Beef cattle genetics for a hotter world – current research on thermotolerance and meat quality on *B. Indicus* influenced cattle

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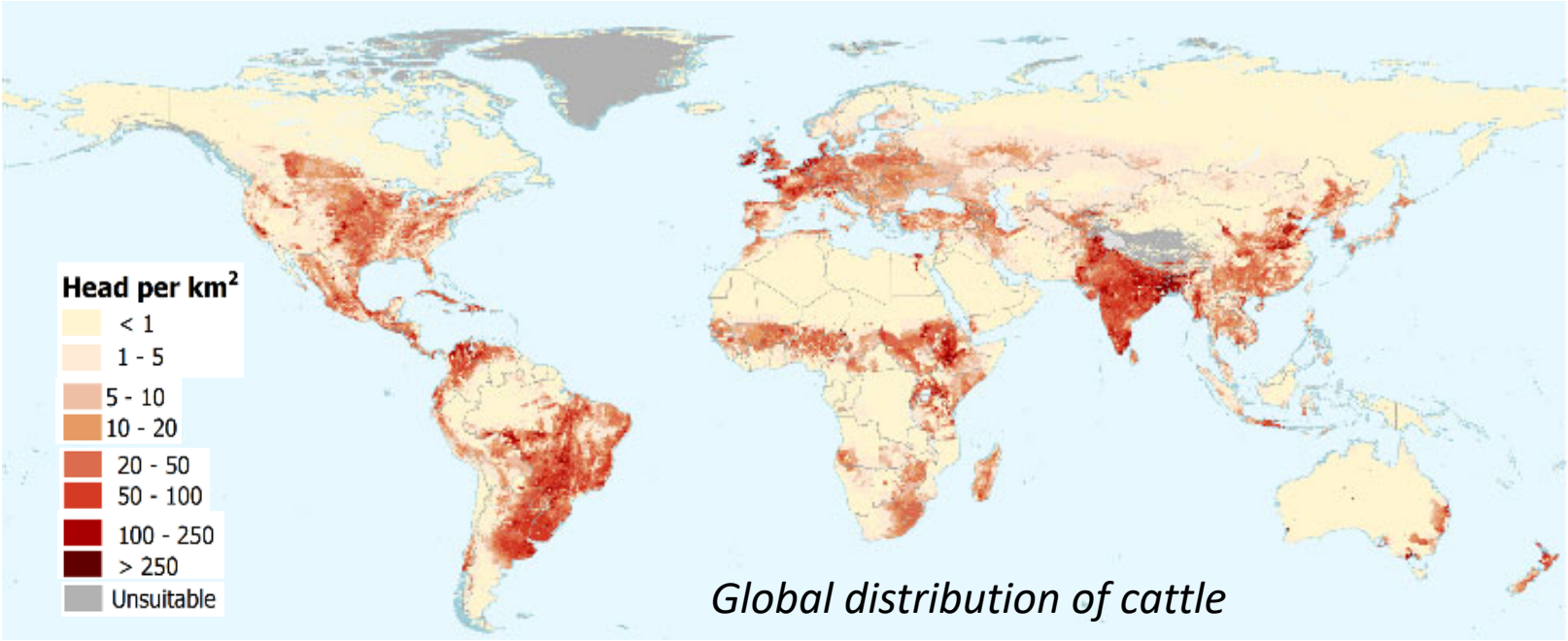
Climatic stress and beef cattle

- Major limiting factor of production efficiency
  - In beef cattle in tropical and subtropics environm.
  - 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



Global distribution of cattle

In response to extreme heat, cows 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 2017, 2018
  - **335 cows**: from 100% Brahman to 100% Angus

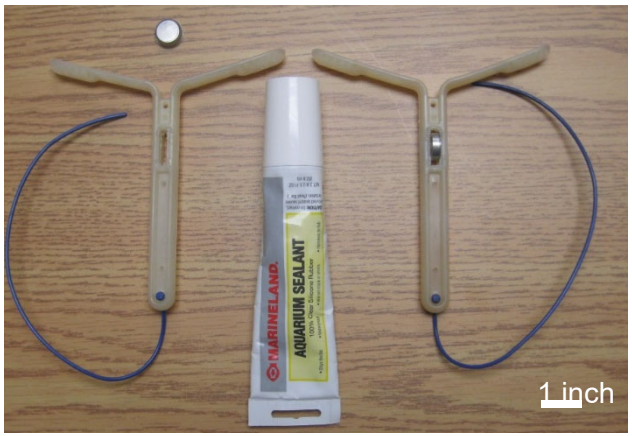
Breed Group		Angus %	Brahman %
1	Angus	100	0
2	75%A	75	25
3	Brangus	62.5	37.5
4	50%A	50	50
5	25%A	25	75
6	Brahman	0	100

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

Internal Body Temperature

- Vaginal **temperature** at 5-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)]

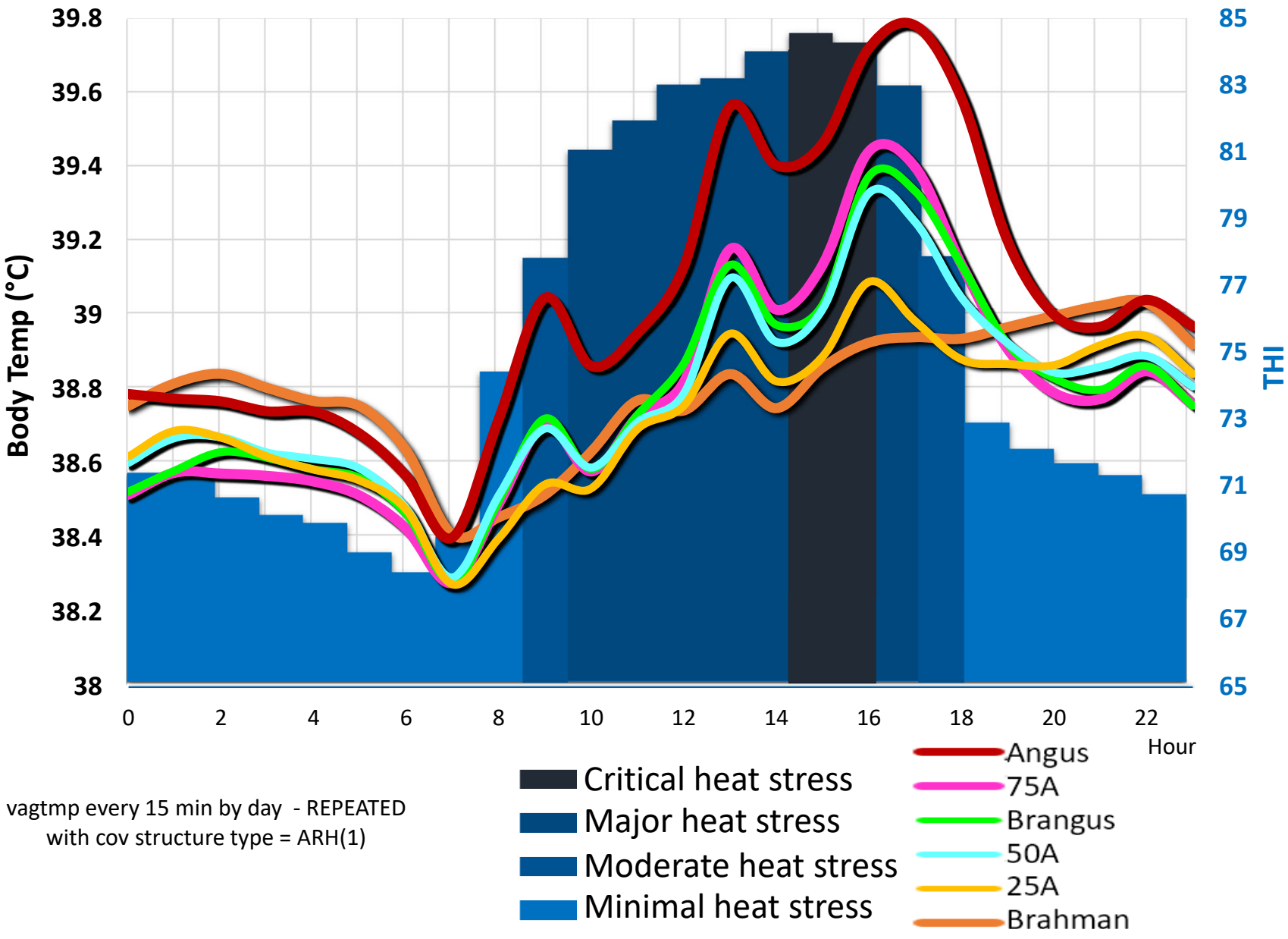


DS1922L iButton Temperature Logger - Maxim Integrated Products, 120 San Gabriel Drive, Sunnyvale, CA
Range: -40°C to +85°C
Resolution: 0.0625°C (11 bit) or 0.5°C (8 bit)

