What is Heat Stress?
- A situation in which high environmental temperature and humidity result in the body's inability to cool itself
- Thermoneutral zone is the environmental temperature range in which the cow does not expend energy to maintain normal body temperature
  - Lower critical temperature: Cold stress
  - Upper critical temperature: Heat stress

Response to Heat Stress
- Increased body temperature (>39.5 °C)
- Increased respiration rate (>80 bpm)
- Drooling – loss of buffer, electrolytes
- Increased water intake
- Reduced activity – less time lying down
- Reduced blood flow to internal organs, udder

Heat Stress: Feed Intake/Digestion
- Increases rumen retention time: greater fermentability of feeds
- Reduced rumen contractions
- Reduced rumen buffering
  - due to saliva losses
  - Decreased rumination
- Increased feed sorting
- Increased feed refusals
- Reduced dry matter intake
Ruminal pH Response to Heat Stress

Cool = 18.3°C (65°F), Hot = 29.4°C (85°F)
HR = high roughage, HG = high grain

Mishra, et al. 1970

Heat Stress: Health Effects
- Suppressed immune function
- Increased mastitis incidence
- Increased retained placenta
- Increased metritis
- Increased metabolic disorders (Ketosis, Displaced abomasum, Lameness)
- Elevated ketones at calving
- Higher NEFA levels at calving
- Effects seen in both dry and lactating cows

Heat Stress Comparisons

<table>
<thead>
<tr>
<th>Analyte</th>
<th>Early Dry</th>
<th>Close-up Dry</th>
<th>Fresh</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>NEFA (mmol/L)</td>
<td>0.306</td>
<td>0.382</td>
<td>0.538</td>
<td>&lt;.0001 &lt;.0001</td>
</tr>
<tr>
<td>BHB (mmol/L)</td>
<td>0.540</td>
<td>0.551</td>
<td>0.620</td>
<td>.0049 .088</td>
</tr>
<tr>
<td>AST (IU/L)</td>
<td>84.0</td>
<td>93.7</td>
<td>105.5</td>
<td>.77</td>
</tr>
<tr>
<td>Albumin (g/L)</td>
<td>35.7</td>
<td>37.9</td>
<td>39.5</td>
<td>.0005</td>
</tr>
<tr>
<td>Calcium</td>
<td>3.13</td>
<td>3.12</td>
<td>3.07</td>
<td>.38</td>
</tr>
<tr>
<td>Phosphorus</td>
<td>1.88</td>
<td>1.81</td>
<td>1.76</td>
<td>.927</td>
</tr>
<tr>
<td>Potassium</td>
<td>4.38</td>
<td>4.37</td>
<td>4.40</td>
<td>.0044</td>
</tr>
<tr>
<td>Chloride</td>
<td>102.3</td>
<td>103.7</td>
<td>105.5</td>
<td>.0042</td>
</tr>
<tr>
<td>Glucose</td>
<td>3.52</td>
<td>3.03</td>
<td>2.94</td>
<td>&lt;.0001</td>
</tr>
<tr>
<td>Cholesterol</td>
<td>3.49</td>
<td>2.68</td>
<td>2.18</td>
<td>.0004</td>
</tr>
</tbody>
</table>

1 Analyte measures in mmol/L unless otherwise indicated
2 NEFA, Chloride, BHB, AST had Period x Health interaction (P=.025; .037)

Heat Stress Effects
- Greater number of significant metabolic changes than other periparturient diseases
- Elevated blood concentrations:
  - NEFA, Chloride – dry, prefresh, fresh
  - BHB, AST – fresh cows only
- Decreased blood concentrations:
  - Glucose, Cholesterol, Albumin
  - Calcium, Phosphorus, Potassium
- Across all groups – dry, prefresh, fresh

Heat Stress: Reproductive Effects
- Reduced estrus activity and duration
- Altered follicular development and growth
- Impaired oocyte quality
- Reduced semen quality/bull fertility
- Reduced conception risk
- Lower pregnancy rate
- Increased risk for multiple ovulation resulting in twinning

Heat Stress – Fertilization Rates

Sartori et al., 2002, 2010
Reproduction: Early Embryonic Effects

From Bailey et al., Consequences of Heat Stress, Elanco Dairy Business

Heat Stress: Pregnancy Effects

- Decreased uterine blood flow
- Reduced placental mass
- Reduced fetal tissue growth
- Reduced mammary tissue growth
- Early calving
- Light, weak or dead calves
- Lower colostrum quality

Heat Stress: Productive Consequences

- Reduced dry matter intake (>10 – 15%)
- Reduced yields of milk (10 – 20% or more)
- Decreased fat and protein content in milk
- Reduced growth rates
- Decreased reproductive performance
- Increased incidence of health disorders, particularly retained placenta, metritis, and lameness

Heat Stress: Productive Effects

Temperature effects on DMI, water intake and energy needs.

