per cent and is higher in early lactation. Crude protein is however a basic measure and can be further classified into one of four fractions; rumen-degradable protein (RDP), rumen-undegradable protein (RUP), non-protein nitrogen (NPN) and indigestible dietary protein. The ratio of each of these four components varies significantly between feed sources and is a big factor in the efficiency of dietary protein utilisation, which depends on several factors including the availability of metabolizable energy in the rumen, the rate of passage though the rumen and the cows' level of DMI.

Feeding higher quality protein sources in the diet during the hot season can assist in mitigation against heat stress effects. Protein supplements such as canola meal contain greater levels of RUP (also called 'bypass' or 'escape' protein) than grazed pasture, and this RUP escapes digestion in the rumen and can be readily digested in the cows' small intestine, which can help offset lower yields of microbial protein from the rumen during hot weather. Increasing the proportion of RUP in the diet may also result in less metabolic heat being created though digestion in the rumen.

The aim should be to use cost-effective protein sources that support increased DMI and milk production, where practical, compared to the regular diet during heat events. Studies as part of the DairyFeedbase Feeding Cool Cows Project showed that adding protein supplements such as canola meal and lupins to a starch based grain mix resulted in milk production being maintained or even increased in some examples, when compared to diets containing starch-based grain only.

Supplementary protein such as canola meal does however have the effect of stimulating increased DMI - a positive outcome during a heat event - provided that body temperature does not become elevated due to more feed having to be digested in the rumen.

The Feeding Cool Cows program evaluated a number of protein concentrate sources and while canola meal and lupins had positive impacts on milk yield and DMI, whole cottonseed had a negative effect on total DMI and milk production during heat events and therefore is not likely to provide benefits during short-term heat events. This may have been due to the high levels of unsaturated fat present in whole cottonseed.

Fats and starches for heat stress

Higher producing cows and those under greater metabolic stress can respond well to this nutritional strategy. Supplementary fat sources like vegetable oil and commercial 'bypass fat' supplements are regularly used, while several starch sources can also be used as they differ in their rate of degradation and subsequent digestion in the rumen, which affects the intensity and duration of metabolic heat production.

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.

However, it is vital to ensure the correct amounts are introduced as too much dietary fat interferes with microbial digestion in the rumen and depresses feed intake. Depending on the ratio of saturated to unsaturated fatty acids in the diet, aim for a maximum of six to seven per cent total fat in the diet (DM basis). If higher levels of unsaturated fatty acids are present in the dietary components, then this threshold may be lower, around five percent of total DM. Excessive amounts of unsaturated fatty acids in the diet are likely to have a negative impact on DMI and milk fat concentration.

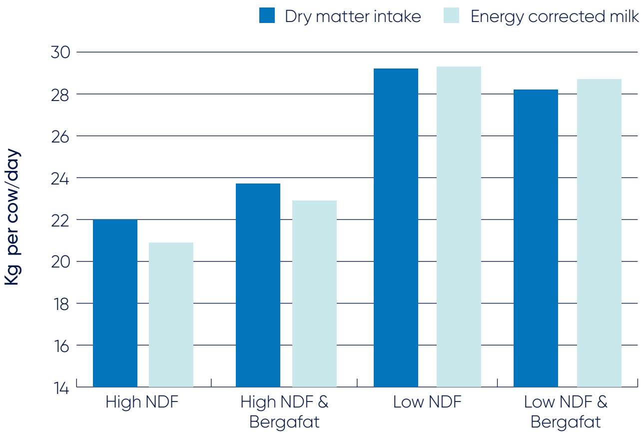
Type of fat is important

The DairyFeedbase Feeding Cool Cows project has demonstrated that environmental conditions will determine the type of fat supplement best suited to each farm.

Canola oil, a predominantly unsaturated fat supplement, was tested at a rate of 700g/cow per day in a heat challenge experiment and results showed it had a negative impact on the amount of dry matter consumed and produced a higher body temperature in cows, despite also increasing milk yield, compared to non-supplemented cows. It is therefore recommended that unsaturated fats only be used during short, sharp heat events (four days or shorter), meaning it is more likely to be a potential strategy in the more temperate southern regions like Gippsland and South-West Victoria, or Tasmania where there is a lower likelihood of extended periods of several consecutive days where the THI is greater than 75.