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

Breed response to THI

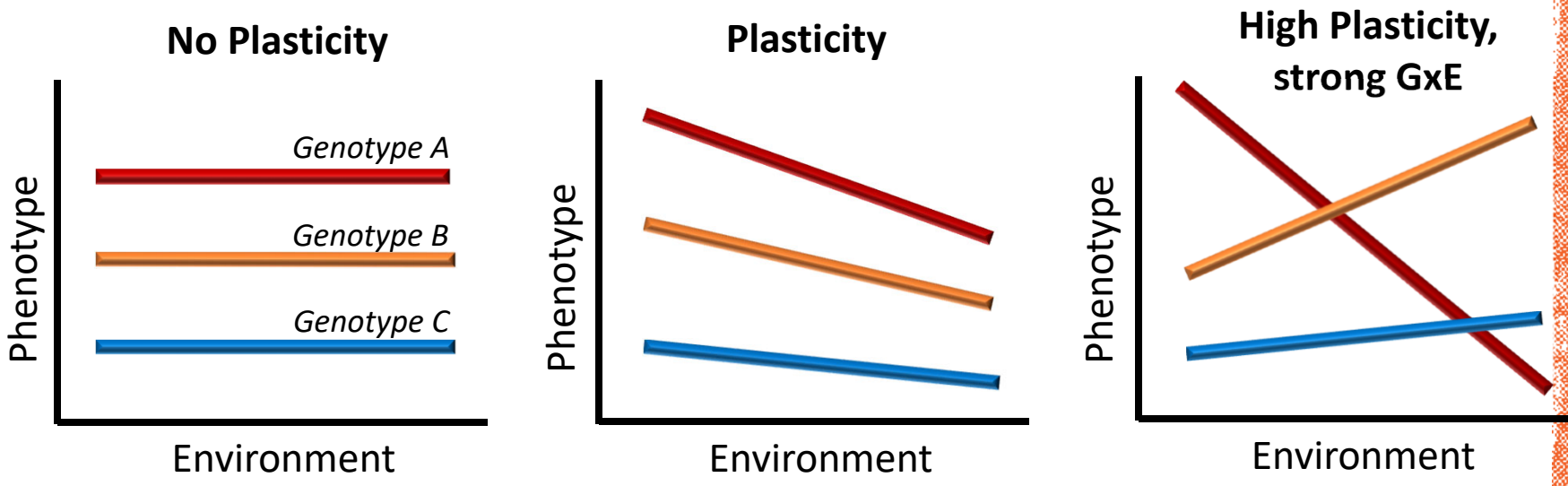


vagtmp every 15 min by day - REPEATED
with cov structure type = ARH(1)

Phenotypic Plasticicty

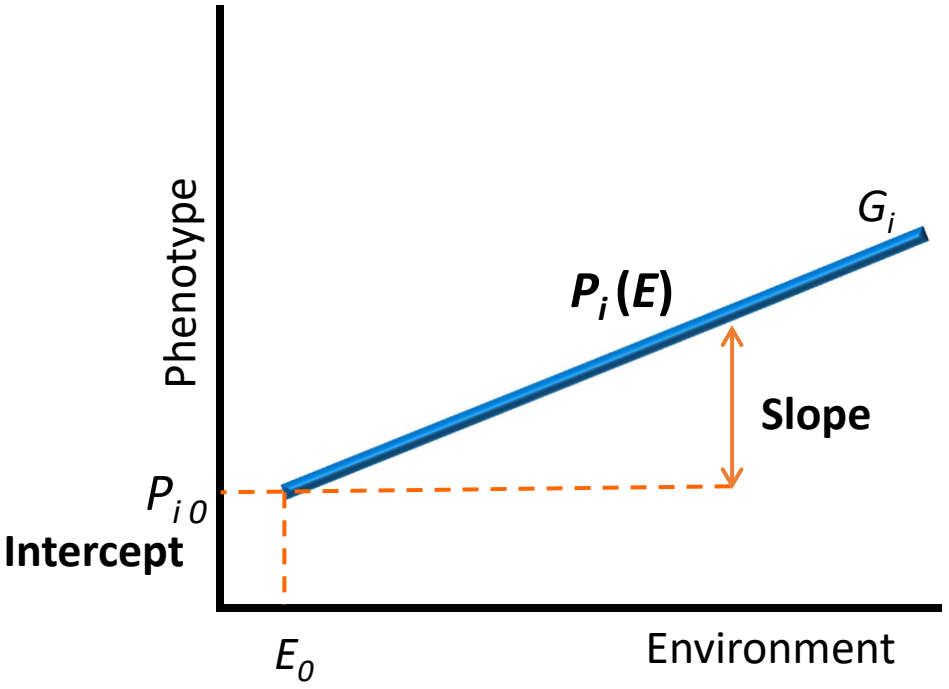
- Ability of an individual to alter its phenotype in response to changes in environmental conditions

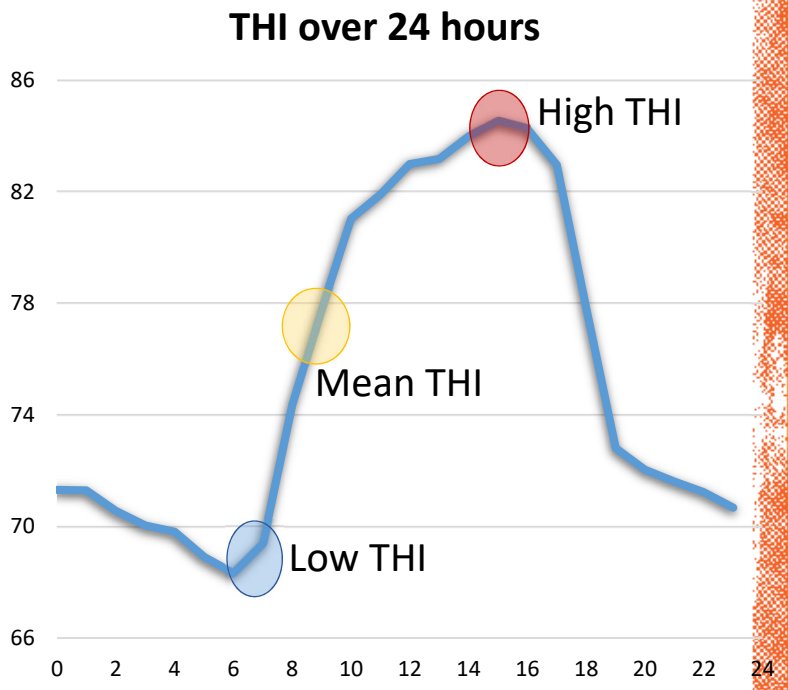
The ability of one **genotype** to produce more than one phenotype when exposed to different environments.



