What is heat stress?
- Impact on daughter milk production

Heat stress during late gestation
- Passive transfer of immunity
- Growth and production performance

Nicole Steele, Virginia Extension (Monteiro et al., 2014;2016)

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When a cow’s heat load exceeds her capacity to dissipate heat.

Most heat is lost via the skin, in times of heat stress, blood will be redirected to the skin to aid heat loss, and away from internal organs.
PHYSIOLOGICAL RESPONSES TO HEAT STRESS

- Reduced DMI
- Panting saliva loss
- Increased respiration rate
- Increased disease incidence
- Impaired reproductive performance
- Reduced lying times
- Vasodilation increased blood flow to skin
- Reduced milk production

IOWA STATE UNIVERSITY
Extension and Outreach
HEAT STRESS DURING THE DRY PERIOD

- Heat stress
- Cooled

Milk Production, kg/d

- Collier et al., 1982b
- Wolfenson et al., 1988
- Avendaño-Reyes et al., 2006
- Adin et al., 2009
- do Amaral et al., 2009
- do Amaral et al., 2011
- Tao et al., 2011
- Thompson et al., 2012
- Tao et al., 2012b
The degree of heat stress exposure for dairy cattle is considered as a temperature humidity index (THI). At a THI of 68, and relative humidity of 50%, cows may experience heat stress and an associated drop in milk yield at temperatures as low as 72°F.

<table>
<thead>
<tr>
<th>DAIRY COW TEMPERATURE HUMIDITY INDEX (THI)</th>
<th>HUMAN HEAT INDEX</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temp °F</td>
<td>0</td>
</tr>
<tr>
<td>Temp °F</td>
<td>72</td>
</tr>
<tr>
<td>74</td>
<td>66</td>
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<tr>
<td>76</td>
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<td>68</td>
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<td>80</td>
<td>69</td>
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<td>104</td>
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<td>106</td>
<td>81</td>
</tr>
<tr>
<td>108</td>
<td>82</td>
</tr>
<tr>
<td>110</td>
<td>83</td>
</tr>
</tbody>
</table>

- **Stress threshold for lactating cows.** Respiration rate may exceed 60 BPM. Milk loses begin ~2.5 lbs/cow/day. Reproductive losses are detectable and rectal temperature exceeds 101.3°F. Caution for people depending on age, exposure and activity. People may not feel heat stress until 80°F and 40% humidity.

- **Mild to moderate stress for lactating cows.** Respiration rates may exceed 75 BPM. Milk loses ~6 lbs/cow/day. Rectal temperatures will exceed 102.2°F. Extreme Caution for people depending on age, exposure and activity.

- **Moderate to severe stress for lactating cows.** Respiration rate exceeds 85 BPM. Milk loses ~8.7 lbs/cow/day. Rectal temperature exceeds 104°F. Danger for people depending on age, exposure and activity.

- **Severe stress!** Life threatening conditions for lactating cows. Respiration rates are 120-140 BPM. Rectal temperatures may exceed 106°F. Extreme Danger of heat exhaustion and/or heat stroke for people when working in these conditions.
HEAT STRESS DAYS BY STATE

Milk lost per cow in next lactation (lbs)

Heat stress days

State

WA
QR
ID
UT
CO
MN
VT
SD
MI
WI
NM
NY
AZ
PA
IA
OH
IL
CA
IN
KS
MO
VA
GA
TX
FL

UF/IFAS
UNIVERSITY of FLORIDA
Department of Animal Sciences

Dairy Update,
Summer 2016
RESEARCH ARTICLE

Periconceptional Heat Stress of Holstein Dams Is Associated with Differences in Daughter Milk Production and Composition during Multiple Lactations

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METHODS

- DHIA data for GA, FL and TX: 2000-2010
- Holstein cows with first 3 full lactations
- Herd size >10 cows

- Thermoneutral conception: TNC (n = 47,000)
  - Conceived December-February
- Heat stressed conception: HSC (n = 29,000)
  - Conceived June-August
- Estimated gestation length = 276 days
- Production – 75,000 records
  - 305-day adjusted mature-equivalent milk
  - % protein and % fat

