Assessing Heat Stress in Dairy Cattle Using Respiration Rate

3 METHODS OF ASSESSING HEAT STRESS IN DAIRY CATTLE

1. Rectal temperatures, which cannot be routinely taken on a large number of loose-housed cows.
2. Temperature-Humidity Index (THI), which can require disturbing the cows to accurately measure.
3. Respiration rate (RR), which is accurate and more convenient to assess.

The heat-stressed dairy cow goes through many physiological, metabolic and behavioral changes to adapt[1] and in effort to reduce the environmental heat load, including:

- Lowering feed intake
- Reducing rumination
- Increasing standing time, lowering lying time and walking activity
- Seeking shade and increased air speed
- More sweating and increased respiration rate (RR)

The increase in RR can cause a shift in the acid-base chemistry of a cow's blood and compromise the saliva bicarbonate content.[2,3] These adaptive responses can have a negative effect on the physiological systems and milk yield.

ASSESSING HEAT STRESS

The Temperature-Humidity Index (THI) has been used for at least 50 years to assess the heat stress challenge in dairy cows.[3] The productivity level of dairy cows has increased over the decades due to advances in improvements in genetics, nutrition, housing and management. Correspondingly, the threshold THI for negative responses to heat stress has reduced.

In other words, higher performing cows generate a lot more of metabolic heat and feel heat stress much earlier than previously thought. The most recent THI recommendations for lactating dairy cows (Figure 1) show the new threshold at 68. At or above a THI of 68, cows have a reduction in milk yield and reproductive performance.[4]

In fact, research shows that as the THI increased above 68, lactating dairy cows have:

- Increased heart rates
- Higher skin temperatures
- Higher rectal temperatures
- Increased RR
- Reduced milk yield

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As little as 17 hours at above a THI of 68 could reduce daily milk yield per cow by -4.9 lb (-2.2 kg).[4,5,6]

Figure 1: Temperature-Humidity Index for Lactating Dairy Cows[7]