Each of the colored lines is a "Reaction Norm"

Representing reaction norms in models



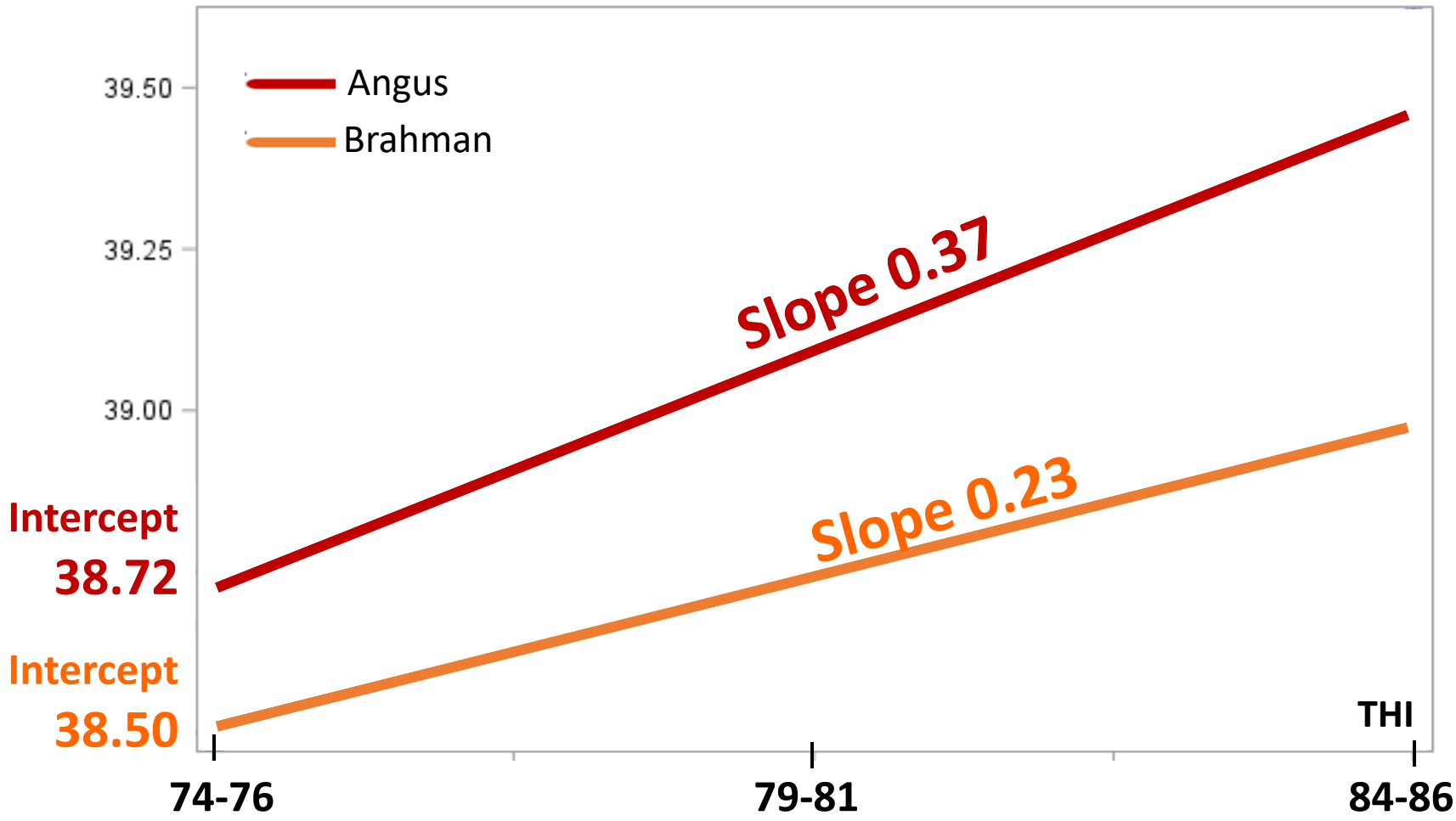


Linear reaction norm

$\{P_{i0}, S\}$: intercept and slope are considered as the evolving traits.

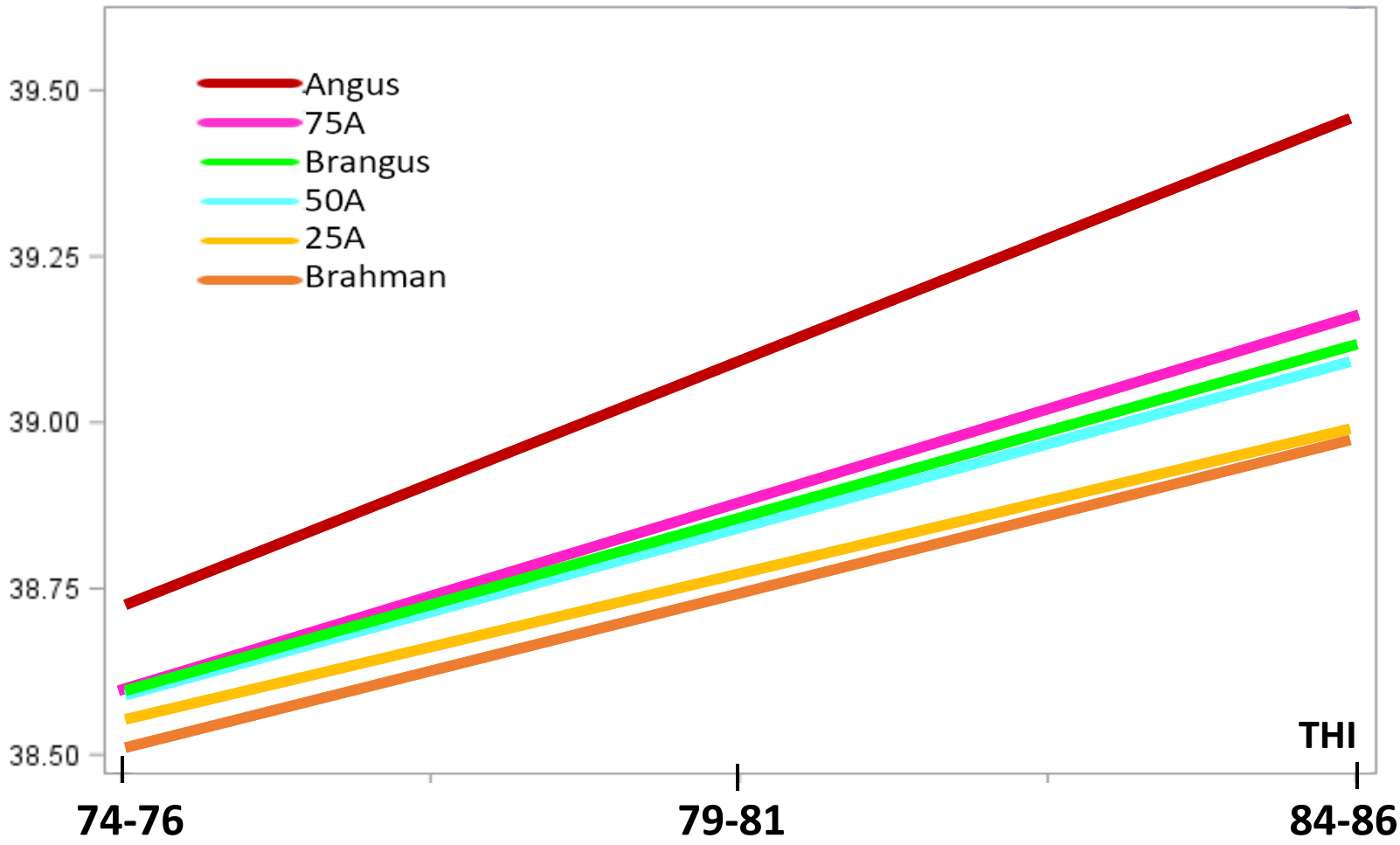
$P_i(E)$: reaction norm is represented by a flexible function which can evolve like a trait

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**.

