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Improving thermotolerance in beef cattle – a genomic approach

UF IFAS UNIVERSITY of FLORIDA

Raluca Mateescu | Associate Professor
Animal Genomics

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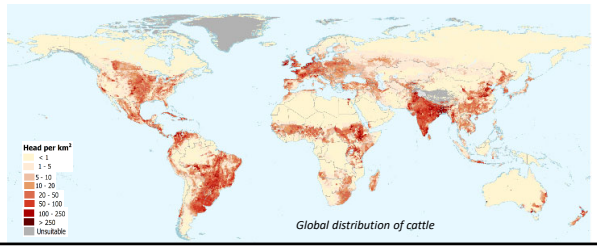
Beef cattle in the world

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



Global distribution of cattle

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Bos Indicus cattle

- Approximately **80%** of global beef production is *Bos Indicus* based.

***Bos indicus* germplasm:**
- Critical role in US and worldwide beef production
- Particularly when used as part of a well-structured crossbreeding program

- **Adapted to heat and humidity**
- **Resistant (or at least tolerant) to internal and external parasites**
- **In crossbreeding systems produce improved cattle:**
  - Fertile
  - Gain well
  - Long lived

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Thermotolerance

- Climatic stress - major limiting factor of production efficiency
- Genomic tools can help select
  - Animals with superior ability for both **thermal adaptation** and **food production**
  - Energy-efficient, **sustainable** approach to meet the challenge of global climate change.

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In response to heat stress, cattle will regulate:

Heat Production	Heat Exchange
Modulating basal metabolic rate	Blood flow to the skin
Changing: feed intake, growth, lactation, activity	Evaporative heat loss through sweating & panting

Goal: **Develop genomic tools to select for superior ability for both thermal adaptation and food production.**

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Research Populations – pilot data

- UF Multibreed Angus x Brahman Herd
  - Summer 2017, 2018
  - **335 cows**: from 100% Brahman to 100% Angus

Breed Group		Angus %	Brahman %
1	Angus	100	0
2	75%A	75	25
3	Brangus	62.5	37.5
4	50%A	50	50
5	25%A	25	75
6	Brahman	0	100

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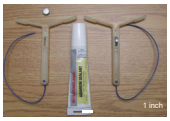
Internal Body Temperature

- Vaginal **temperature** at 15-min intervals for 5 days
- Air temperature and relative humidity - recorded continuously in the pastures

THI = (1.8 * dbt + 32)-[(0.55-0.0055*rh)*(1.8*dbt-26.8)]



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)

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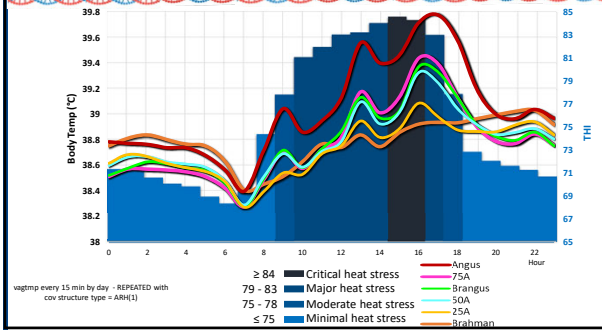
Breed effect on body temperature



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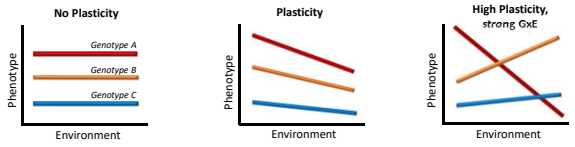
Phenotypic Plasticity

- Ability of an individual to alter its phenotype in response to changes in environmental conditions

The ability of one **genotype** to produce more than one phenotype when exposed to different environments.



Each of the colored lines is a "Reaction Norm"

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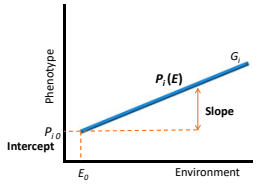
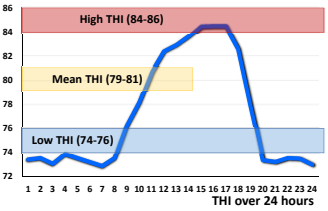
Representing reaction norms in models





Linear reaction norm

$\{P_{i0}, S\}$: intercept and slope are considered as the evolving traits.
$P_i(E)$: reaction norm is represented by a flexible function which can evolve like a trait

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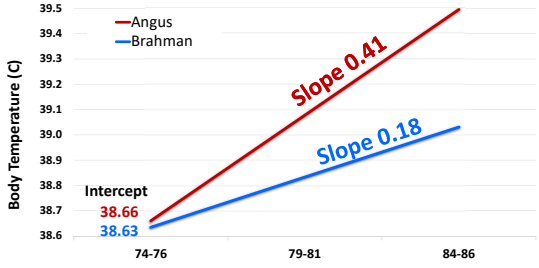
Breed effect on phenotypic plasticity



Estimate the effect of various % of **Brahman genes** on phenotypic plasticity
Use a reaction norm approach via **random regression mixed models**.

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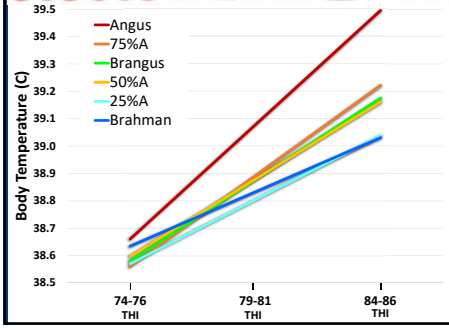
Breed effect on phenotypic plasticity



- Estimate the effect of various % of **Brahman genes** on phenotypic plasticity
- Use a reaction norm approach via **random regression mixed models**.

