Beef cattle thermoregulation in response to naturally occurring heat stress on pasture

Climatic stress and beef cattle

• Major limiting factor of production efficiency
  • In beef cattle in tropical and subtropical environments.
  • In dairy cattle throughout most of the world.

• > 50% cattle in the world – maintained in hot and humid environments
  • including ~ 40% of beef cows in US.

• Substantial differences in thermal tolerance
  • Among breeds
  • Among animals within breeds

• Indication of opportunities for selective improvement.
In response to heat stress cattle will:

• Regulate internal **heat production**
  • Modulating basal metabolic rate
  • Changing: feed intake, growth, lactation, activity

• Regulate **heat exchange**
  • Increasing blood flow to the skin
  • Increasing evaporative heat loss through sweating & panting
Research Populations

• UF Multibreed Angus x Brahman Herd
  • Summer 2015, 2017
  • **286 cows**: from 100% Brahman to 100% Angus

<table>
<thead>
<tr>
<th>Breed Group</th>
<th>Angus %</th>
<th>Brahman %</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>100</td>
<td>0</td>
</tr>
<tr>
<td>2</td>
<td>75</td>
<td>25</td>
</tr>
<tr>
<td>3</td>
<td>62.5</td>
<td>37.5</td>
</tr>
<tr>
<td>4</td>
<td>50</td>
<td>50</td>
</tr>
<tr>
<td>5</td>
<td>25</td>
<td>75</td>
</tr>
<tr>
<td>6</td>
<td>0</td>
<td>100</td>
</tr>
</tbody>
</table>

• Brangus heifers, Seminole Tribe of Florida
  • Summer 2016, 2017
  • **1,500 two-year old heifers**
Internal Body Temperature

- Vaginal temperature at 5-min intervals for 5 days
- Air temperature and relative humidity on pasture – every 15 min.
- The temperature-humidity index (THI) was used to quantify heat stress and it was calculated as in Dikmen et al., 2008:

\[ THI = (1.8 \times T_{db} + 32) - [(0.55 - 0.0055 \times RH) \times (1.8 \times T_{db} - 26)] \]

DS1922L iButton Temperature Logger -
Maxim Integrated Products, 120 San Gabriel Drive, Sunnyvale, CA
Range: -40°C to +85°C
Resolution: 0.0625°C (11 bit) or 0.5°C (8 bit)

iButton

CIDR
**Thermotolerance measurements**

- Vaginal **temperature** 15 min over 5 days
- Environmental data: temperature, humidity, **THI**
- **Sweating** rate
- **Coat**: color, coat score, hair length & diameter
- **Temperament**: chute and exit score
- Body **condition** score
- **Skin** biopsies: for histology & gene expression
- **Weight gain** over the summer/fall
- Rump fat and rib fat ultrasound
- Subsequent **pregnancy** status
- **250K** genotypes
Body temperature variables

• **Low** THI: 74 and 76
• **High** THI: 84 – 86
• **Average** THI: 79 – 81

• Vaginal temperature for each cow Low, High, Avg. = average temp of all the 5-min measurements when the cow was exposed to that respective THI.

• Diff THI: High-Low THI
Effect of breed composition on body temp

Body Temperature (°C) under High THI (heat stress)

100% Angus
75% Angus
Brangus
50% Angus
25% Angus
0% Angus
Effect of breed composition on body temp

Body Temperature (°C) under **High** and **Low** THI

<table>
<thead>
<tr>
<th>Trait</th>
<th>h²</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temp Diff Hi-Low</td>
<td>0.27</td>
</tr>
<tr>
<td>Temp High</td>
<td>0.11</td>
</tr>
<tr>
<td>Temp Low</td>
<td>0.25</td>
</tr>
</tbody>
</table>
Thermotolerance in Brangus

- 1,500 Brangus 2-year old heifers (2016-2017)

| Effect          | Estimate | Std. err | t value | Pr > |t| |
|-----------------|----------|----------|---------|-------|---|
| Coat 1 vs 2     | -0.097   | 0.021    | -4.64   | <.0001|
| Chute 1 vs 2    | -0.047   | 0.019    | -2.42   | 0.015 |
| Exit 1 vs 2     | 0.011    | 0.020    | 0.57    | 0.567 |

Coat score:
1. excessively smooth
2. fairly smooth
3. long coat
4. woolly
5. excessively woolly coat

Score 1
Excessively Smooth
N = 526

Score 2
Fairly Smooth
N = 197
Skin histology

6mm biopsy in formalin => histology

- Histological skin characteristics:
  - Distance from the sweat gland top to the skin surface
  - Distance from the sweat gland bottom to the skin surface
  - Skin, epidermis, dermis thickness
  - Sweat and sebaceous gland number
  - Sweat and sebaceous gland area
Effect of breed composition on sweat glands

Sweat Gland area

- 100% Angus: c
- 75% Angus: bc
- Brangus: bc
- 50% Angus: b
- 25% Angus: a
- 0% Angus: a
Distance from the top of the SG to the skin surface

- 100% Angus: 903
- 75% Angus: 863
- Brangus: 891
- 50% Angus: 842
- 25% Angus: 771
- 0% Angus: 666
Conclusions

• **Climatic stress** - major limiting factor of production efficiency in beef cattle in tropical and subtropical environments.
  • Expected to increase due to climate change.

• Differences in **thermal tolerance** exist:
  • Opportunities for selective improvement.

• **Genomic tools** are needed to select replacement heifers or bulls with increased thermotolerance.

• Development of the “**cow of the future**” with high productivity and resistant to heat stress will be realized through use of **genomic selection**.
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United States Department of Agriculture
National Institute of Food and Agriculture
Comments / Questions