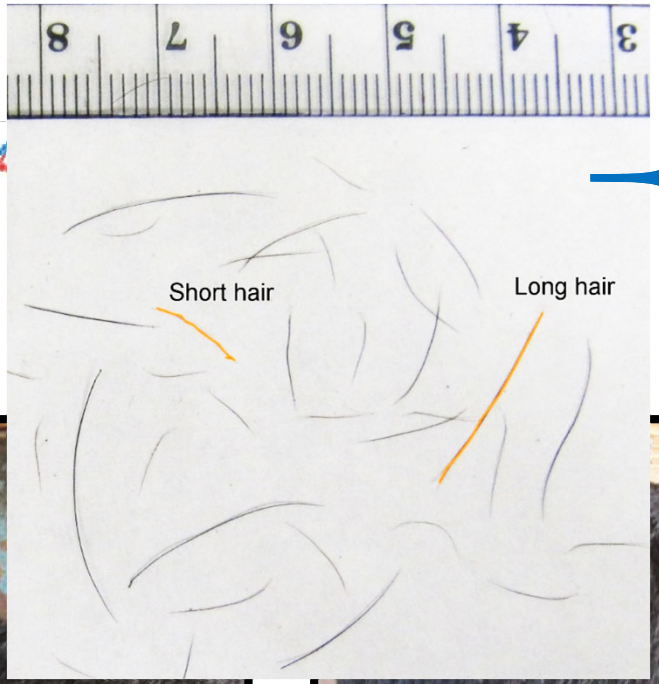
Breed effect on phenotypic plasticity



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

Coat Score

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



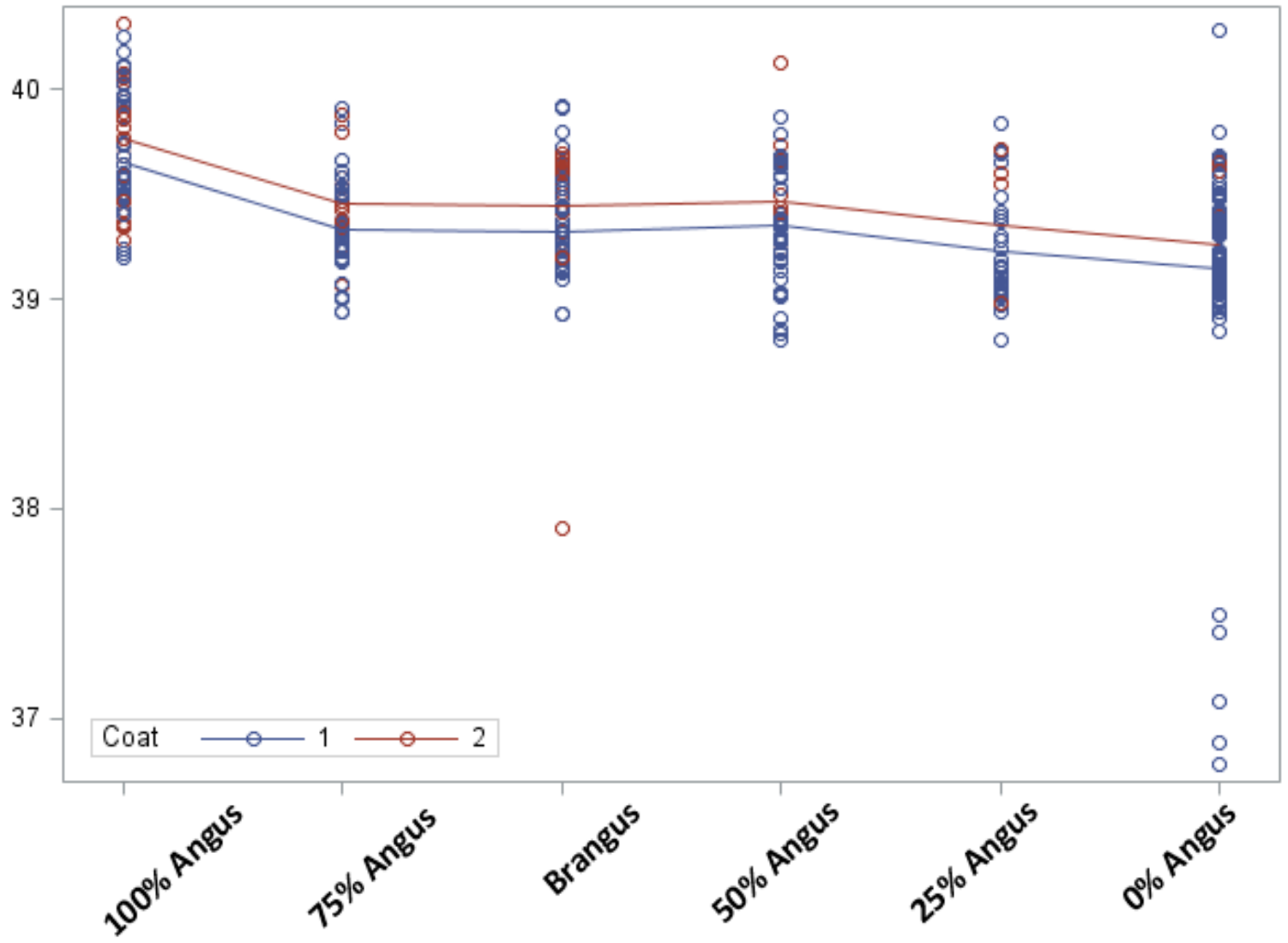
Long Hair Length
Long Hair Diameter
Short Hair Length
Short Hair Diameter

Score 1
Excessively Smooth

Score 2
Fairly Smooth

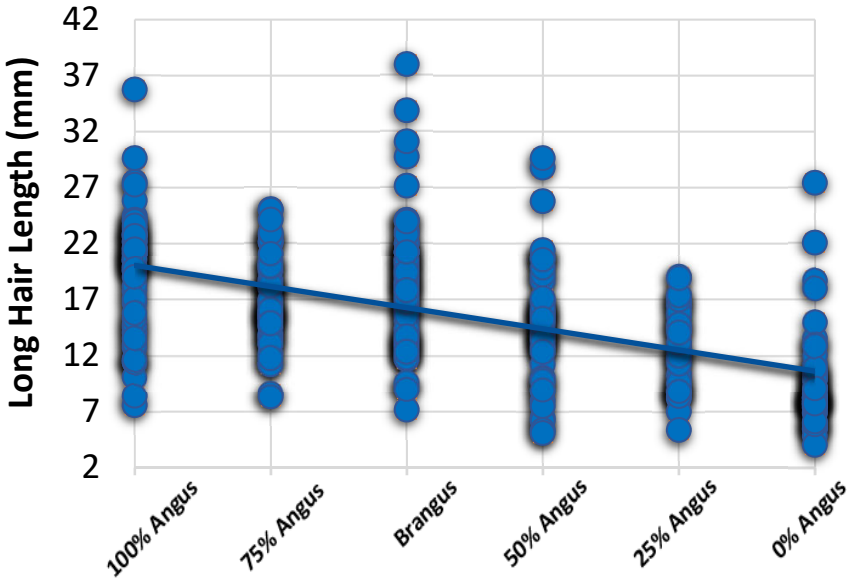
Coat score – breed effect and impact on body temperature

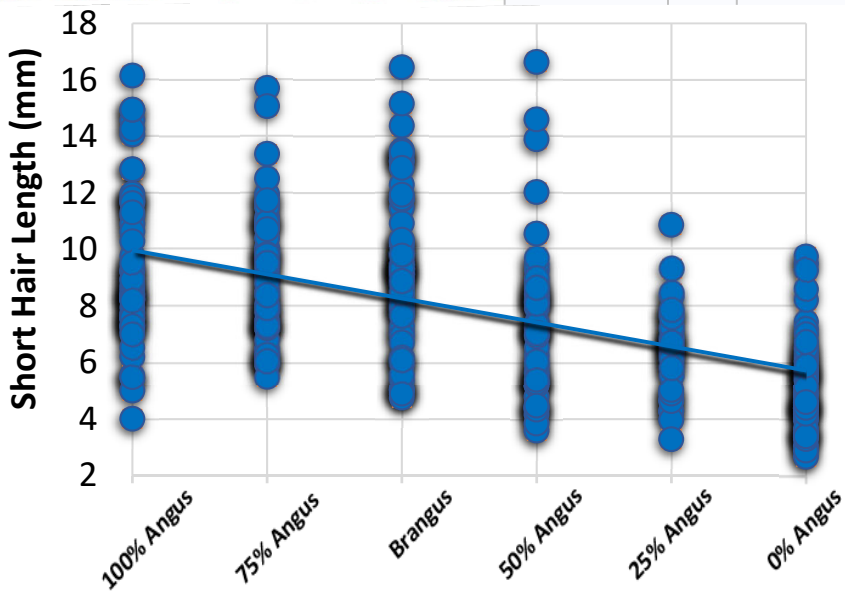
Source	DF	F Value	Pr > F
Coat	1	4.98	**0.0263**