Breed	Intercept	Slope
Angus	38.66	0.42
75%A	38.56	0.33
Brangus	38.58	0.30
50%A	38.60	0.28
25%A	38.57	0.23
Brahman	38.63	0.20

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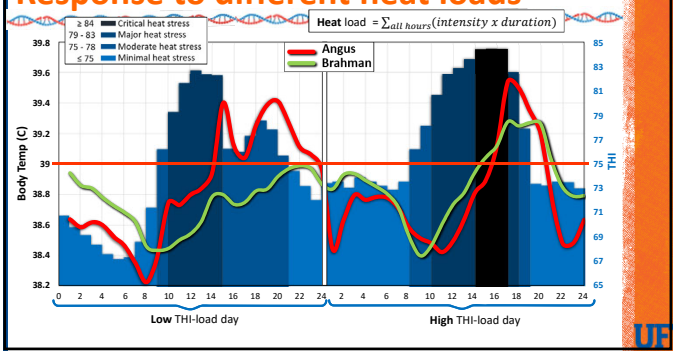
Response to different heat loads



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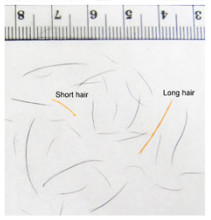
Factors important in thermotolerance

Coat Hair

Sweat Glands

Other Skin Prop.



Long Hair Length
Long Hair Diameter
Short Hair Length
Short Hair Diameter

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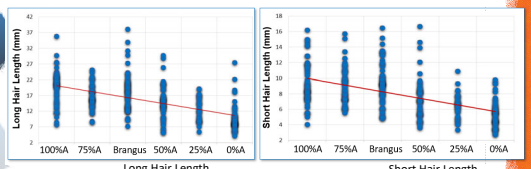

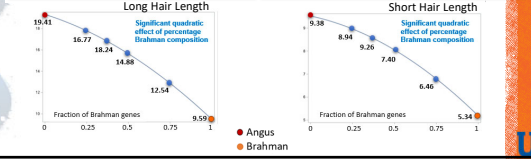

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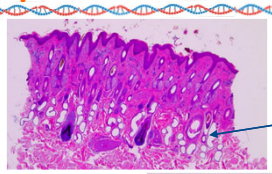
Factors important in thermotolerance

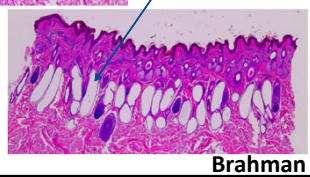
Coat Score

Sweat Glands

Other Skin Prop.



Angus



Sweat Glands

Brahman

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Factors important in thermotolerance

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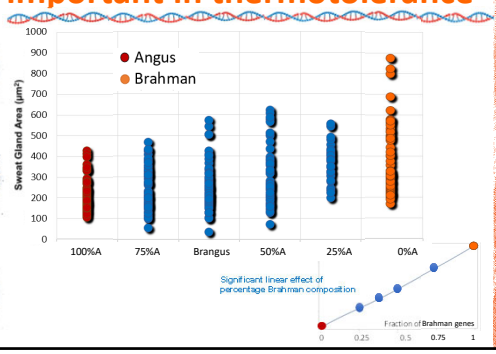

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Factors important in thermotolerance

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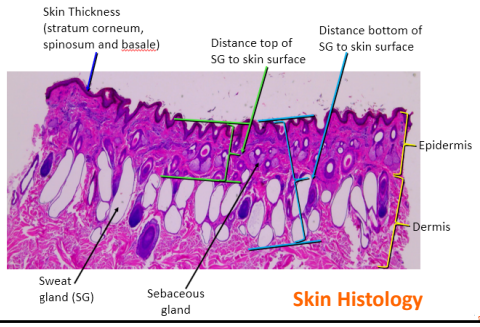

Skin Histology

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Research (Training) Population

- Brangus heifers, Seminole Tribe of Florida
  - Summer 2016, 2017, 2018
  - **2,300** two-year old heifers

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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

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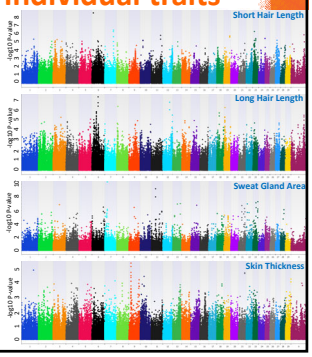
GWAS – genomic regions individual traits

- SVS (SNP & Variation Suite) v8.8.1 (Golden Helix)
  - **Mixed Model GWAS** using a single locus (EMMAX)
  - Genomic relationship matrix
  - Temperature under High and Low THI, Sweat gland area, Hair length
    - 140,467 SNPs
- Heritability estimates:
  - Temp Low THI = **0.24**
  - Temp High THI = **0.36**
  - Hair length = **0.21**
  - Sweat gland area = **0.23**



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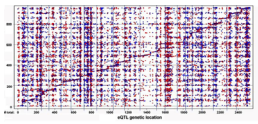
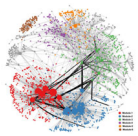
Future work

- Gene networks for individual thermoregulation and production traits
- Transcriptomics analysis of skin tissues
- eQTL analysis to reveal **genetic pathways for thermotolerance** which are independent or positively associated with production performance





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Conclusions

- Cattle with different **Brahman** percentage vary in their phenotypic plasticity of core body temperature in response to environmental heat stress.
- The thermoregulation associated traits have a genetic component (h^2 ~ 0.2 - 0.3)
- Multi-omics approach can identify **genetic pathways for thermotolerance** which are independent or positively associated with production performance

Increase **tolerance to heat stress**, while simultaneously allowing for increased **efficiency of production**.

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