Saturated fat supplements, sometimes in the form of "protected fat" or "bypass fat" theoretically can increase the energy density of the diet and the total Metabolisable Energy (ME) intake in periods of heat stress without negatively affecting DMI or milk fat concentration. This is due to the inert nature of the fatty acids in the rumen meaning that the predominant site of digestion is post-ruminal. A commercial saturated fat supplement (Bergafat™; 300g/cow per day) was tested in the Feeding Cool Cows project at two different levels of intake using either high NDF or low NDF forage (vetch hay). Unlike other experiments, this one was conducted over a 40-day period in summer which included several hot days.

Figure 14 Effect of Bergafat (saturated fat) supplementation on intake and milk production using high and low NDF vetch hay



There was a dramatic difference in total DMI between high and low NDF vetch hay, and importantly the saturated fat supplement only improved DMI in the poor quality, high NDF forage. However, the use of Bergafat with good quality, low NDF forage did not improve DMI or milk yield. While this result was observed with one specific type of forage (vetch) it does suggest that saturated fat supplements such as Bergafat may have limited effectiveness during summer where high quality, low NDF forage is fed.

No negative impact of the saturated fat supplement was shown on body temperature however, which means that for farmers in regions where heat events are of greater duration and intensity, such as Northern Victoria or NSW/Queensland, use of saturated fats with higher NDF forage in summer can improve intake and milk yield and may be a profitable strategy.

Starches as a source of glucose

Heat stressed cows have a greater need for glucose, and starch is a good source of glucose or glucose precursors. Providing a form of starch that will slowly ferment in the rumen means that the cow has a steady supply of glucose. Research globally has repeatedly shown that corn (maize) is the most readily available, slow fermenting starch source of all the starch-based grains commonly used on Australian dairy farms (wheat, barley, triticale, sorghum grain, maize grain). The starch in wheat grain for example, is almost all degraded in the rumen while conversely in maize grain, the effective degradability of starch in the rumen at high passage rates has been shown to be approx. 70 per cent in previous work conducted at the Ellinbank SmartFarm (home of DairyFeedbase), meaning that a substantial portion is digested post-ruminally. In theory this should limit the intensity of metabolic heat production in the rumen, especially at relatively high rates of grain feeding. Earlier research at Ellinbank has also shown that replacing a portion of wheat with maize grain in high yielding cows fed more than 7kg DM of grain proved to be beneficial in terms of energy-corrected milk yield responses.

The Feeding Cool Cows project tested some of these starch-based grain options in cows subjected to a heat challenge and the results were inconclusive - effects observed appeared to be based on several different mechanisms. Cows were fed wheat, maize grain and barley in varying combinations to evaluate effects on milk yield, dry matter intake and body temperature. Results were inconsistent, with maize grain proving to be a more beneficial option in late lactation cows (220 days in milk), but in peak lactation (86 days in milk), cows consuming wheat produced more milk across the total experimental period than cows offered maize grain. How-ever, in both experiments, there was a greater decline in cows offered wheat than maize grain during the days where the THI was greater than 75 and cows were under the most intense period of heat stress in the experiment. Milk yield was also greater in this period in both late lactation and peak lactation cows in the maize grain treatment. This agrees with the consensus around slower fermenting starch sources such as maize grain being more beneficial to cows during period of heat stress.

Manure screening is a useful and easy way to monitor the efficiency of grain digestion during hot weather, or indeed during normal temperatures. The optimum grain particle size varies for different starch grains but if you are seeing large particles present in the dung, then efficacy of grain utilisation is poor and the grain needs to be crushed to a smaller particle size. If feeding maize grain, it generally should be crushed into finer particles than wheat for example to maximise its digestibility.