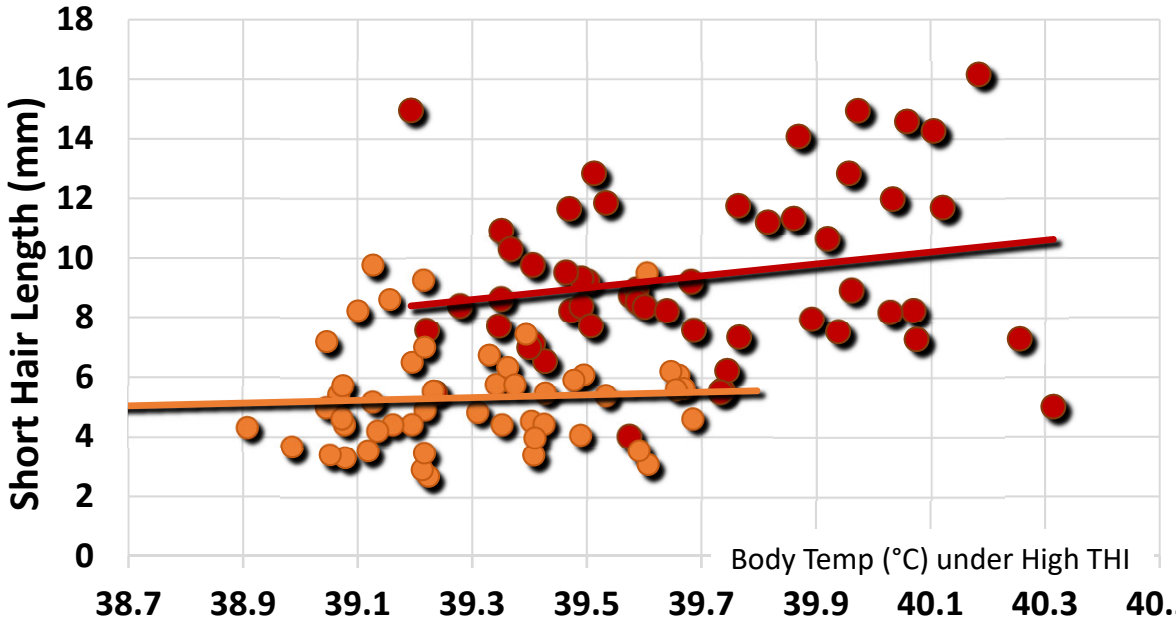


Hair length and diameter

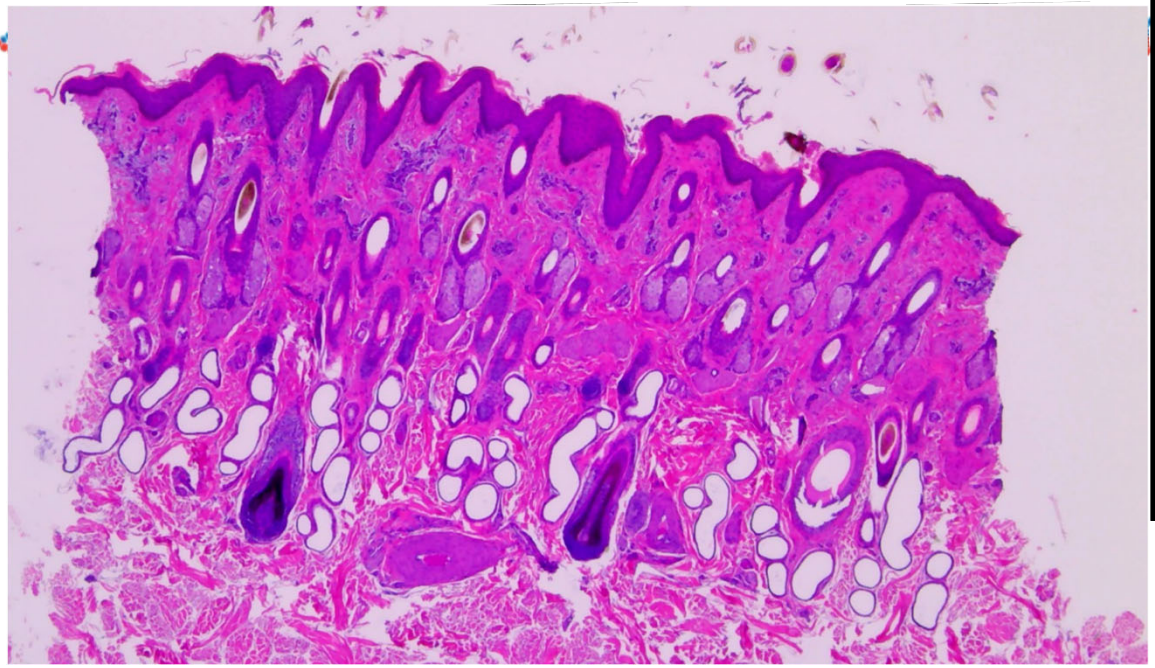
Source	DF	F Value	Pr > F
Breed	5	12.36	<.0001
ShortHair	1	4.49	0.0350





