Environmental Stress in Dairy Cattle

Part 1: How a Cow Cools Herself

Under high heat and humidity conditions, cows struggle to dispose of metabolic heat as well as heat absorbed from their surroundings. If the cow is unable to dispose of enough heat, her core body temperature will rise. This rising body temperature, due to stressful environmental conditions, triggers a reduction in milk production, appetite, and overall health and an increase in respiration rate and sweating rate. Higher producing cows, which generate more body heat, are more susceptible.

Cows utilize all four modes of heat transfer to dispose of excess body heat: evaporation, convection, radiation, and conduction. The cow's physiological response to heat stress not only reduces her heat load but also enhances heat transfer to her environment, especially evaporative and convective heat transfer. Technologies to mitigate heat stress focus on enhancing one or more of these modes of heat transfer.

How cows lose heat

Cows lose body heat by all four modes of heat transfer as shown in Figure 1. Heat loss from respiration is due to evaporation and convection in the lungs. Heat-stressed cows increase their respiration rate to increase respiratory heat loss. Cows also lose heat via evaporation, convection, and radiation exchange with the surroundings. Convection and evaporation occur over the cows' whole body surface while standing and all areas exposed to the ambient air while lying. However, when cows are lying, their underside is not exposed to air currents so will not be cooled much by convection or evaporation but can be cooled by conduction to the resting surface. Sweating increases evaporative heat loss, and fans and sprinklers also increase convective and evaporative heat loss. Radiation exchange with the surroundings is proportional to the temperature difference between the cow and the closest surface, to the 4th power. Thus even when a cow is in a shaded portion of a barn, if the roof is hotter than her body temperature, she will absorb infrared radiation from the roof. This is a potentially overlooked mode of heat transfer (and is quantified by use of the black globe humidity

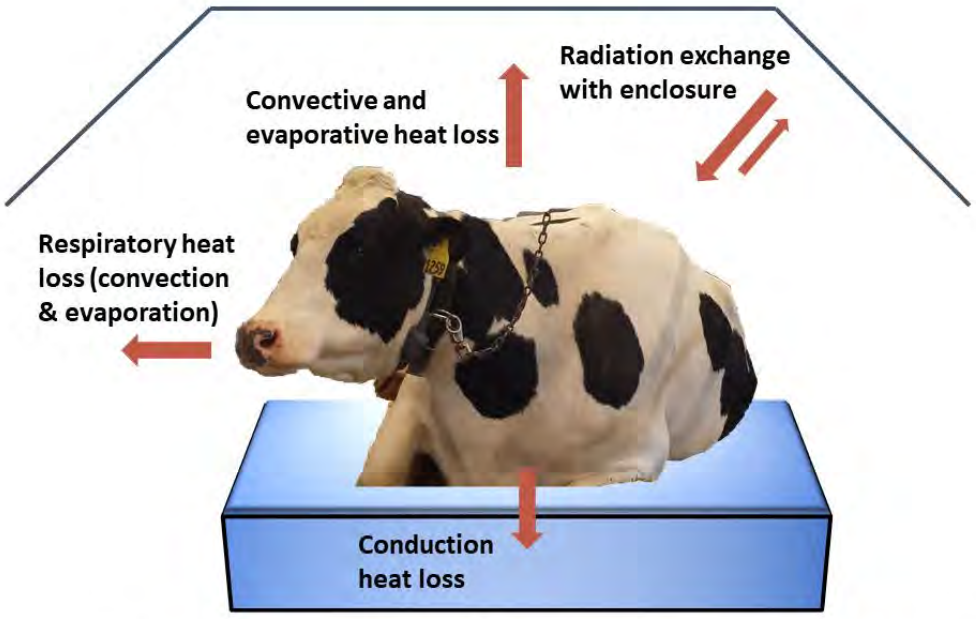

Figure 1. Different modes of heat transfer for cows housed in barns

index discussed in the Environmental Stress in Dairy Cattle factsheet, Part 2).

Relative breakdowns of heat loss

Depending on the environment, the cow will lose more heat or less heat via each of these modes of heat transfer. Various studies have estimated the amount of heat loss by different mechanisms. One study[1] that modeled heat loss from lactating dairy cows estimated that for a 1,230 lb cow whose metabolic heat generation was 1158 Watts, 23% of the cow's body energy could be lost by respiration and the rest would be lost by other mechanisms.

Technologies to enhance heat transfer

Cooling technologies enhance the cow's natural heat loss to provide more heat stress relief. How much cooling is needed is based on both the ambient environment and the individual cow's response. However, decisions on management of heat stress are typically made at the herd level, based on when pre-set environmental parameters are exceeded.

The most basic cooling technologies are provision of shade and fans. Shade is important to reduce the radiant heat load, and the majority of dairy cows are either housed in a barn or have access to shade. Fans enhance convective and evaporative cooling (due to the cow's own sweat) over the cow's body. Sprinklers enhance direct evaporative cooling. Sprinklers have larger water droplets to saturate the hair coat of the cow so that water is evaporated by the cow's body heat. Misters and foggers have finer water droplets that cool the ambient air and thus provide indirect evaporative cooling for the cows. Indirect evaporative cooling is effective in lower humidity conditions. Any cooling technology that cools the air should also increase respiratory heat loss due to convection and evaporation.

Intensively conductive cooling cows when they are lying in their stalls is a possible way to cool cows pending availability of a commercially available system. Sand bedding naturally provides some conductive cooling. Conductive cooling could be enhanced by pumping chilled water through a water-filled mattress or by chilling a surface underneath bedding. However, if a hard surface is used as a heat exchanger, the thick bedding needed to cushion the cow will insulate the cow from the cooling effect. For conductive cooling to be sustainable, the mattress/bedding system must provide acceptable comfort to the cows and preclude wear on cows' hocks while economically providing meaningful cooling.

FACT SHEET SERIES
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Part 1: How a Cow Cools Herself
Part 2: Ways to Quantify Environmental Stress
Part 3: Thresholds for Environmental Stress

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REFERENCES

[1] Gebremedhin, K. G., Wu, B., and Perano, K. (2016). Modeling conductive cooling for thermally stressed dairy cows. *J. Therm. Bio., 56, 91-99.* http://dx.doi.org/10.1016/j.jtherbio.2016.01.004

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