Detecting and Abating Heat Load in Dairy Cows

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Summary

Heat stress is widely understood to be an important, practical challenge in dairy production. Two key aspects of managing this challenge on farm are discussed: detecting increased heat load and abating it before consequences occur. We focus on tools for use on farms, based on research and insights from the cows. We suggest that monitoring the responses of mature animals informs best management practices across all types of dairy systems.

Introduction

Heat stress is a challenge for both cows and producers. Many dairy farms are located in regions that regularly have warm weather conditions for several months of each year. In the summer or warm conditions, cows will accumulate heat load, and if they are unable to dissipate this heat, consequences include reduced milk production, impaired fertility, and in extreme cases, death (St-Pierre et al., 2003). In addition to these well-studied biological and financial implications, there is also evidence that the animals face other welfare challenges, including pain associated with higher rates of lameness in summer months (DeFrain et al., 2013), higher somatic cell counts, and impaired immune function. It is also possible that cattle experience breathlessness during periods of rapid breathing and panting (Mellor and Stafford, 2004), although this potential aspect has received little attention to date. Finally, there are also longer-term implications for other animals on the farm. Calves are affected when dams experience high heat load during gestation.

Heat stress results from an accumulation of heat load within the animal. An animal-centered approach to understanding heat stress provides insights specific to the management and conditions of each farm, in all types of dairy systems, regardless of how abatement is provided. Rather than an endpoint- is she heat stressed or not? - we find it useful to think about the progression of responses. The exact timing and thresholds for each response are often not known, but in general, cows try to dissipate heat by increasing respiration rate, sweating, seeking shade or other abatement, spending more time standing, eating less and drinking more (Table 1). If these responses are unsuccessful, then consequences set in: body temperature rises, often above fever thresholds, milk production is reduced and fertility is compromised. Often, the consequences, like a drop in bulk tank milk or pregnancy rates, tells the producer that a problem has already occurred. Cows were not able to stay cool. By focusing on the initial responses instead, we are able to prevent longer-term consequences for the producer and cows.

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Detecting Heat Load

Body temperature

Elevated body temperature is a clear sign that cattle are accumulating heat load. Monitoring tools, such as intra-vaginal or rumen-based loggers, can provide insights into "pinch points" for heat stress on a dairy. Loggers may be incorporated into regular monitoring systems on the farm, or a consultant or veterinarian may conduct a heat stress evaluation for the farm using this type of technology. Monitoring body temperature over several days in the summer provides valuable information and is justified for several reasons. First, measuring rectal temperature once or a few times per day does not capture what happens for a cow over a 24-h period (Tresoldi et al., 2019). We find that more frequent monitoring, at least every 2 hours, is required to capture a fuller picture. Secondly, using loggers to gather body temperature information allows us to collect data over days, even at night, when cows may be less likely to be observed by the producer or employees. This fuller picture from the body temperature loggers allows us to identify when cows accumulate heat load and tells us what and where abatement is needed. An example of 24-hour body temperature patterns from the UC Davis dairy are provided in Figure 1.

Examples of specific "pinch points" could include, but are not limited to:

- Body temperature rises when cows wait for milking, but not at other times, then investment in cooling in the crowd pen may be warranted,
- Cows are not cooling down overnight, then next step may be to examine cooling in the home pen, where the cows rest, and
- In pasture-based systems, the walk to or from the parlor could be identified as an area that needs attention, based on a rise in body temperature during this activity.

Temperature thresholds that define fever are as low as 102°F/38.9°C (Hillman et al., 2005) to as high as 104°F/40°C (Burfeind et al., 2012; Pohl et al., 2014), encompassing values within this range: 102.6°F/39.2°C, 102.9°F/39.4°C, 103.1°F/39.5°C, and 103.5°F/39.7°C (summarized by Tresoldi et al., 2019). These fever thresholds aid interpretation of data collected with loggers. It may be useful to look at if fever levels are reached, due to heat stress, and how many hours cows experience these levels of elevated body temperature.

Respiration rate and signs of panting

Increasing respiration rate is a flexible response cows use to reduce heat load. It can be measured by counting flank movements, that is, one full breath includes both the inward and outward motion. Various tools, including the free Thermal Aid app from University of Missouri (thermalnet.missouri.edu/ThermalAid) facilitate taking this information. We have found that we need to measure respiration rate every 90 min over the hottest part of the day to have a full picture of the heat load experienced by lactating dairy cows. Interpreting respiration rate is straightforward at the extremes. Thirty breaths/min is a cool cow; 100 breaths/min indicates she is hot. It is more difficult to interpret the values in between extremes. Information about when cows will choose to use heat abatement and when body temperature begins to rise inform our understanding of respiration rate: these changes occur between 50 and 80 breaths/min.