Feed additives for heat stress

Feed additives assist cows in hot conditions in many ways. However not all supplements have the same degree of effectiveness, and the cost of supplementation can make the benefits under certain conditions quite marginal. Consulting with your animal nutritionist is highly recommended when feeding additives to mitigate against heat stress.

Betaine

Betaine is an amino acid derivative that helps to maintain feed intake and reduce the amount of energy used to stay cool and continue normal metabolic processes. To ensure effectiveness, betaine needs to be fed for several weeks before hot weather commences and then continued to be fed while the weather remains hot. An effective method for using betaine will be to incorporate it into the summer diet regardless of temperature.

The Feeding Cool Cows project evaluated the impact of betaine on cows undergoing a period of heat stress. Results showed that feeding 16g of betaine per cow per day resulted in a modest improvement in milk yield per cow, which would equate to a benefit of $30 per cow extra profit across the entire 7-month period from September to March when simulated under typical Northern Victorian temperatures and humidity in that period.

Previous work in Australia by University of Melbourne scientists with grazing dairy cows (Dunshea et al 2019*) showed dietary betaine provided a significant milk yield increase of six per cent in summer (February/March) over cows not receiving betaine. Other studies from overseas in Total Mixed Ration (TMR) systems have also shown an increase in milk production in betaine supplemented cows under thermoneutral conditions while positive effects of betaine on cow reproductive outcomes have also been reported.

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.

Microminerals and vitamins

There is evidence in the scientific literature of a large number of commercial micromineral and vitamin supplements with potential to improve the cow's ability to cope with hot conditions. Some of the research suggests that these products could support the animal via increased intestinal integrity (ameliorate leaky gut), improved liver and immune function and superior energy metabolism under heat stress conditions. However, in some cases the research has been inconclusive, possibly due to the differential mechanism of absorption or action depending on level of rumen protection (eg. Niacin), organic (chelated) or inorganic form (eg., Selenium, Chromium, Zinc), feeding system (TMR vs grazing) and dose. Careful consideration and consultation with a nutrition advisor is recommended to choose a product that may be suitable for each system.

Yeast and yeast metabolites

This class of additive has been shown to promote feed intake in hot weather, increase fibre digestion and microbial yield and ultimately provide more energy yield per kilo of feed. All of these outcomes help offset the lower nutrient intake that occurs with low dry matter intake. In addition, data suggests that yeast and yeast metabolites can lower the impact of leaky gut and reduce partitioning of nutrients that would otherwise move away from milk and towards inflammation and potential health issues.

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, slightly higher than the 1.1 percent recommended in non-heat stressed conditions.

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. However, recent updates to the NASEM dairy feed recommendations** in 2021 (previously known as NRC 2001) indicate a normal sodium level of 0.25 percent DM in the total diet is adequate in both hot and normal weather conditions.

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

A nutritional advisor will have a solid knowledge about 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 rumen 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.

Buffers offset the acidity challenge that occurs commonly, where acid loads increase, the pH declines and microbe populations come under duress.

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 animal nutrition adviser for more specialised advice.

*Dunshea, Frank R., et al. "Betaine improves milk yield in grazing dairy cows supplemented with concentrates at high temperatures." Animals 9.2 (2019): 57.

**National Academies of Science, Engineering, and Medicine (NASEM) 8th Revised Edition of the Nutrient Requirements of Dairy Cattle. 2021.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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.

For more information about water and housing refer to Chapter 6 of the **National Guidelines for Dairy Feedpads and Contained Housing**.

KEY TO SUCCESS

ENSURE every paddock on the farm has water troughs for grazing dairy herds.

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.

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.

While sprinklers can be effective in boosting evaporative cooling, their effectiveness will be lost when humidity is high and airflow is low.

Dairy yard sprinklers

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 offload heat via evaporation with the assistance of fans.

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

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.

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

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.

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.

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.

REMEMBER

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

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

Paddock sprinklers

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. 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 cows will position themselves into the evaporative cooling zone and as the water evaporates, heat is offloaded from the cow to the surrounding environment. Paddock sprays and sprinklers will wet the cow's hair and skin in low humidity conditions and provide evaporative cooling.

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.

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.

