Genetic parameters for body temperature under hot and humid conditions in an Angus–Brahman population

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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
Genetics of thermotolerance

- **Heritability** of rectal temperature
  - 0.19, Brahman x Angus crossbred pop. (Riley et al. 2012)
  - 0.17, dairy cattle in FL (Dikmen et al. 2012)

- Selection for improved thermal tolerance is possible
  - If we can identify animals with genetically superior core body temperature regulation when exposed to environmental thermal stress.
  - Need phenotypes and tools to make selection decisions

Reveal the **genetic architecture** of traits defining **thermal tolerance** in *Bos Indicus* influenced cattle.
**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>
<th>Angus %</th>
<th>Brahman %</th>
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</thead>
<tbody>
<tr>
<td>1</td>
<td>100</td>
<td>0</td>
<td>100-80</td>
<td>0-20</td>
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<tr>
<td>2</td>
<td>75</td>
<td>25</td>
<td>79-60</td>
<td>21-40</td>
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<tr>
<td>3</td>
<td>62.5</td>
<td>37.5</td>
<td>62.5</td>
<td>37.5</td>
</tr>
<tr>
<td>4</td>
<td>50</td>
<td>50</td>
<td>59-40</td>
<td>41-60</td>
</tr>
<tr>
<td>5</td>
<td>25</td>
<td>75</td>
<td>39-20</td>
<td>61-80</td>
</tr>
<tr>
<td>6</td>
<td>0</td>
<td>100</td>
<td>19-0</td>
<td>81-100</td>
</tr>
</tbody>
</table>
Internal Body Temperature

- Summer 2015, 2017
- **286 cows**: from 100% Brahman to 100% Angus
- Vaginal temperature at 5-min intervals for 5 days
- Air temperature and relative humidity – recorded continuously in the pastures

DS1922L iButton Temperature Logger, Range: -40°C to +85°C, Resolution: 0.0625°C (11 bit) or 0.5°C (8 bit)
Environmental Measurements

• HOBO data loggers recorded every 15 minutes:
  • **dry bulb temperature** \((T_{db})\)
  • **relative humidity** \((RH)\)
  • **dew point temperature** \((T_{dp})\)
  • **black globe temperature** \((T_{bg})\)

• The temperature-humidity index \((THI)\) was used to quantify heat stress and it was calculated as in Dikmen et al., 2008:

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

- **Low** THI: 74 and 74.5
- **High** THI: 84 – 84.5
- **Average** THI: 77 – 77.5

- 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
- **WOMBAT**: univariate animal models - genetic and residual variances, heritability.
Outside temperature – by replicate

High heat stress
Medium heat stress
Low heat stress

DBT (°C)

HOUR
Vaginal Temp. under high heat stress

VAGINAL TEMP (°C)

HIGH HEAT STRESS

0  5  10  15  20  25

HOUR

Vaginal Temperature under high heat stress for different breeds:
- Angus
- 3/4A, 1/4B
- Brangus
- 1/2A, 1/2B
- 1/4A, 3/4B
- Brahman
Vaginal Temp. under low heat stress

LOW HEAT STRESS

- Angus
- 3/4A, 1/4B
- Brangus
- 1/2A, 1/2B
- 1/4A, 3/4B
- Brahman
LSMeans - 6 different breed groups

<table>
<thead>
<tr>
<th>Trait</th>
<th>$h^2$</th>
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<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>
<tr>
<td>Temp Average</td>
<td>0.20</td>
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</table>

<table>
<thead>
<tr>
<th>Trait</th>
<th>$\sigma^2_a$</th>
<th>$\sigma^2_e$</th>
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<tbody>
<tr>
<td>Temp Diff Hi-Low</td>
<td>0.17</td>
<td>0.45</td>
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<tr>
<td>Temp High</td>
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<td>Temp Low</td>
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<td>0.42</td>
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<tr>
<td>Temp Average</td>
<td>0.09</td>
<td>0.35</td>
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</tbody>
</table>

Body Temperature, Difference (High - Low)

- High THI 84-84.5
- Low THI 74-74.5

Body Temperature

- High and Low
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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Comments/Questions