Temperature		% Relative Humidity																					
°F	°C	0	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100
72	22.0	64	65	65	65	66	66	67	67	67	68	68	69	69	69	70	70	70	71	71	72	72
73	23.0	65	65	66	66	66	67	67	68	68	68	69	69	70	70	71	71	71	72	72	73	73
74	23.5	65	66	66	67	67	67	68	68	69	69	70	70	70	71	71	72	72	73	73	74	74
75	24.0	66	66	67	67	68	68	68	69	69	70	70	71	71	72	72	73	73	74	74	75	75
76	24.5	66	67	67	68	68	69	69	70	70	71	71	72	72	73	73	74	74	75	75	76	76
77	25.0	67	67	68	68	69	69	70	70	71	71	72	72	73	73	74	74	75	75	76	76	77
78	25.5	67	68	68	69	69	70	70	71	71	72	73	73	74	74	75	75	76	76	77	77	78
79	26.0	67	68	69	69	70	70	71	71	72	73	73	74	74	75	76	76	77	77	78	78	79
80	26.5	68	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	78	79	80	80	81
82	28.0	69	69	70	71	71	72	73	73	74	75	75	76	77	77	78	79	79	80	81	81	82
83	28.5	69	70	71	71	72	73	73	74	75	75	76	77	78	78	79	80	80	81	82	82	83
84	29.0	70	70	71	72	73	73	74	75	75	76	77	78	78	79	80	80	81	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	84	84	85
86	30.0	71	71	72	73	74	74	75	76	77	78	78	79	80	81	81	82	83	84	84	85	86
87	30.5	71	72	73	73	74	75	76	77	77	78	79	80	81	81	82	83	84	85	85	86	87
88	31.0	72	72	73	74	75	76	76	77	78	79	80	81	81	82	83	84	85	86	86	87	88
89	31.5	72	73	74	75	75	76	77	78	79	80	80	81	82	83	84	85	86	86	87	88	89
90	32.0	72	73	74	75	76	77	78	79	79	80	81	82	83	84	85	86	86	87	88	89	90
91	33.0	73	74	75	76	76	77	78	79	80	81	82	83	84	85	86	86	87	88	89	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	91	92	93
94	34.5	74	75	76	77	78	79	80	81	82	83	84	86	86	87	88	89	90	91	92	93	94
95	35.0	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95
96	35.5	75	76	77	78	79	80	81	82	83	85	86	87	88	89	90	91	92	93	94	95	96
97	36.0	76	77	78	79	80	81	82	83	84	85	86	87	88	89	91	92	93	94	95	96	97
98	36.5	76	77	78	80	80	82	83	83	85	86	87	88	89	90	91	92	93	94	95	96	98
99	37.0	76	78	79	80	81	82	83	84	85	87	88	89	90	91	92	93	94	95	96	98	99
100	38.0	77	78	79	81	82	83	84	85	86	87	88	90	91	92	93	94	95	96	98	99	100
101	38.5	77	79	80	81	82	83	84	86	87	88	89	90	92	93	94	95	96	98	99	100	101
102	39.0	78	79	80	82	83	84	85	86	87	89	90	91	92	94	95	96	97	98	100	101	102
103	39.5	78	79	81	82	83	84	86	87	88	89	91	92	93	94	96	97	98	99	101	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	79	80	82	83	84	86	87	88	89	91	92	93	95	96	97	99	100	101	102	103	105
106	41.0	80	81	82	84	85	87	88	89	90	91	93	94	95	97	98	99	101	102	103	104	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
108	42.0	81	82	83	85	86	88	89	90	92	93	94	96	97	98	100	101	103	104	105	107	108
109	43.0	81	82	84	85	87	89	89	91	92	94	95	96	98	99	101	102	103	105	106	108	109
110	43.5	81	83	84	86	87	89	90	91	93	94	96	97	99	100	101	103	104	106	107	109	110
111	44.0	82	83	85	86	88	90	91	92	94	95	96	98	99	101	102	104	105	107	108	110	111
112	44.5	82	84	85	87	88	90	91	93	94	96	97	99	100	102	103	105	106	108	109	111	112
113	45.0	83	84	86	87	89	91	92	93	95	96	98	99	101	102	104	105	107	108	110	111	113
114	45.5	83	85	86	88	89	92	92	94	96	97	99	100	102	103	105	106	108	109	111	112	114
115	46.0	84	85	87	88	90	92	93	95	96	98	99	101	102	104	106	107	109	110	112	113	115
116	46.5	84	86	87	89	90	93	94	95	97	98	100	102	103	105	106	108	110	111	113	114	116
117	47.0	85	86	88	89	91	93	94	96	98	99	101	102	104	106	107	109	111	112	114	115	117
118	48.0	85	87	88	90	92	94	95	97	98	100	102	103	105	106	108	110	111	113	115	116	118
119	48.5	85	87	89	90	92	94	96	87	99	101	102	104	106	107	109	111	112	114	116	117	119
120	49.0	86	88	89	91	93	95	96	98	100	101	103	105	106	108	110	111	113	115	117	118	120

- **Stress Threshold** Respiration rate exceeds 60 BPM. Milk yield losses begin. Repro losses detectable. Rectal temperature exceeds 38.5°C (101.3°F)
- **Mild-Moderate Stress** Respiration rate exceeds 75 BPM. Rectal temperature exceeds 38°C (102.2°F)
- **Moderate-Severe Stress** Respiration rate exceeds 85 BPM. Rectal temperature exceeds 40°C (104°F)
- **Severe Stress** Respiration rate 120-140 BPM. Rectal temperature exceeds 41°C (106°F)

ASSESSING THE COW

Producers have looked for a way to easily detect and evaluate heat stress within the animal. Some of the most common ways to make this cow-side evaluation would be through rectal temperature, THI of cows in the pen or building and RR.