What is clear is once signs of panting are involved, cows are at the upper end of their attempts to cope and reduce heat load. Panting involves breathing with the mouth open. The tongue may or may not extend out of the mouth.

On California dairy farms, panting is seen at approximately 100 breaths/min (Tresoldi et al., 2016). Another component of panting is drool. We often see stringy drool before open-mouth panting begins. We think that it may be an indicator that cows are trying to cope and that it may be easier to measure than either respiration rate or body temperature. Current work at UC Davis is investigating the use of early signs of stringy drool as a measure of heat load in dairy cattle.

Environmental monitoring

To supplement an animal-centric approach, we can also measure aspects of the environment. Many recommendations about environmental monitoring focus on ambient air temperature, humidity, solar radiation (or black globe air temperature) and wind speed. The combination of these four measures (heat-load indices, HLI) or of air temperature and humidity (temperature-humidity indices, THI) are often referenced in literature about heat stress in dairy cattle. Authors often delineate clear thresholds using these metrics. The trend across the literature is that accumulated heat load begins to affect dairy cow behavior and production as soon as 71 to 73°F/22 to 23°C or THI of 65 to 68. The challenge with this type of environmental monitoring is that the key parameters (temperature, humidity, wind speed and solar radiation) are rarely all monitored on farm. This type of information about the environment is often available and useful in terms of predicting and preparing for heat-wave events in a given region. As technology becomes less expensive, it will become easier to incorporate these metrics into controllers for soakers, fans or other forms of cooling on individual dairy farms.

On farms, several other aspects of environmental monitoring are valuable to consider in an assessment of the dairy's heat stress management. Taking ground or bedding temperatures, with a point-and-shoot infrared gun or an infrared camera, can be useful. Bedding in freestalls with direct sun, for example, can get very hot and increase the "effective" stocking density of the pen in those hours by reducing the number of usable stalls or amount of usable space. Knowing this and raising the producer's awareness of this type of issue can inform how the beds are managed. In drylot dairy farms, we have found that the dirt surface, in full sun, can easily exceed 120°F/49°C. Unsurprisingly, cows in these systems spend less than 2 minutes out of the shade, likely because this unprotected environment is inhospitable (Tresoldi et al., 2017). Infrared images of cows before and after cooling can also be influential visual aids for understanding how well cooling strategies work.

Finally, as a consultant in these matters, it may be helpful to also evaluate how climate is taken into account for soakers or fan activation. If a person turns soakers on or off, discussions comparing the human vs. bovine thermal comfort zones (83 to 90°F/28 to 32°C for humans vs. 41 to 68°F/5 to 20°C) may be useful. By the time a human feels hot, a cow has already begun to accumulate heat and invest energy into dissipating it. Alternatively, if soakers or fans are controlled with a thermostat, it may be helpful to compare the microclimate of the controller location to where the cows are located. If the controller is located in a cooler corner of the barn, adjustments may need to be made to the activation temperature to match what the cows experience.

Abating Heat Load: What Cows Tell Us

Milk production and fertility: the problem has already occurred

When cows cannot dissipate heat load effectively, they produce less milk, their fertility is impaired and in extreme cases, they die. By the time these consequences are apparent, the problem has already occurred. This is costly for the dairy producer in several ways: the direct cost of the problems described above, as well as indirect costs associated with reduced feed intake and efficiency and possibly also in terms of higher levels of lameness or claw lesions seen in summer. Higher culling rates associated with low milk production, failure to become and remain pregnant and other health issues are also an indirect cost. The cows also pay a price. They rest less, because they spend more time standing, possibly to increase air flow around their body. It is possible that resting less plays a role in predisposing cows to the higher rates of lameness seen in summer. Lameness is painful. Reduced immune function and higher somatic cell counts are related to other painful conditions, like mastitis. Little is known about what cows experience while panting or with high respiration rates. We have documented that they will assume a statue-like, inactive position at higher respiration rates (Tresoldi et al., 2017), but it is unknown what cows experience during this time.

Water cooling and shade: when cows prevent the problem

If cows have a choice, they will prevent heat load accumulation. This has been well described for shade. More recently, in several studies where we gave cows control over cooling with water, they began to use either soakers or a cow shower, when their respiration rates were 50 to 60 breaths/min (Legrand et al., 2011; Chen et al., 2013). By doing this, cows prevented the rise in body temperature seen in their counterparts that did not have access to or control over their cooling. Similarly, we have begun to monitor when cows stand at the feedbunk, fitted with soakers, but do not eat. More than 80% of cows at the UC Davis dairy are eating when they are at the bunk overnight or in the early morning, but in mid-afternoon and evening, when ambient conditions are warmest, our cows only feed about 50% of the time they are at the bunk (Tresoldi et al., 2019). These findings bolster what we already knew about shade: cows will seek cooling with water too, especially when combined with shade. Taken together, all of this information indicates that cows have "heat load" intelligence. They will prevent buildup of heat if we give them the opportunity.