Brown et al. 2015
Difference in milk production: 
82 ± 42 to 399 ± 61 kg per lactation 
(180 - 877 lbs per lactation)

- when cows conceived in summer, their daughter’s milk production was lower compared with offspring that were conceived during winter (Brown et al., 2015).
Effect of late-gestation maternal heat stress on growth and immune function of dairy calves

S. Tao, A. P. A. Monteiro, I. M. Thompson, M. J. Hayen, and G. E. Dahl
Department of Animal Sciences, University of Florida, Gainesville 32611

In utero heat stress decreases calf survival and performance through the first lactation

A. P. A. Monteiro, S. Tao, I. M. T. Thompson, and G. E. Dahl
Department of Animal Sciences, University of Florida, Gainesville 32611
THE FETUS IN LATE GESTATION

- 60% of body weight gained in last 2 months
- 0.6°C higher body temp
- Higher metabolic rate
- 85% heat loss through fetal-placental circulation
For 5 consecutive summers:
- Cows dried off 46 days before calving date
- Freestall barn
- Assigned randomly to CL or HT group

Calves fed 1 gallon (3.8 L) of colostrum within 4 h of birth

- D 1-29: 1.9 L pasteurized milk, twice daily
- D 30-41: up to 3.8 L / twice daily
- D 42-48: 1.9 L once daily
- D 49: weaned

Management same for both HT and CL calves

<table>
<thead>
<tr>
<th>No. dams</th>
<th>HT 16</th>
<th>CL 16</th>
<th>SEM 1.2</th>
<th>P value &lt;0.01</th>
</tr>
</thead>
<tbody>
<tr>
<td>THI</td>
<td>78.3</td>
<td>78.3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rectal temperature (°C)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>AM</td>
<td>38.64</td>
<td>38.55</td>
<td>0.04</td>
<td>0.12</td>
</tr>
<tr>
<td>PM</td>
<td>39.34</td>
<td>38.98</td>
<td>0.05</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Respiration rate (breath/min)</td>
<td>69.2</td>
<td>48.3</td>
<td>2.8</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>DMI (kg/d)</td>
<td>10.2</td>
<td>11.4</td>
<td></td>
<td>0.10</td>
</tr>
<tr>
<td>BW gain over dry period (kg)</td>
<td>9.6</td>
<td>26.0</td>
<td>4.5</td>
<td>0.01</td>
</tr>
<tr>
<td>Gestation length (d)</td>
<td>272</td>
<td>276</td>
<td>1.2</td>
<td>0.02</td>
</tr>
<tr>
<td>Milk yield in subsequent lactation (kg/d)</td>
<td>27.7</td>
<td>34.0</td>
<td></td>
<td>&lt;0.01</td>
</tr>
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</table>
COLOSTRUM IGG: DAM

<table>
<thead>
<tr>
<th></th>
<th>HT</th>
<th>CL</th>
<th>SEM</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Colostrum IgG</td>
<td>8,681</td>
<td>7,727</td>
<td>726</td>
<td>0.36</td>
</tr>
<tr>
<td>(mg/dL)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Serum IgG: calf

- CL
- HT

Tao et al. 2012
COLOSTRUM QUALITY OR CALF ABSORPTIVE CAPACITY?

Monteiro et al. 2014

1. HT and CL calves fed pooled colostrum from non-heat stressed cows
   - CL calves had greater AEA

2. Calves born in winter (not heat-stressed)
   - Fed HT or CL colostrum
   - No difference in AEA or growth

→ Issue with absorption of IgG
CONCLUSIONS

- Cooling cows did reduce exposure to heat stress

- Calf birth weight reduced when cows were heat stressed during late gestation

- Passive transfer of immunity was compromised
In utero heat stress decreases calf survival and performance through the first lactation

A. P. A. Monteiro, S. Tao, I. M. T. Thompson, and G. E. Dahl
Department of Animal Sciences, University of Florida, Gainesville 32611
### Methods