<table>
<thead>
<tr>
<th>Temperature °F</th>
<th>% of Maintenance required at 50°F</th>
<th>DMI (lbs/day)</th>
<th>Expected DMI (lbs/day)</th>
<th>Water Intake (gal/day)</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>151</td>
<td>47</td>
<td>45</td>
<td>14</td>
</tr>
<tr>
<td>32</td>
<td>110</td>
<td>47</td>
<td>41</td>
<td>17</td>
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<td>68</td>
<td>100</td>
<td>40</td>
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<td>18</td>
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<tr>
<td>86</td>
<td>111</td>
<td>42</td>
<td>37</td>
<td>21</td>
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<tr>
<td>95</td>
<td>120</td>
<td>43</td>
<td>37</td>
<td>32</td>
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<tr>
<td>104</td>
<td>132</td>
<td>45</td>
<td>23</td>
<td>28</td>
</tr>
</tbody>
</table>

Economic Impact of Heat Stress

- Predicted losses based on THI load, duration and impact from:
  - Decrease feed intake
  - Reduced milk production
  - Impaired reproduction
  - Increased reproductive culling
  - Increased death loss

- Total US Dairy Losses:
  - $848 Mill (Optimal)
  - $1,458 Mill (Without)

- Average losses due to heat stress:
  - Without any heat abatement: $167 per cow per year
  - With optimal heat abatement system: $100 per cow per year

St-Pierre et al. JDS, 2003

Predicted Annual Dairy Cattle Losses (minimum heat abatement)

<table>
<thead>
<tr>
<th>State</th>
<th>Dry matter intake (kg/cow/yr)</th>
<th>Milk (kg/cow/yr)</th>
<th>Days open</th>
<th>Repro culling (per 1000 cows)</th>
<th>Deaths (per 1000 cows)</th>
<th>Heat Stress (hr/year)</th>
<th>Loss ($Mill/year)</th>
</tr>
</thead>
<tbody>
<tr>
<td>PA</td>
<td>159</td>
<td>321</td>
<td>13.2</td>
<td>10.6</td>
<td>2.2</td>
<td>1061</td>
<td>41.98</td>
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<tr>
<td>NY</td>
<td>69</td>
<td>139</td>
<td>7.3</td>
<td>5.1</td>
<td>1.0</td>
<td>115</td>
<td>23.19</td>
</tr>
<tr>
<td>WI</td>
<td>91</td>
<td>183</td>
<td>8.7</td>
<td>6.3</td>
<td>1.3</td>
<td>776</td>
<td>56.9</td>
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<tr>
<td>NM</td>
<td>168</td>
<td>338</td>
<td>23.0</td>
<td>22.2</td>
<td>4.6</td>
<td>1756</td>
<td>22.7</td>
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<tr>
<td>FL</td>
<td>894</td>
<td>1803</td>
<td>59.2</td>
<td>79.9</td>
<td>17.2</td>
<td>4261</td>
<td>50.13</td>
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<tr>
<td>CA</td>
<td>145</td>
<td>293</td>
<td>12.1</td>
<td>9.1</td>
<td>1.9</td>
<td>1039</td>
<td>118.04</td>
</tr>
</tbody>
</table>

St-Pierre et al. JDS, 2003

Key Points

- Cows as ruminants are sensitive to heat stress response at lower temperatures compared to humans
- Both lactating and dry cows are adversely affected by heat stress
- All aspects of cow performance – milk production, reproduction and health are compromised with heat stress
- Some form of heat abatement is economically justified across all states

Resources

- Archived webinars on DAIReXNET site (http://www.extension.org/pages/15830/archived-dairy-cattle-webinars#.UulafNI7u-0)
  - Economics of heat stress: Implications for management
  - Nutritional programs for a heat stressed herd
  - Strategies to Improve Reproduction During Summer Heat Stress
  - Cooling strategies during heat stress

If you think you know
Penn State Cooperative Extension...

Think Again

Penn State Extension