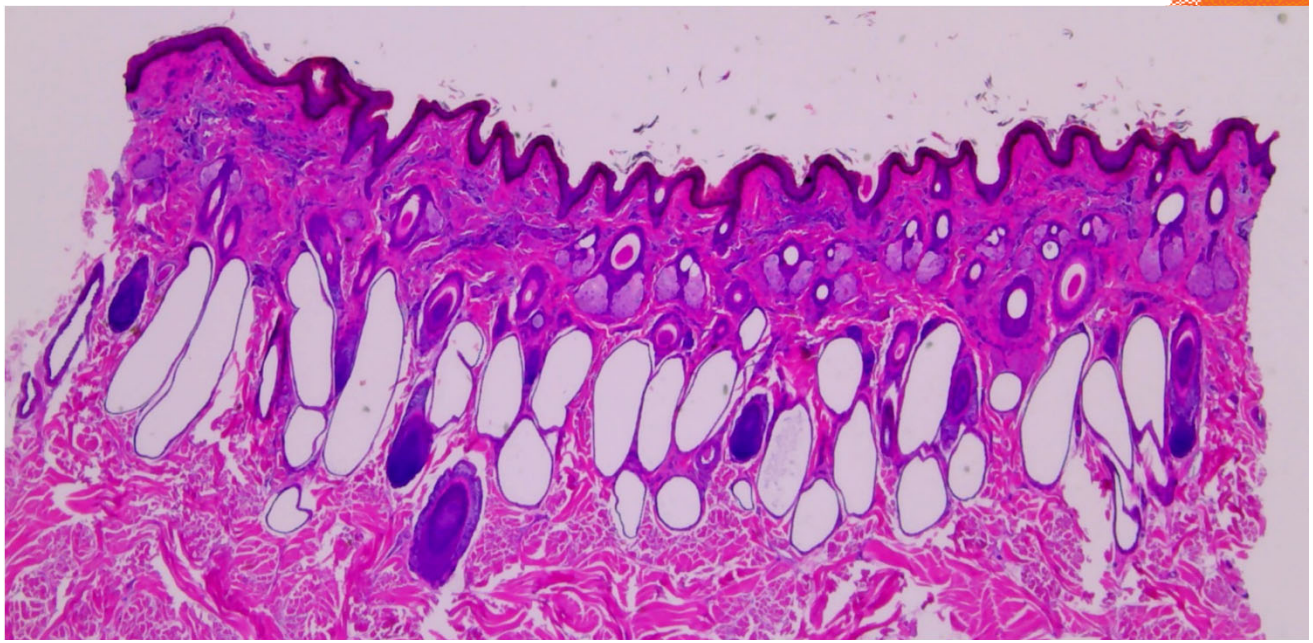


Skin histology



Angus

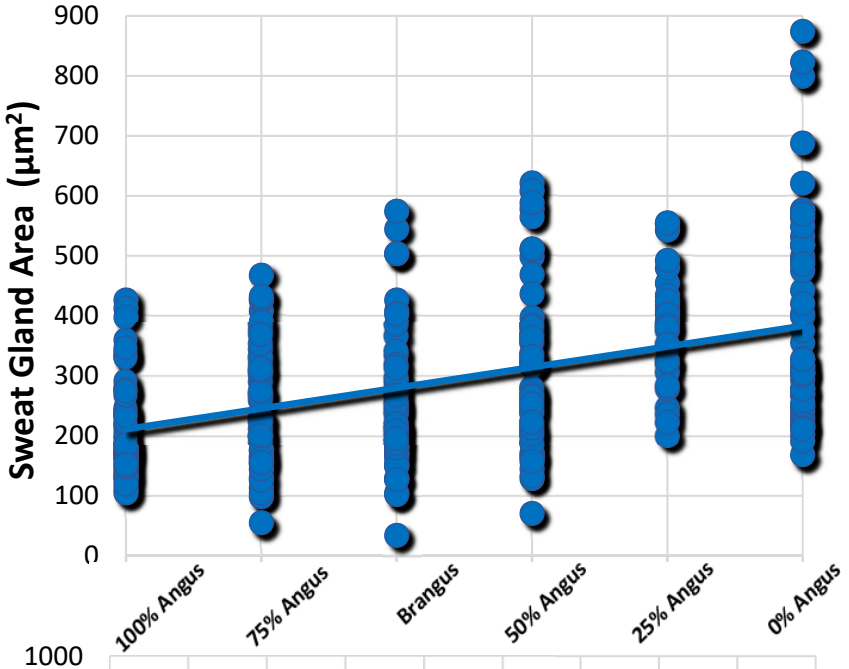
6mm biopsy in formalin
=> histology

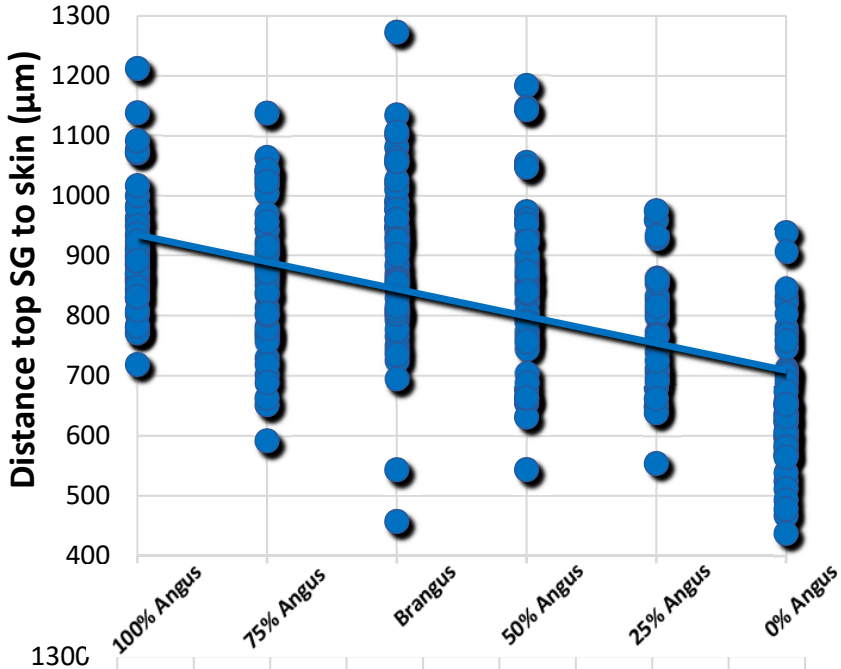


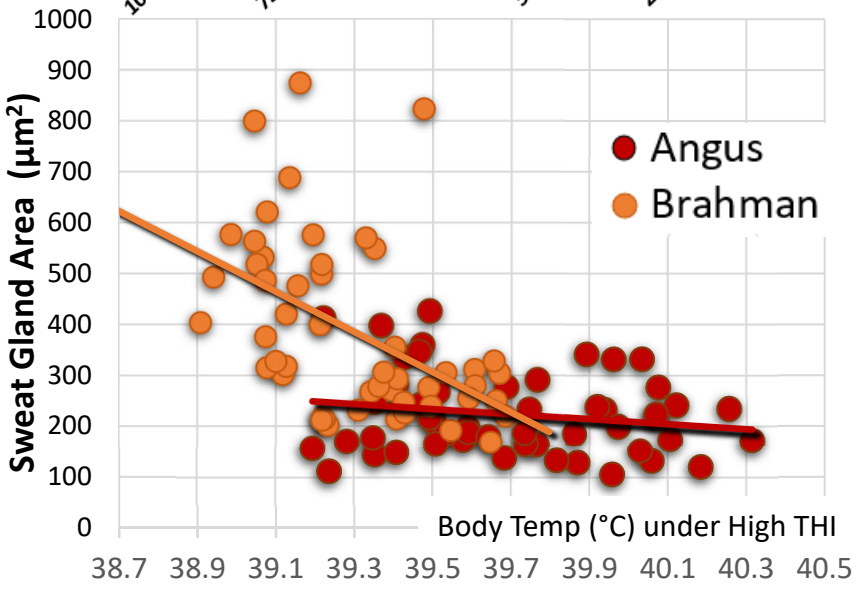
Brahman

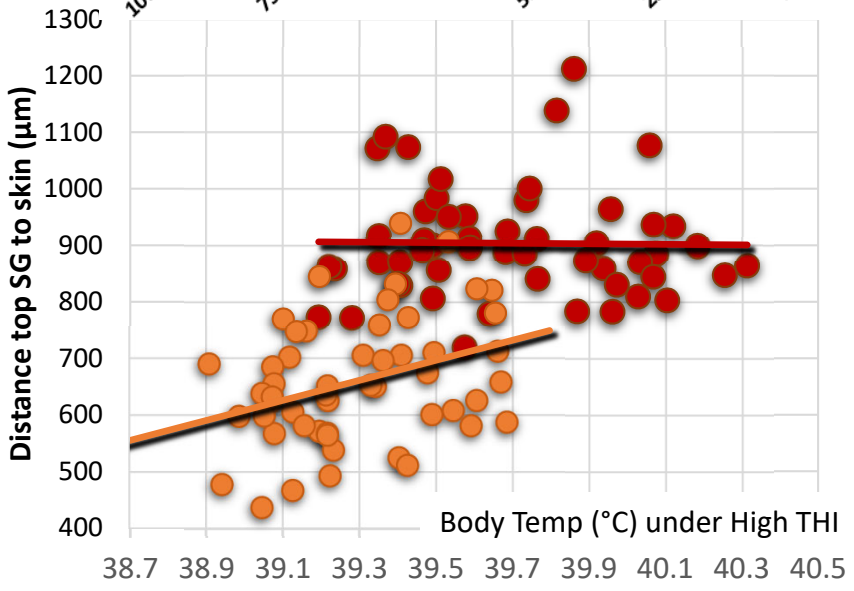
Sweat glands

Source	DF	F Value	Pr > F
Breed	5	13.42	<.0001
SweatGlandArea	1	18.40	<.0001









Genetics of thermotolerance

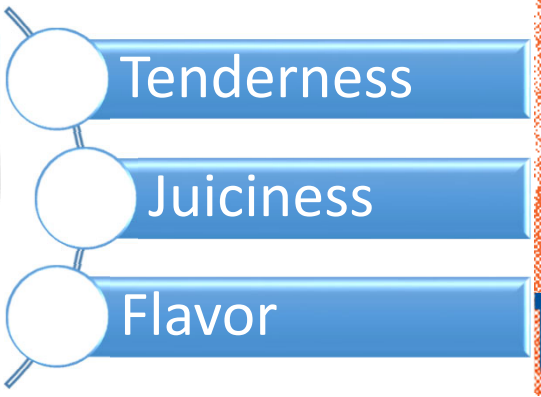
- Cow of the future: high productivity and resistant to heat stress
- Genomic selection within indicine-influenced breeds
- Gene editing for rapid incorporation into non-adapted breeds.

