Managing heat stress in dairy heifers

Bob James

Heifers – weaning to calving

- Low input animal
- Low cost feeds
- Low cost facilities
- Low intensity management
- Impact of management not readily evident
  - Records?
  - Reproduction
  - Calving age and 1st lactation performance

Heat stress in the U.S.

- Thermo neutral zone for dairy cattle – 5 – 25°C (41 – 77°F)
U.S. Climatic differences

- Duration of heat stress
  - 4 – 6 months in southeastern U.S.
- Onset of heat stress
- Intensity of heat stress
- Night time cooling

Dairy heifer management system differences

Dairy heifer management systems
Heat stress and dairy heifers

- Holstein females raised at latitudes less than 34°N weighed 6 – 10% less (NRC, 1981)
- Great maintenance requirements during hot weather for larger animals
  - More difficult to relieve heat load due to smaller surface area relative to body size.
- Lower DMI
- Poorer forage quality
- Extensive housing systems in S.E.

Animal responses to heat stress

- Increased water intake
- Decreased ration dry matter intake
- Decreased reproductive performance
- Influence on prepartum dairy heifers
  - Colostrum production and quality
  - Calf size and health

Impact on water intake

- Arias and Mader (2011)
- 7 studies with Angus crossbred feed lot cattle
- Recorded climatic data
- Simple and multiple regression analysis by season and for overall data
- Best predictors of water intake ($R^2$)
  - THI = .57, Mean ambient temperature = .57, Min Temp. = .56 and Max Temp. = .54
  - Solar radiation and DMI had smaller influence.
**Impact on Dry Matter Intake**

(10 month old Friesian Heifers)

<table>
<thead>
<tr>
<th>Item</th>
<th>Control Temperature</th>
<th>Heat stress 3 days</th>
<th>Heat stress 24 days</th>
<th>Control vs. Heat stress [P]</th>
</tr>
</thead>
<tbody>
<tr>
<td>DMI (kg/day)</td>
<td>8.01 a</td>
<td>7.48 a</td>
<td>7.18 b</td>
<td>.01</td>
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<tr>
<td>Water intake (L/day)</td>
<td>27.55 a</td>
<td>42.61 a</td>
<td>45.54 b</td>
<td>.01</td>
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<tr>
<td>DM digestibility (%)</td>
<td>57.3 a</td>
<td>68.4 b</td>
<td>60.6 a</td>
<td>.05</td>
</tr>
<tr>
<td>BW (kg)</td>
<td>312 a</td>
<td>325 b</td>
<td>343 c</td>
<td>.05</td>
</tr>
<tr>
<td>Body condition score</td>
<td>3.0 a</td>
<td>2.9 a</td>
<td>2.7 b</td>
<td>.05</td>
</tr>
</tbody>
</table>

Bernabucci et al., 2011

Control THI = 64, Heat stress THI = 84

**Impact on Dry Matter Intake**

- 118 Holstein heifers – 100 – 400 kg
- Rations from 85 to 115% of NRC requirements (1978) for energy. – corn silage/grass hay/corn/soybean meal.
- Inclusion of ambient temperature in model to predict DMI had negligible impact on DMI.
- Heifers waited to cooler night time hours to eat?

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Control THI = 64, Heat stress THI = 84

**Expanded model was:**

\[
DMI (\text{kg/day}) = -1.906.91 + 0.04 * \text{BWT} + (0.37 * \text{MBWT}) + (32.36 * \text{ADF}) + (2305.51 * \text{NEM}) + (-664.06 * \text{NEG}) + (-0.08 * \text{AMBT}) + (-0.13 * \text{ADFSQ}) + (-637.68 * \text{NEMSQ}) + (42.31 * \text{NEGSQ}) + (-5.35 * \text{BULKSQ}) + (0.001 * \text{AMBTC}) + (-1.56E-04 * \text{BWT} * \text{ADF}) + (8.87E-05 * \text{BWT} * \text{AMBT}) + (246.30 * \text{NEM} * \text{NEG}) + (-21.30 * \text{NEM} * \text{ADF}) + (7.83 * \text{NEG} * \text{ADF}) + (0.04 * \text{NEG} * \text{AMBT}) + (0.01 * \text{GAIN} * \text{ADF}) + (-0.01 * \text{GAIN} * \text{AMBT});
\]

- \( n = 4429, r^2 = .65, s_{yx} = 1.09.\)
• Simplified model was: DMI (kg/day) = -29.86 + (-54E-05 * BWT) + (.157 * MBWT)
  + (2.090 * GAIN) + (-.118 * GAIN²) + (.730 * TDN) + (.005 * TDN²) + (.001 * BWT * GAIN) + (-.019 * TDN * GAIN);
  n = 4797, r² = .59, sy.x = 1.18.

