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

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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

Research Populations

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

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

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

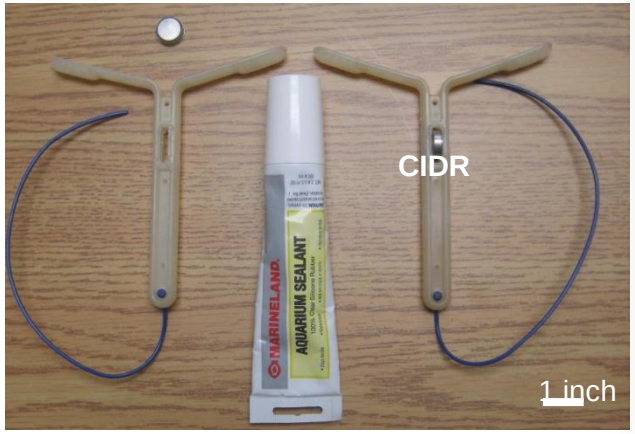
Internal Body Temperature

- 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



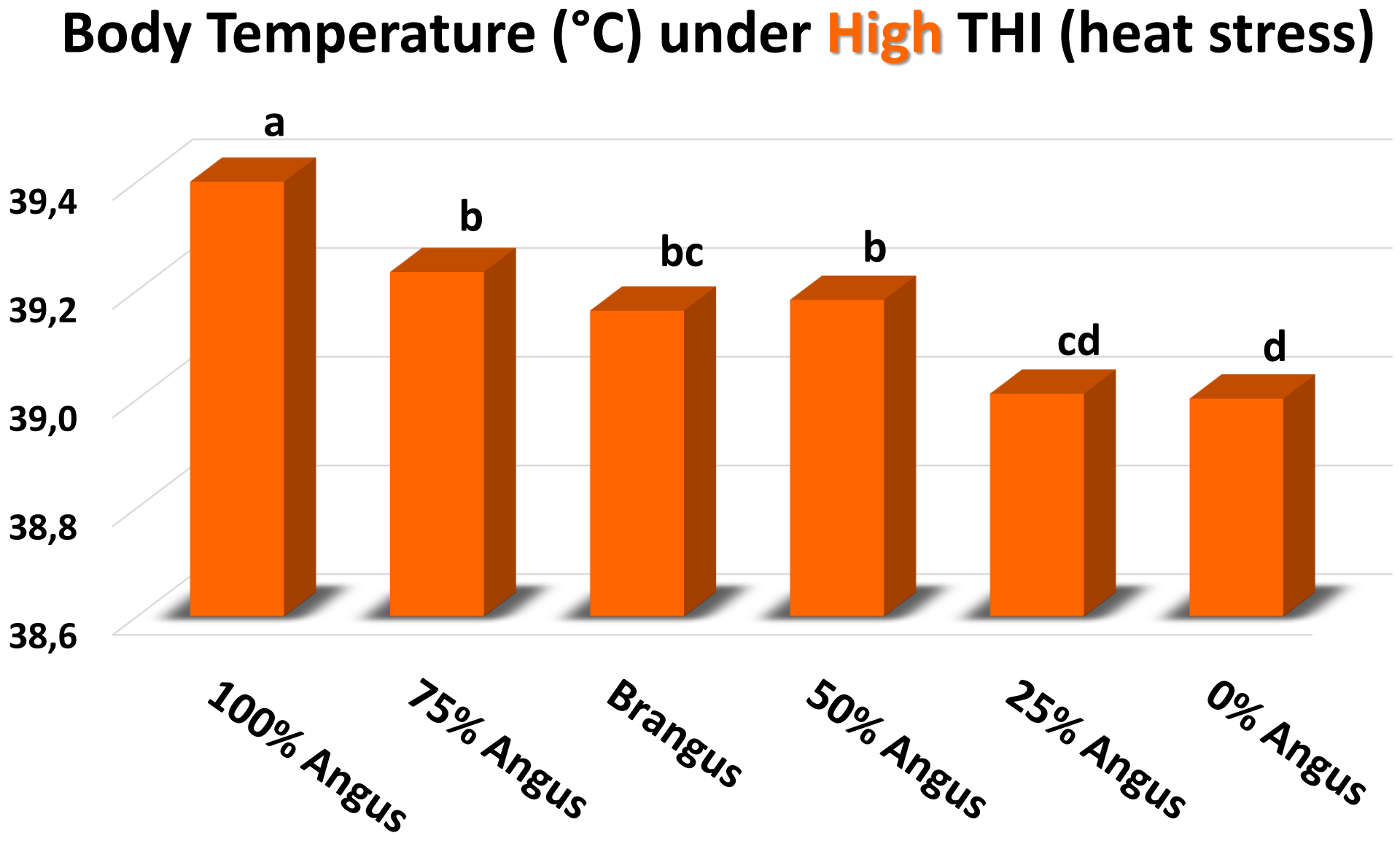
Thermotolerance measurements

- 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

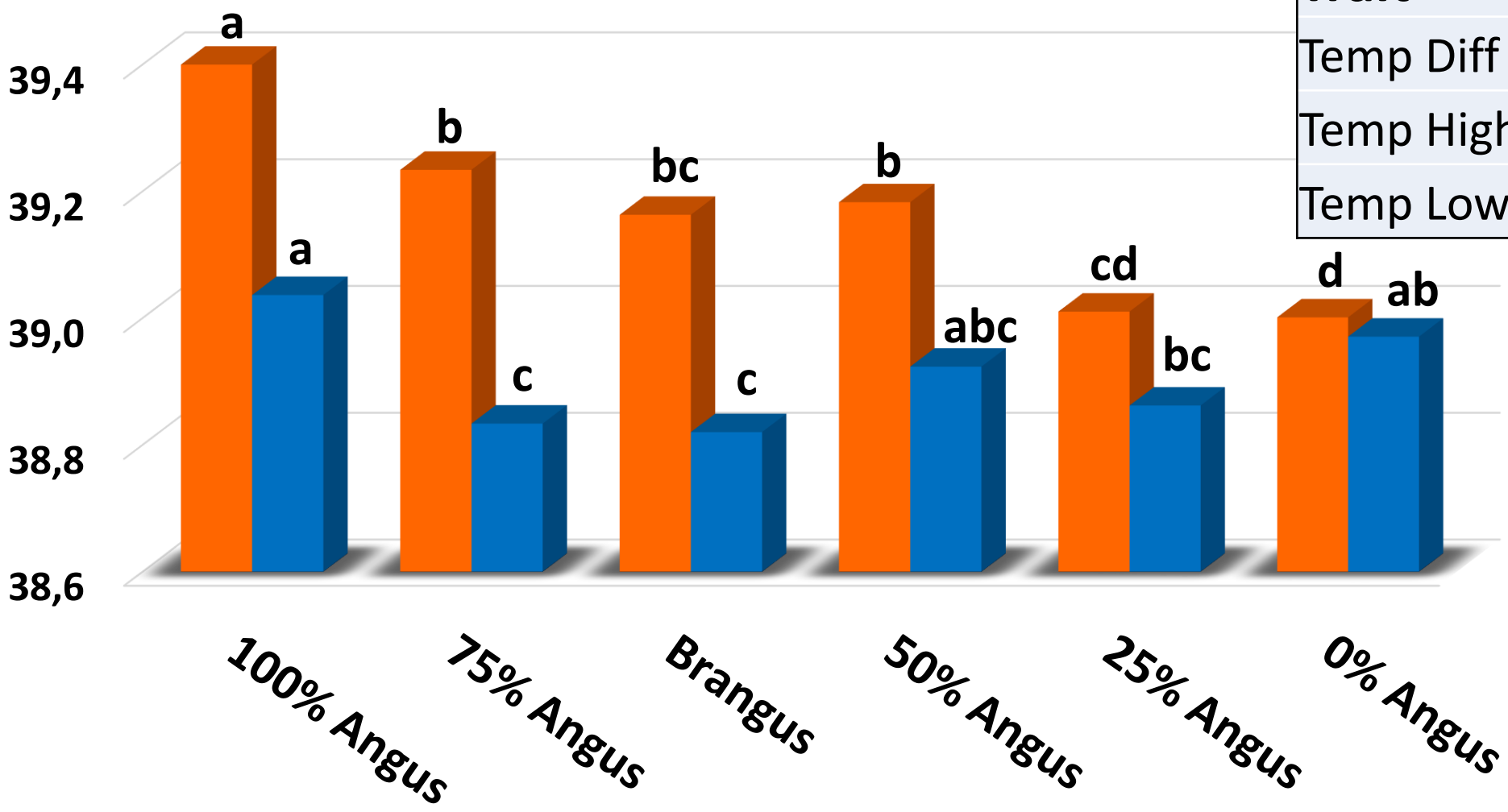
- **Low** THI: **74** and **76**
- **High** THI: **84** – **86**
- **Average** THI: **79** – **81**
- Vaginal temperature for each cow Low, High, Avg. = **average temp of all the 5-min** measurements when the cow was exposed to that respective THI.
- Diff THI: High-Low THI