Sprinkler system design

Sprinkler nozzles

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

Type	Benefit Limitation	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 coat hair 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 where sprinklers are used will minimise radiant heat and improve effectiveness. Concrete flooring will minimise mud build up and reduce pathogen loads.

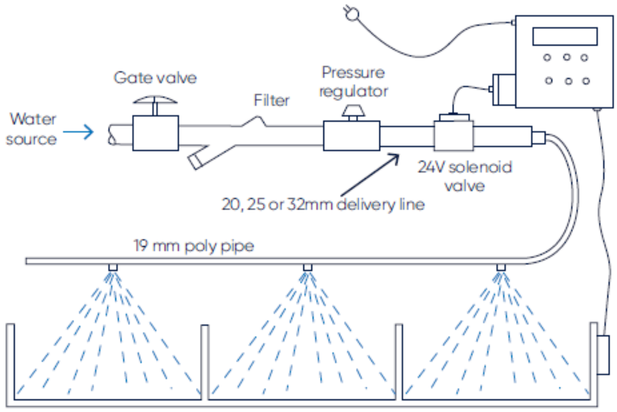
Pipes

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 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	**Consideration**
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.

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 (39°C).
- The cow is wet.

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.

Fan system design

Considerations need to be made 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.

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.

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.

Fan sizing, type and placement
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 m3/min with a 0.45 kW motor spaced every 6m • 1,300mm blade, 840 m3/min with a 1 kW motor spaced every 12m • The base of the fan blade should be at least 2.3m from the ground
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

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

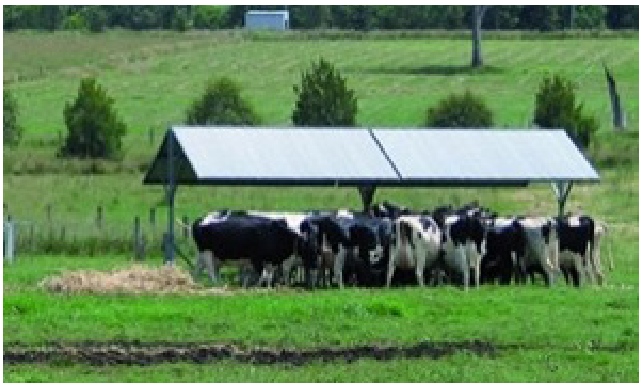
- Enables you to bring the shade to the cows, as opposed to cows to the shade.
- Best suited to smaller herds.
- Can be readily moved with animals, or moved to cleaner, drier locations close to feed and water when necessary.

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.

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 4m^2 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/**

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

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 tension to shade cloth prevents 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.

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 quicker 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.
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

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

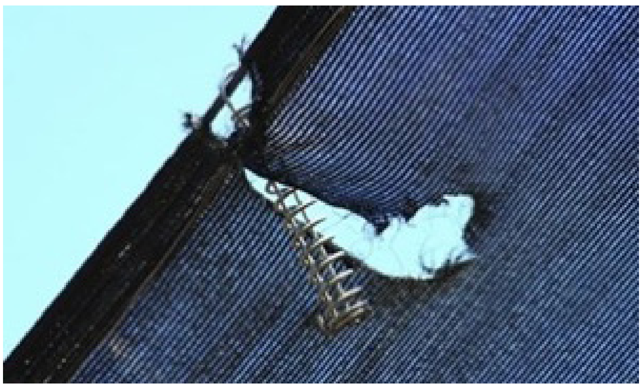
Prevent cloth damage by:

- 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.

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

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 cause 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.