Conclusion

An animal-centered approach to heat stress assessment will work across dairy types and climatic conditions. By focusing on responses like respiration rate, panting, cow behavior and body temperatures, we can optimize heat abatement on farms. Consultants and veterinarians providing this type of value-added service will benefit cows and the producer's bottom line.

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Table 1. Responses to dissipate heat and consequences if heat load continues to accumulate in dairy cattle.

Cattle responses to dissipate heat	Consequences if heat load accumulates
Increase respiration rate, pant[1]	Body temperature rises above fever levels[1]
Sweat	Milk production drops
Seek shade or other abatement[1]	More lameness, claw lesions; higher SCC, impaired immune function
Spend more time standing up, less active	Impaired fertility
Drink water	Death
Eat less[1]	

[1]Promising measures to use in an animal-centered approach to heat stress management

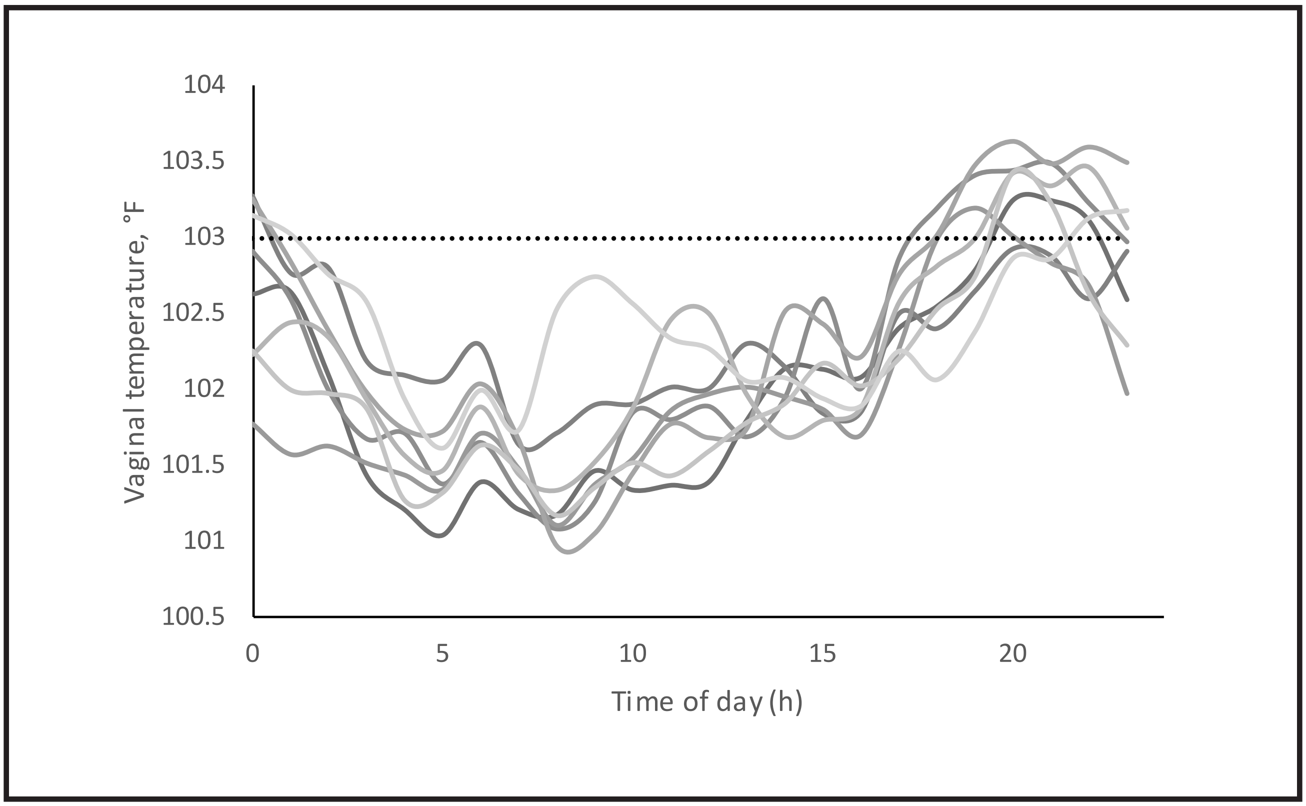

Figure 1. Vaginal temperatures (°F) for 8 cows over 24-hours on the UC Davis dairy. Each solid line represents an individual lactating cow. Several patterns can be seen in this graph. Cows cooled down by early morning and the effect of heat abatement (fans and water spray) while waiting to be milked (black arrow) is evident; all animals were milked at the same time. Depending on the fever threshold used, for example 103°F or the dashed line, some of these cows would be considered hot in the late afternoon or evening. Indeed, only some of the cows received adequate cooling in the evening because of experimental heat abatement treatments.