Effect of breed composition on body temp



Effect of breed composition on body temp

Body Temperature (°C) under High and Low THI



Trait	h^2
Temp Diff Hi-Low	0.27
Temp High	0.11
Temp Low	0.25

Thermotolerance in Brangus

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

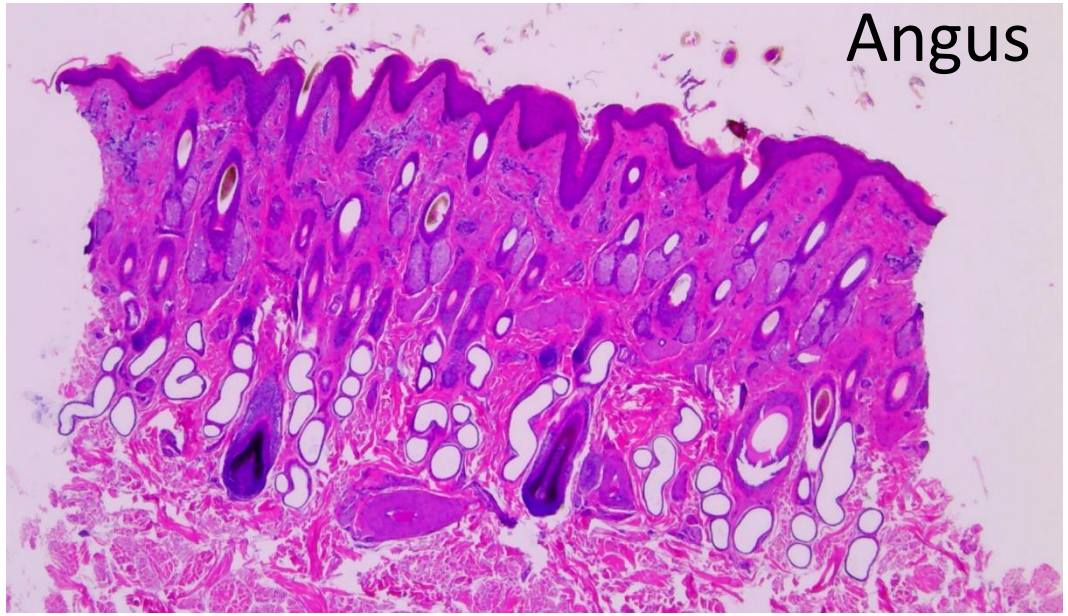
Score 1
Excessively Smooth
N = 526

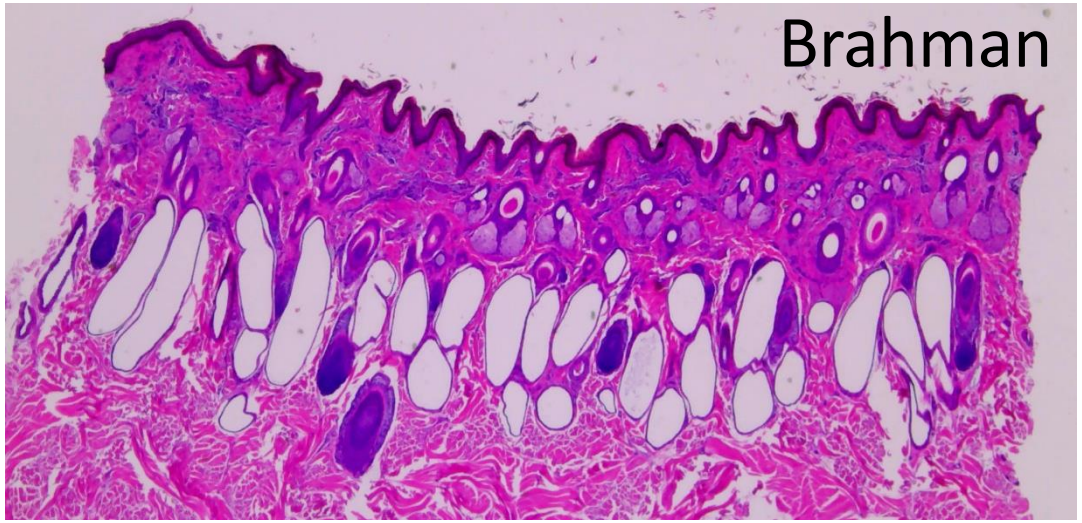
Score 2
Fairly Smooth
N = 197

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

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

Skin histology