Reveal the **genetic architecture** of traits defining **thermal tolerance** in *Bos Indicus* influenced cattle.

Meat quality in *Bos Indicus* influenced cattle

Beef Industry Future Outlook

- Strong "**high-quality**" branded beef programs
  - Consumers are willing to pay for assured quality
- Important to maintain and increase current consumers brand loyalty (meeting and exceeding quality expectations)
- Important to **expand** consumer base
- Improving quality – critical for beef industry
- **Tenderness** – the most important sensory attribute

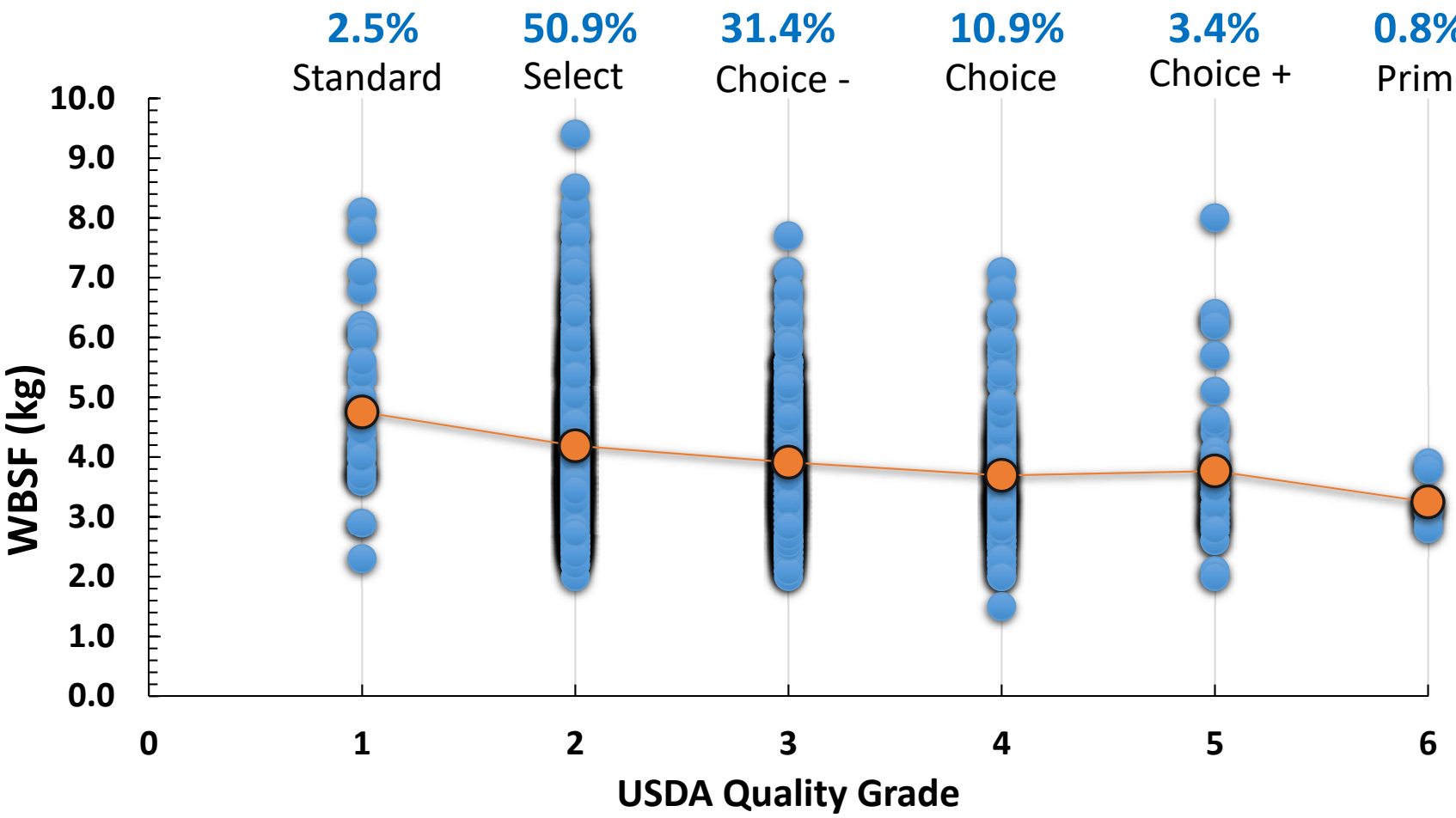


How do we communicate quality level?

- Currently USDA grading system (**marbling** and **maturity**) is used to predict **eating quality** of beef
  - Limitation in the ability to predict eating quality
  - Limited consumer understanding of the system