With loose-housed cows, it is not easy to routinely measure rectal temperatures. Similarly, it is not always convenient to measure THI where the cows are located, without disturbing the animal's normal behaviors. One convenient and non-invasive approach is to use RR, which can be closely related to the THI and heat stress exposure.

RESPIRATION RATE

A normal range for RR in an unstressed dairy cow is 25 to 50 breaths per minute (Figure 2).[8] Published data has shown a strong correlation of increased RR, elevated THI and heat stress in dairy cows.[4] Once a cow's RR gets above 60 breaths per minute, the THI is above 68. This indicates the cow is stressed (Figure 3). Figure 4 indicates that as THI increases, milk yield deceases. Therefore, using RR as a metric for THI and corresponding heat stress exposure, as RR increases then milk yield is lowered.[5]

Figure 2: Resting Respiratory Rates[8]

Species	Breaths/min (range)
Cat	16-40
Dairy cow	26-50
Dog	18-34
Horse	10-14
Pig	32-58
Sheep	16-34

Figure 3: Effects of increasing Temperature-Humidity Index on respiration rate based on hourly arithmetic means from the data set of lactating Holstein cows.[5]

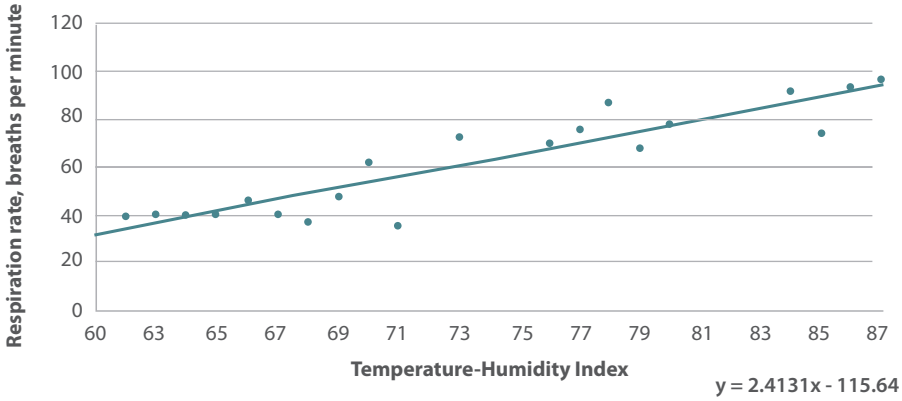
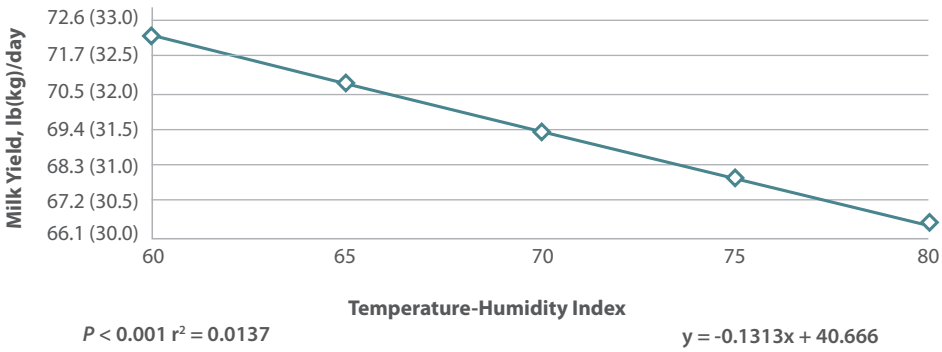


Figure 4: Effect of increasing Temperature-Humidity Index on milk yield in lactating Holstein cows.[5]



SUMMARY

The increasing sensitivity of cattle to heat stress has made finding an accurate and easy method for routine assessment necessary. Research has proven RR is a suitable technique for determining heat stress exposure and as a way to evaluate heat abatement strategies within an operation. Using a threshold of 60 breaths per minute, producers can better understand when heat stress may be negatively affecting milk production and take steps to avoid losses.

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