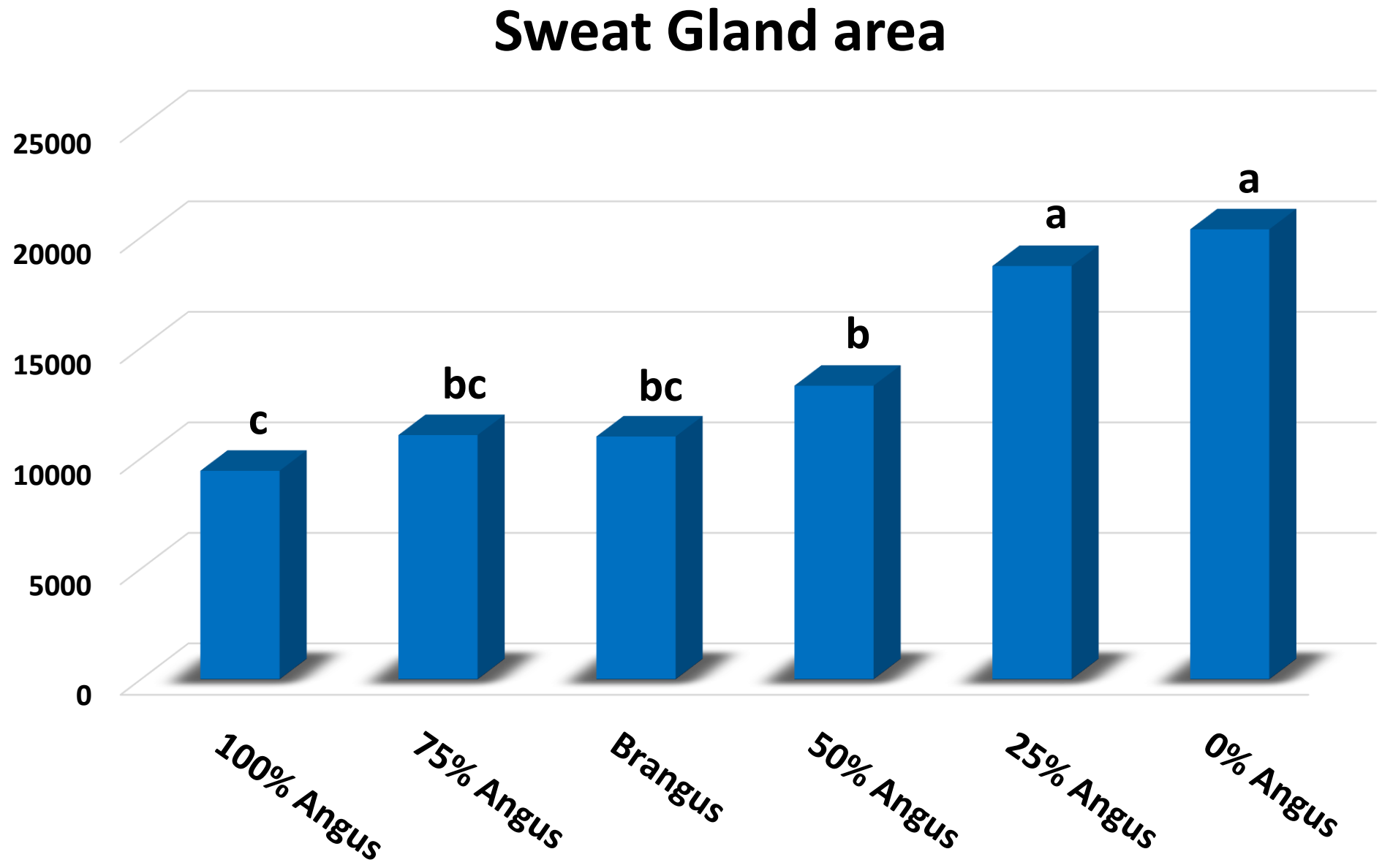




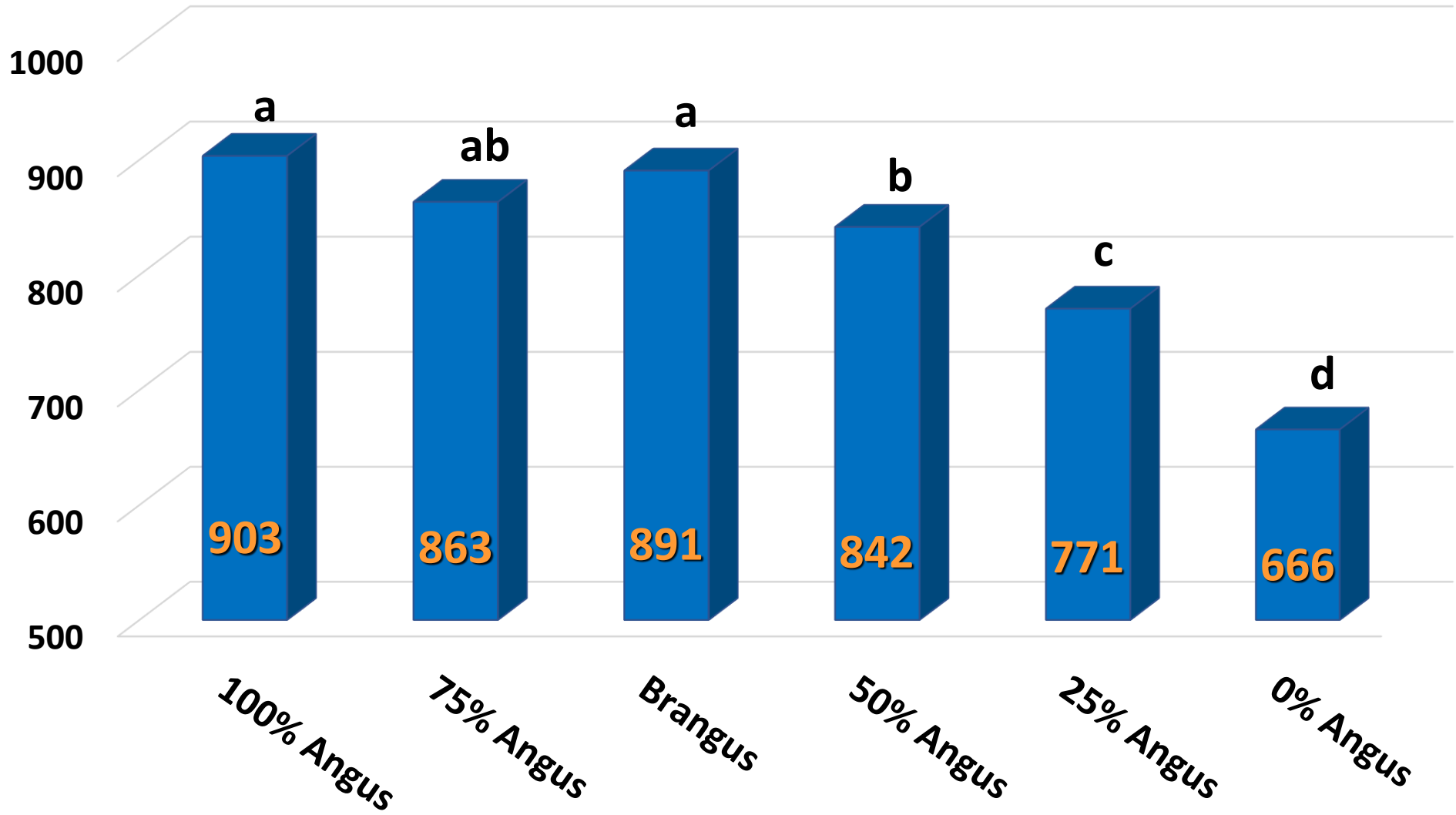
6mm biopsy in formalin => histology

- **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



Distance from the top of the SG to the skin surface



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