Higher quality grade = **more tender** and palatable meat

Tenderness by USDA Quality Grade

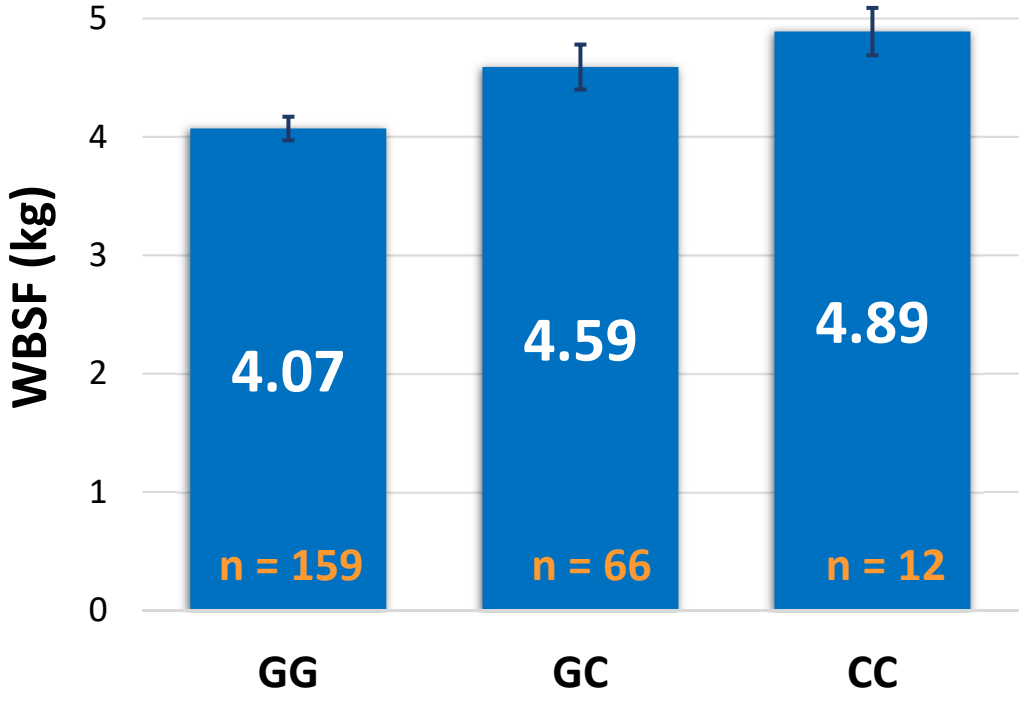


UF Angus x Brahman

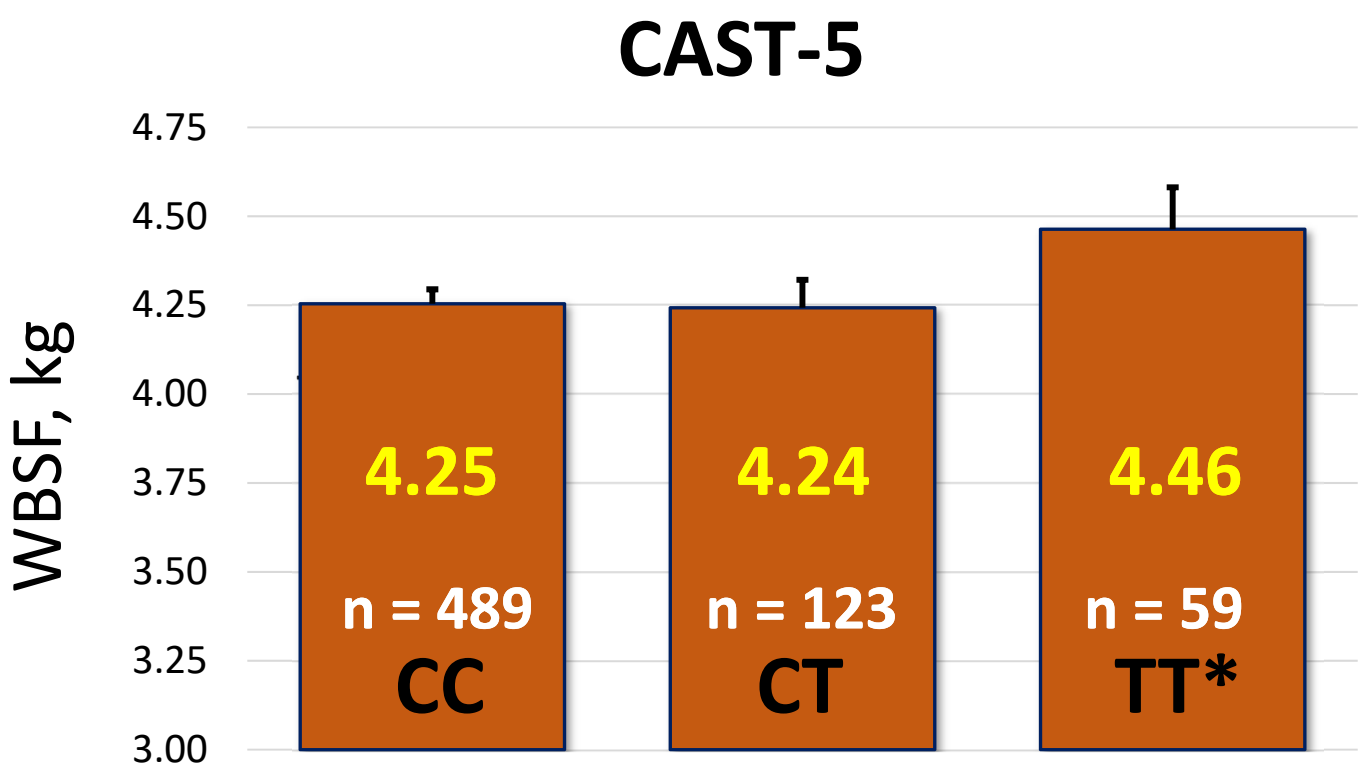
(N = 1,253)

Tenderness - calpain

- CAPN1-316 = marker for tenderness
- One of the SNPs in the **GeneStar** Tenderness test
  - **GG** was **1.10** kg **tougher** than GC *(Pinto et al., 2010)*
  - **GG** was **0.36** kg **tougher** than GC *(Curi et al., 2010)*
  - **CC** is **1.23** kg **tougher** than CG *(UF multibreed pop., Casas et al., 2010)*

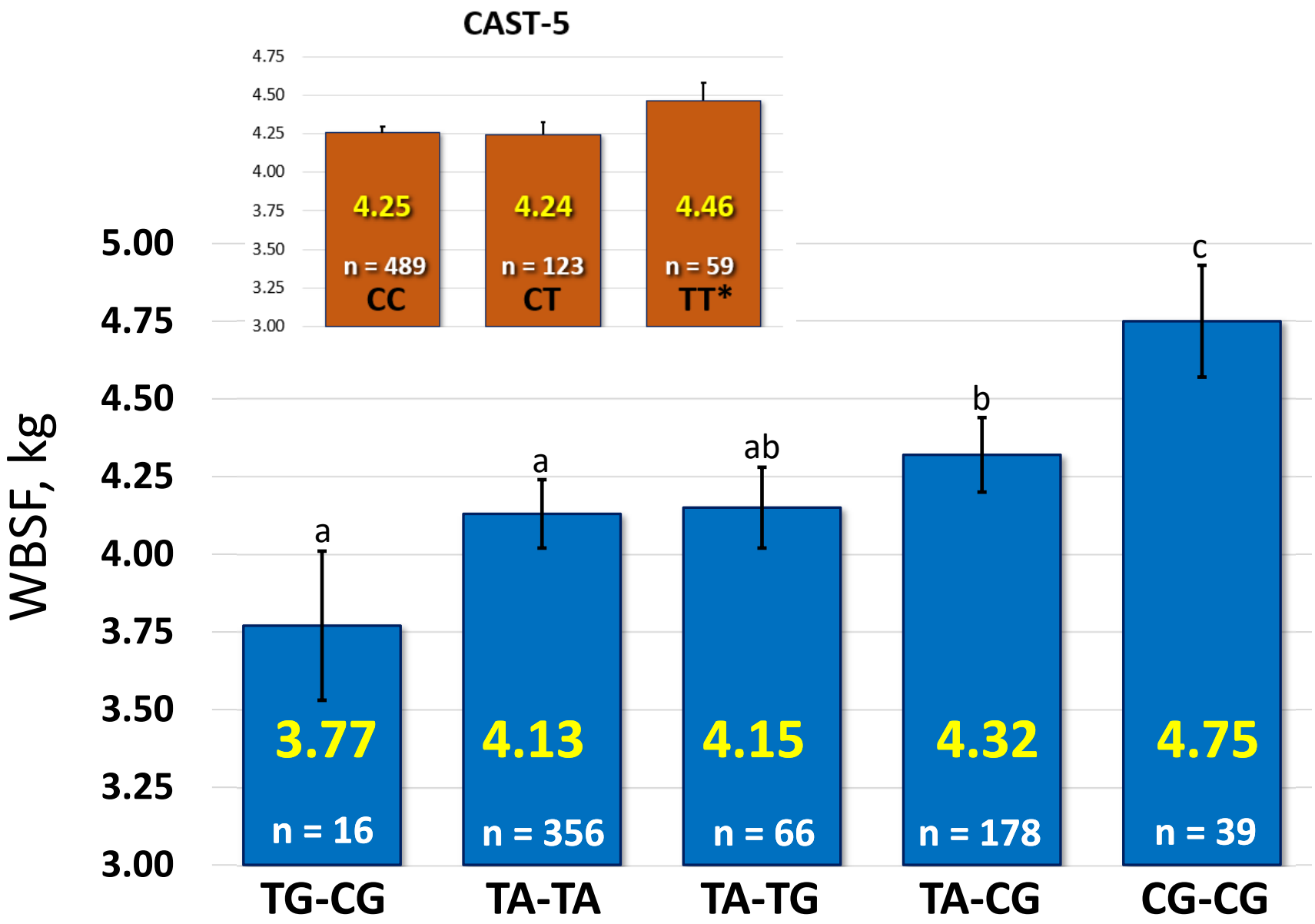


Effect of known CAST markers



UF Angus x Brahman (N ~ 670)

Marker combination for calpastatin



Breed-specific genomic tools

- To meet consumer expectation, the average **tenderness** needs to be **improved** and the **variation** in meat tenderness must be **controlled/managed**

- To be effective - genomic tools need to be developed in the **target** populations

Large resource populations with phenotypes are required for discovery and estimation.

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