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

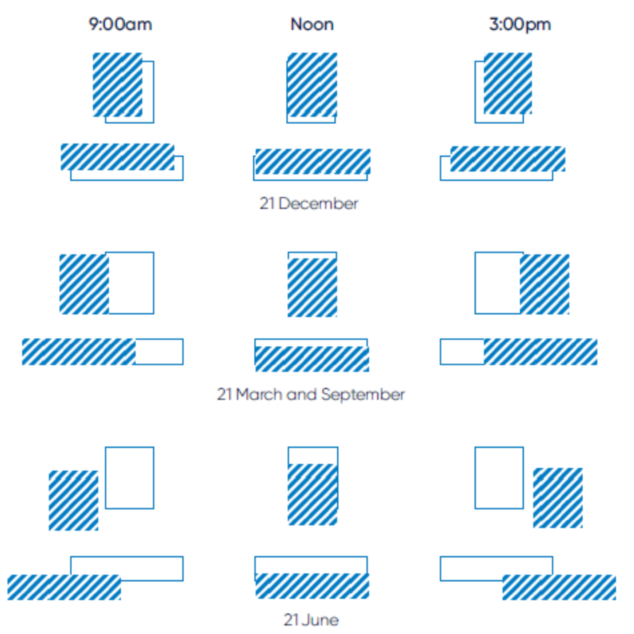
ADVANTAGES OF A SHADE CLOTH STRUCTURE OVER A SOLID-ROOFED SHADE STRUCTURE:
More than 50% cheaper than solid-roofed structures
Easy to remove if not needed in cooler months or during a storm (store it away from vermin)
Easy to upgrade and maintain in responses to farm's changing needs
If well made, the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

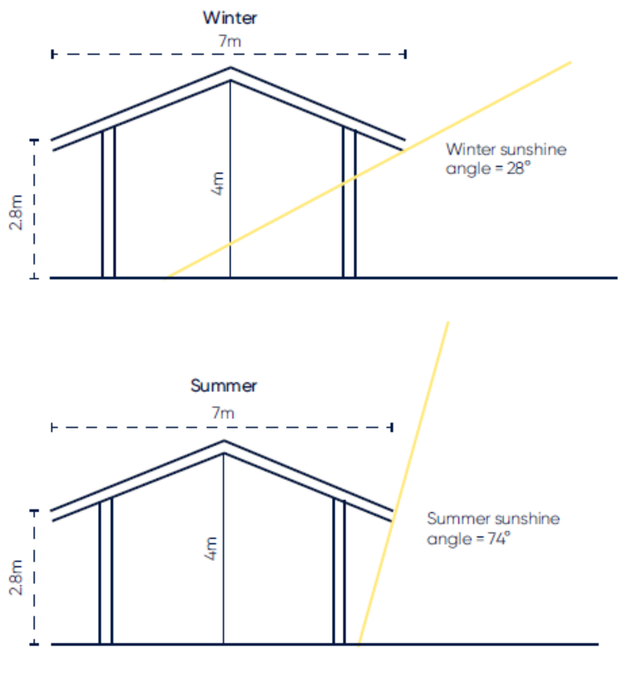
If concrete is too costly, the north-south orientation works best. It works well for a compacted clay or gravel floor because the sun strikes every part of the floor area under and on either side of the roof at some time during the day. This helps to keep the floored area dry and restricts pathogen build 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.

Figure 15 Shed profiles at 9:00am, midday and 3:00pm 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 sheds roof height and width, as below.




QUILOR
FARMS

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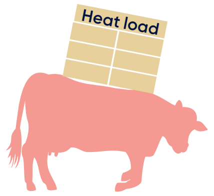
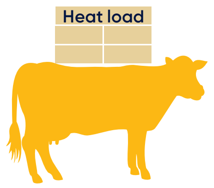
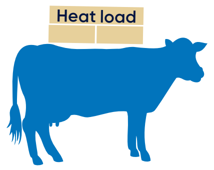
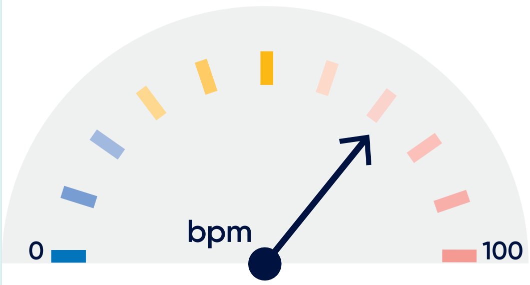
5510.1 | Oct 2023

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 a guide to counting your cows' average breathing rate, visit dairyaustralia.com.au	

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																															