Environmental Stress in Dairy Cattle

Part 3: Thresholds for Environmental Heat Stress

Introduction

As air temperature and relative humidity (RH) of the air rise, dairy cows have trouble disposing of excess body heat. Ambient temperature and RH, air movement, and radiation in the environment are all factors in environmental stress (as discussed in the Environmental Stress in Dairy Cattle factsheet, Part 2). This factsheet focuses on the role of high temperature and RH in causing stress due to environmental conditions, which is referred to as heat stress here.

In challenging environments, core body temperature rises as the cow is unable to dissipate heat. The increase in core body temperature causes many adjustments in the cow's physiology including a decrease in milk production and feed consumption and, for early lactation cows, an increase in the cow's negative energy balance. Heat stress also has long-term effects of decreasing fertility and immune system function. Higher producing cows are generally affected more severely than lower producing cows, yearling heifers, or young calves. The negative effects of heat stress have motivated research into the thresholds for heat stress in dairy cattle. Heat stress is generally estimated by the temperature-humidity index (THI), which combines temperature and RH into a single value to describe heat stress. However, individual cows will respond differently to the same amount of heat stress so it is important to keep in mind that some cows may be stressed while others are not.

Thresholds for lactating cows

The **THI threshold of 68** is typically used for the beginning of heat stress for lactating, moderate-producing cows (77 lbs/day or more of milk). This would be, for example, 70°F with 60% RH. However, for THI 68 to affect cows' production, cows have to be exposed to these conditions for about 17 hours per day[1]. Other studies identified THI 72 as the threshold for heat stress, but that is now considered to be when more noticeable effects start, not the very beginning of heat stress[1].

Another important consideration is not just sustained conditions over THI 68 but also the maximum and minimum THI, and thus the chance the cows get to cool off at night as well as how stressed they are even for a shorter time in the afternoon. **A maximum THI of 76** (ex: 85°F with 40% RH) or **a minimum THI of 65** (ex: 67°F with 60% RH) will also cause noticeable effects of heat stress[1]. This is because regaining normal body temperature overnight is key for cows to cope with daytime heat stress, so a cool period at night of less than 70°F for 3 to 6 hrs helps cows maintain milk yield during heat stress[2,3].

The black globe humidity index (BGHI) uses black globe temperature (T_{BG}) rather than the dry bulb temperature (T_{DB}) used by THI. T_{BG} includes the warming effects of solar radiation as well as the cooling effects of air currents and thus is a more complete measure of the cows' thermal environment than T_{DB}. BGHI is especially important when cows are exposed to radiation (direct or indirect). However, since the majority of dairy cows are housed indoors and THI is easier to measure, more studies have examined thresholds for THI than thresholds for BGHI. However, one study that did examine BGHI heat stress thresholds found that a BGHI above 75 will cause heat stress for dairy cows[4].

If humidity data is not available, heat stress can be estimated from T_{BG} or T_{DB} only. In one study, T_{BG} above 77°F caused heat stress in lactating dairy cows[5]. In a different study considering T_{DB} instead of T_{BG}, noticeable signs of heat stress in lactating dairy cows started around T_{DB} of 83°F[6].

Thresholds for dry cows and calves

A recent study estimating the economics of cooling dry cows used the threshold of daily average THI = 68 to estimate when dry cows would begin to experience heat stress[7]. Although dry cows have less metabolic heat to dissipate, their endocrine systems may be more susceptible to heat stress than lactating cows[7]. Another study used heat stress thresholds of THI 70 for dairy cows, THI 72 for yearling heifers, and THI 77 for young heifer calves and quantified heat stress by subtracting the THI threshold for heat stress from the daily maximum THI in the environment the cattle were experiencing and using the difference to estimate the effects of the heat stress[8].

Categories of THI

As heat stress increases, cows' respiration rate (RR) and rectal temperature (RT) will increase. For dairy cows, normal RR is 26 – 50 breaths per minute and normal RT is 100.4 – 102.7°F[9]. Higher values of RR or RT are a sign of heat stress or sickness (unless the animal is exercising and thus temporarily has higher RR or RT). Table 1 shows temperatures (°F) and RH and the resulting values for THI as well as categorical estimates for how severe the heat stress is in each category[10]. However, cooling methods may help relieve heat stress without lowering the THI (see Part 2 of Environmental Stress in Dairy Cattle). Thus, if cows are being cooled, they may be less heat stressed than the table suggests.

Table 1. Temperatures (°F) and relative humidities and resulting THI

	Relative humidity (%)										
Temp (°F)	0	10	20	30	40	50	60	70	80	90	100
65	61.6	61.9	62.3	62.6	63.0	63.3	63.6	64.0	64.3	64.7	65.0
70	63.8	64.5	65.1	65.7	66.3	66.9	67.5	68.2	68.8	69.4	70.0
75	66.1	67.0	67.9	68.8	69.7	70.5	71.4	72.3	73.2	74.1	75.0
80	68.3	69.5	70.7	71.8	73.0	74.2	75.3	76.5	77.7	78.8	80.0
85	70.6	72.0	73.5	74.9	76.4	77.8	79.2	80.7	82.1	83.6	85.0
90	72.8	74.6	76.3	78.0	79.7	81.4	83.1	84.9	86.6	88.3	90.0
95	75.1	77.1	79.1	81.1	83.1	85.0	87.0	89.0	91.0	93.0	95.0
100	77.3	79.6	81.9	84.1	86.4	88.7	90.9	93.2	95.5	97.7	100.0
105	79.6	82.1	84.7	87.2	89.8	92.3	94.8	97.4	99.9	102.5	105.0
110	81.8	84.7	87.5	90.3	93.1	95.9	98.7	101.6	104.4	107.2	110.0

Mild discomfort: 68 ≤ THI < 72 | Discomfort: 72 ≤ THI < 75 | Alert: 75 ≤ THI < 79
Danger: 79 ≤ THI < 84 | Emergency: THI ≥ 84

FACT SHEET SERIES

Environmental Stress in Dairy Cattle

Part 1: How a cow cools herself
Part 1: Ways to quantify environmental stress
Part 2: Thresholds for environmental stress

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