Impact on reproductive performance

• Effects of controlled heat stress on ovarian function of dairy cattle. 2. Heifers (Wilson et al. J. Dairy Sci. 81;2132)
  • Estrus synched heifers – estrus = day 0
    – Thermo neutral = 21 C ~ 60% humidity
    – Heat stress = 33 C ~ 60% humidity - day 9 – 22 of cycle
  • Growth and regression of follicles and CL
  • Bled daily – progesterone and estradiol

Wilson, cont’d

• Thermo neutral heifers - 2nd wave dominant follicle larger with ovulation – 9 - 11 days. (9 of 11 heifers)
• Heat stressed – 2nd wave follicle regressed and followed by ovulatory 3rd wave follicle.
  – Lower estradiol d 11-21
  – Delayed luteolysis
Prepartum heifers

• Composition of colostrum from heifers exposed to high air temperatures during late pregnancy and the early postpartum period. (Nardone et al., J. Dairy Sci. 80:838)
• Control – THI = 65

Nardone, cont’d

• Heat stressed heifers
  – Decline of plasma Ig during last 2 wk of pregnancy was less.
  – Lower mean concentration of IgG and IgA, total protein, casein, lactalbumin, fat, lactose, short and medium chain F. A. ........ in colostrum.

Other observations on the heat stressed prepartum heifer

• Smaller birth weight of calves
• Less vigorous calves
• Reduced immune signaling molecules from calves born to heifers during high solar load.
• Reduced absorption of colostral antibodies
  – Impact of dam’s hormonal condition
  – Impact of greater bacterial environmental load
Managing heat stress in heifers
Focus points

- Facility design
  - Extensive systems - Shade
  - Intensive systems -
    • Mechanically ventilated facilities
    • Naturally ventilated facilities
- Water – plenty and clean
- Dietary modification

Facilities

Extensive management systems.

Huffard Dairy Farms – Crockett, VA
Reproduction barn

Extensive management systems

- Stocking density is major concern
- Management intensive grazing – Portable shade?
- Trees are short term solution
  – Usually will not survive as shade provider.
- Need is dependent on existence of night time cooling.

Intensive management systems
Intensive management systems

- Open side walls with east/west orientation and roof overhang for summer shade
- Cost effective
  - Improved feed efficiency – 12 – 25% lower maintenance expense
  - Water availability and disposal for cooling systems

Vanderhyde Dairy – Chatham, VA

Intensive management systems

Before – 500 cow dairy in south central Virginia
Intensive management systems
After – south central Virginia

Cost of heifer expansion
• Land preparation
• Facility construction
• Capacity – cost / animal
• Additional advantages above heat abatement
  – Labor savings – feeding, manure, animal handling.
  – Feed management

Cost – Two central Virginia dairies
• Turn key cost
  – Dairy #1 – 500 cows
    • 250 heifers @ $290,000 = ~$1,160/stall
  – Dairy #2 – 1,000 cows
    • 953 stalls @ $1,150,000 = ~$1207/stall
Water

Estimated water intake for heifers

<table>
<thead>
<tr>
<th>Weight (lb)</th>
<th>40°F</th>
<th>60°F</th>
<th>80°F</th>
</tr>
</thead>
<tbody>
<tr>
<td>200</td>
<td>2.0</td>
<td>2.4</td>
<td>3.3</td>
</tr>
<tr>
<td>400</td>
<td>3.8</td>
<td>4.6</td>
<td>6.1</td>
</tr>
<tr>
<td>600</td>
<td>5.4</td>
<td>6.5</td>
<td>8.7</td>
</tr>
<tr>
<td>800</td>
<td>6.8</td>
<td>8.2</td>
<td>11</td>
</tr>
<tr>
<td>1000</td>
<td>8.0</td>
<td>9.6</td>
<td>12.7</td>
</tr>
<tr>
<td>1200</td>
<td>9.0</td>
<td>10.8</td>
<td>14.5</td>
</tr>
</tbody>
</table>


About 1 – 1.5 gallons of water/100 lb. body weight

Coefficients of determination of environmental variables and DMI on daily water intake