- Results pooled from 5 consecutive summers

<table>
<thead>
<tr>
<th></th>
<th>No. animals</th>
<th>HT</th>
<th>CL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Birth weight</td>
<td>146</td>
<td>74</td>
<td>72</td>
</tr>
<tr>
<td>Calf survival</td>
<td>146</td>
<td>74</td>
<td>72</td>
</tr>
<tr>
<td>Monthly body weight (2-12mo)</td>
<td>72</td>
<td>34</td>
<td>38</td>
</tr>
<tr>
<td>Fertility outcomes</td>
<td>72</td>
<td>34</td>
<td>38</td>
</tr>
<tr>
<td>Milk production</td>
<td>64</td>
<td>29</td>
<td>35</td>
</tr>
</tbody>
</table>

Monteiro et al. 2016
GROWTH PERFORMANCE

Rate of BW gain: not different

Birth weight
- HT 40 kg
- CL 45 kg

Weaning weight
- HT 66 kg
- CL 79 kg

Monteiro et al. 2016
## Survival to First Lactation

<table>
<thead>
<tr>
<th></th>
<th>HT</th>
<th>CL</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. heifers</td>
<td>44</td>
<td>41</td>
<td>--</td>
</tr>
<tr>
<td>Still born</td>
<td>3</td>
<td>0</td>
<td>0.25</td>
</tr>
<tr>
<td>% leaving pre-puberty</td>
<td>22.7%</td>
<td>12.2%</td>
<td>0.26</td>
</tr>
<tr>
<td>% leaving due to sickness, malformation, growth</td>
<td>18.2%</td>
<td>2.4%</td>
<td>0.03</td>
</tr>
<tr>
<td>% leaving after puberty, before 1st lactation</td>
<td>6.8%</td>
<td>2.4%</td>
<td>0.62</td>
</tr>
<tr>
<td>% completing 1st lactation</td>
<td>65.9%</td>
<td>85.4%</td>
<td>0.05</td>
</tr>
</tbody>
</table>
# Fertility Outcomes

<table>
<thead>
<tr>
<th></th>
<th>HT</th>
<th>CL</th>
<th>SEM</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. heifers</td>
<td>32</td>
<td>36</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Age at first AI (mo)</td>
<td>13.8</td>
<td>13.6</td>
<td>0.2</td>
<td>0.32</td>
</tr>
<tr>
<td>Services per pregnancy (d30)</td>
<td>2.5</td>
<td>2.0</td>
<td>0.2</td>
<td>0.05</td>
</tr>
<tr>
<td>Age at pregnancy (mo)</td>
<td>16.9</td>
<td>16.1</td>
<td>0.3</td>
<td>0.07</td>
</tr>
<tr>
<td>Services per pregnancy (d50)</td>
<td>2.6</td>
<td>2.3</td>
<td>0.2</td>
<td>0.32</td>
</tr>
<tr>
<td>Age at calving</td>
<td>25.0</td>
<td>24.8</td>
<td>0.4</td>
<td>0.72</td>
</tr>
<tr>
<td>BCS at calving</td>
<td>3.5</td>
<td>3.5</td>
<td>0.2</td>
<td>--</td>
</tr>
</tbody>
</table>
27 kg/d for HT vs. 32 kg/d for CL
Over 35 weeks = 1,250 kg milk difference
Heifers from heat-stressed dams produced, on average, 11 lbs. of milk/d less than those from cooled dams, equating to a total difference of approximately 2750 lbs. of milk/cow during the first 245 DIM.
CONCLUSIONS

Calves from heat stressed cows:

- Were lighter at birth, through to 12 mo
- Fewer survived to complete the first lactation
- Had poorer fertility outcomes
- Lower milk production in the first lactation
SUMMARY

- Heat stress conditions at **conception or late gestation** reduces daughter milk production
- Lower birth weights and compromised transfer of immunity compromised calves heat stressed in utero
- Cooling cows during late gestation effective to lessen impacts of heat stress on calves