<table>
<thead>
<tr>
<th>Variable</th>
<th>Summer model</th>
<th>Winter model</th>
<th>Overall model</th>
</tr>
</thead>
<tbody>
<tr>
<td>Min. ambient temp (°C)</td>
<td>.10</td>
<td>.02</td>
<td>.56</td>
</tr>
<tr>
<td>Max. ambient temp (°C)</td>
<td>.06</td>
<td>.07</td>
<td>.54</td>
</tr>
<tr>
<td>Mean ambient temp (°C)</td>
<td>.00</td>
<td>.04</td>
<td>.57</td>
</tr>
<tr>
<td>Solar radiation W/m²</td>
<td>.14</td>
<td>.05</td>
<td>.47</td>
</tr>
<tr>
<td>Wind speed m/s²</td>
<td>.00</td>
<td>.04</td>
<td>.00</td>
</tr>
<tr>
<td>DMI – kg/d</td>
<td>.00</td>
<td>.02</td>
<td>.12</td>
</tr>
<tr>
<td>Relative humidity</td>
<td>.00</td>
<td>.07</td>
<td>.00</td>
</tr>
<tr>
<td>Precipitation (cm/d)</td>
<td>.00</td>
<td>.02</td>
<td>.01</td>
</tr>
<tr>
<td>THI</td>
<td>.12</td>
<td>.05</td>
<td>.57</td>
</tr>
</tbody>
</table>

### Partial regression coefficients for models assessing environmental factors and DMI influences on DWI

<table>
<thead>
<tr>
<th>Variable</th>
<th>Summer model Partial R²</th>
<th>Winter model Partial R²</th>
<th>Overall model Partial R²</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>4.81</td>
<td>16.10</td>
<td>5.92</td>
</tr>
<tr>
<td>DMI (kg/d)</td>
<td>0.04</td>
<td>0.01</td>
<td>0.02</td>
</tr>
<tr>
<td>Solar radiation W/m²</td>
<td>0.14</td>
<td>0.01</td>
<td>0.07</td>
</tr>
<tr>
<td>Max. temp (°C)</td>
<td>-</td>
<td>0.05</td>
<td>-</td>
</tr>
<tr>
<td>Min. temp (°C)</td>
<td>0.50</td>
<td>-</td>
<td>0.56</td>
</tr>
<tr>
<td>Wind speed</td>
<td>-</td>
<td>0.04</td>
<td>-</td>
</tr>
<tr>
<td>Precipitation (cm/d)</td>
<td>-</td>
<td>0.05</td>
<td>-</td>
</tr>
<tr>
<td>Total R²</td>
<td>0.23</td>
<td>0.23</td>
<td>0.65</td>
</tr>
</tbody>
</table>


### Water quality

- Mineral and nitrogen content
  - Nitrates – manure and fertilizer contamination
  - Minerals of concern
    - Total dissolved solids – salinity
    - Magnesium compounds plus sodium sulfate < 50% of TDS
    - Sulfate
    - Iron
    - Manganese
- Organoleptic – taste

### Evaluating water quality for livestock

**Beede, D., 2006, High Plains Dairy Conference Proceedings.**

<table>
<thead>
<tr>
<th>Quality Factor</th>
<th>Threshold concentration mg/L</th>
<th>Limiting concentration mg/L</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total dissolved solids</td>
<td>2,500</td>
<td>5,000</td>
</tr>
<tr>
<td>Calcium</td>
<td>500</td>
<td>1,000</td>
</tr>
<tr>
<td>Magnesium</td>
<td>250</td>
<td>500</td>
</tr>
<tr>
<td>Sodium</td>
<td>1,000</td>
<td>2,000</td>
</tr>
<tr>
<td>Bicarbonate</td>
<td>500</td>
<td>500</td>
</tr>
<tr>
<td>Chloride</td>
<td>1,500</td>
<td>3,000</td>
</tr>
<tr>
<td>NO₂</td>
<td>10</td>
<td>100</td>
</tr>
<tr>
<td>NO₃</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>Sulfate</td>
<td>500</td>
<td>1000</td>
</tr>
</tbody>
</table>

Threshold – sensitive animals show slight effect
Limiting – definite adverse reactions.
Water quality
Minerals
- Growing heifers tolerated 1.75% NaCl during the winter but only 1.2% NaCl during the summer (Weeth and Haverland 1961)
- Sulfur and Sulfate – H₂S - cattle adapt?
  - Sulfate and chloride <1000 ppm
- Iron - <0.3 ppm
  - Dark slime from iron loving bacteria – palatability and water flow
  - Interferes with Cu and Zn absorption
- Manganese – palatability

Nitrates – NO₃⁻
- Young calves? <50 ppm
- Adult cattle <100 ppm
- Algal blooms of cyanobacterium
  - Anorexia, diarrhea, weakness
  - Palatability?
- Bacterial growth? No documented studies

Dietary modification
  - 17 vs. 36°C
  - With or without water and ammonium acetate (diaphoretic)
Effect of summer conditions and diaphoretic plus water spray

<table>
<thead>
<tr>
<th>Item</th>
<th>Winter</th>
<th>Summer</th>
<th>Change</th>
<th>Water and diaphoretic</th>
<th>Change (above summer)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Daily solids gain (g/day)</td>
<td>313.8</td>
<td>170.8</td>
<td>-45.6%</td>
<td>266.6</td>
<td>+56.1%</td>
</tr>
<tr>
<td>Roughage intake</td>
<td>28.0</td>
<td>21.5</td>
<td>-23.2%</td>
<td>25.0</td>
<td>+16.3%</td>
</tr>
<tr>
<td>Concentrate intake</td>
<td>52.5</td>
<td>52.5</td>
<td>-</td>
<td>52.5</td>
<td></td>
</tr>
<tr>
<td>Feed efficiency</td>
<td>.16</td>
<td>.11</td>
<td>-31.7%</td>
<td>.136</td>
<td>+25.9%</td>
</tr>
</tbody>
</table>

• kg/day/10 calves

Managing feeding programs for heat-stressed dairy heifers

• Animals of greatest concern
  – Weaning pens – fragile intake
    • Highest quality forage – dry hay
    • Silage?
    • Palatability
  – Breeding age animals
    • Heat detection and strength of estrus
  – Prepartum heifers
    • Colostrum production
    • Calving

The challenge in managing heifer feeding programs

• Monitoring feed intake?
• Monitoring heifer performance?
• Compensatory gain
Cameiro Heifer Ranch
Brawley, CA

- Jerry Craveiro/Diana Lujano
- ~10,000 heifer feedlot –
- Daytime temperatures – 100 – 125°F – April – Sept.
  - Track dry matter intakes
  - Continuous evaluation of body condition
  - Weights - 3 weeks post arrival, breeding, departure – too much lag for routine weighing.

Mitigating influence of climate

- Anticipate reaction of heifer based upon past experience and records
- Monitor weather
- Palatable diets without excessive moisture to optimize dry matter intake and digestive health
- Know dry matter and nutrient content of feeds
- Trained feeders to evaluate animal responses and intake.
- Minimum space requirements for feed bunk and corral space.

- Feed for empty bunks so there is no spoiled feed in the bunks.
- Care for feed inventory
- Truck scales checked every Monday.
Adjust DMI for expected weather

- Not a problem with most heifers due to “luxury” of ad lib intake.
- Research with limit fed heifers – Wisconsin/Penn State University

Limit feeding dairy heifers
Hoffman, Univ. of Wisconsin

<table>
<thead>
<tr>
<th>Item</th>
<th>Control</th>
<th>Restricted - 80</th>
<th>Restricted - 90</th>
</tr>
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<tbody>
<tr>
<td>Forage</td>
<td>94.3%</td>
<td>80.3%</td>
<td>62.7%</td>
</tr>
<tr>
<td>Concentrate</td>
<td>5.7%</td>
<td>19.7%</td>
<td>37.3%</td>
</tr>
<tr>
<td>NDF</td>
<td>47.3%</td>
<td>41.8%</td>
<td>35.6%</td>
</tr>
<tr>
<td>DMI</td>
<td>21.3</td>
<td>19.9</td>
<td>18.3</td>
</tr>
<tr>
<td>NEg Mcal/d</td>
<td>9.4</td>
<td>9.4</td>
<td>9.5</td>
</tr>
<tr>
<td>Weight – initial</td>
<td>1016</td>
<td>1012</td>
<td>1011</td>
</tr>
<tr>
<td>Weight – final</td>
<td>1220</td>
<td>1234</td>
<td>1217</td>
</tr>
<tr>
<td>Feed effic. *[DMI/gain]</td>
<td>11.2</td>
<td>10.7</td>
<td>11.1</td>
</tr>
<tr>
<td>Excretion – lb/d**</td>
<td>7.7</td>
<td>7.9</td>
<td>3.8</td>
</tr>
<tr>
<td>Post partum BW</td>
<td>1238</td>
<td>1245</td>
<td>1275</td>
</tr>
<tr>
<td>0-150 d Ave. milk prod.</td>
<td>68.8</td>
<td>68.9</td>
<td>72.4</td>
</tr>
</tbody>
</table>

Other tools for heat stressed heifers

- Yeast
  - Lactating dairy cattle supplemented with 5g S. cerevisiae (10^10cfu/d)
  - Monitor rumen pH with in dwelling pH meter.
  - Ave. rumen pH was greater with Yeast
  - Higher meal frequency
  - Response within one week of supplementation.
Tools for heat stressed heifers

• Ionophores – Rumensin / Bovatec
• Clarify – larvicide

Heat stress in heifers

• Address those groups most affected –
  – Youngest, breeding age, prepartum
• Water availability and quality.
• Facilities
  – Will the expense be offset by improved performance?
  – Payback is intertwined with feed efficiency, labor
    efficiency as well as feed efficiency.
• Diet – formulate for reduced DMI. Luxury that
  DMI is not limiting factor for heifer growth.