

# Host susceptibility of cattle to horn flies: genetics and phenotyping strategies

John Keele

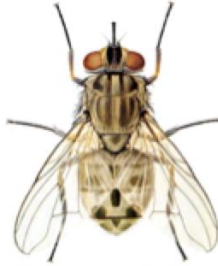
USMARC





From Greenberg's "Flies and Disease"

**House fly**  
*Musca domestica*



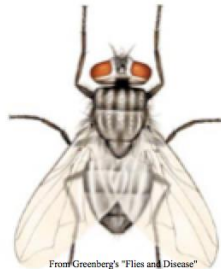
From Greenberg's "Flies and Disease"

**Stable fly**  
*Stomoxys calcitrans*



From Greenberg's "Flies and Disease"

**Horn fly**  
*Haematobia irritans*



From Greenberg's "Flies and Disease"

**Face fly**  
*Musca autumnalis*



# Possible Genetic Mechanisms for Resistance of Cows (host) to Horn Flies

- Genetic differences in thrombin
  - Different bovine thrombin isoforms might interact differently with hornfly salivary thrombostasin (anticoagulant)
  - Also there are many proteins in the blood clotting pathway which are potential candidates for interacting and potentially resisting the influence of thrombostasin.
- Immunity
  - Acquired
  - innate
- hair follicle density
  - Follicles and sebaceous glands may provide a physical barrier to horn fly predation.

ARTHROPOD/HOST INTERACTION, IMMUNITY

**Salivary Gland Thrombostasin Isoforms Differentially  
Regulate Blood Uptake of Horn Flies Fed on Control- and  
Thrombostasin-Vaccinated Cattle**

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DUNHUA ZHANG,<sup>1,6</sup> XIN YUE,<sup>1,7</sup> LATORA TODD,<sup>1,8</sup> AND VICTOR  
PANANGALA<sup>4,9</sup>

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# Thrombostasin inhibits blood clotting.

- Horn fly feeds by creating injury from which cow bleeds. Anti-clotting factors allow fly to feed on blood.
- Cupp et al. (Auburn) isolated thrombostasin from horn fly saliva.
- Made a recombinant protein which they used to make a vaccine.
- Response of cow to vaccine reduced fly's ability to feed and reproduce.
- Vaccination of cows with one thrombostasin isoform had reduced impact on flies with a different isoform relative to flies with the same isoform the cows were vaccinated with, host pathogen interaction.

*Medical and Veterinary Entomology* (1997) **11**, 257–264

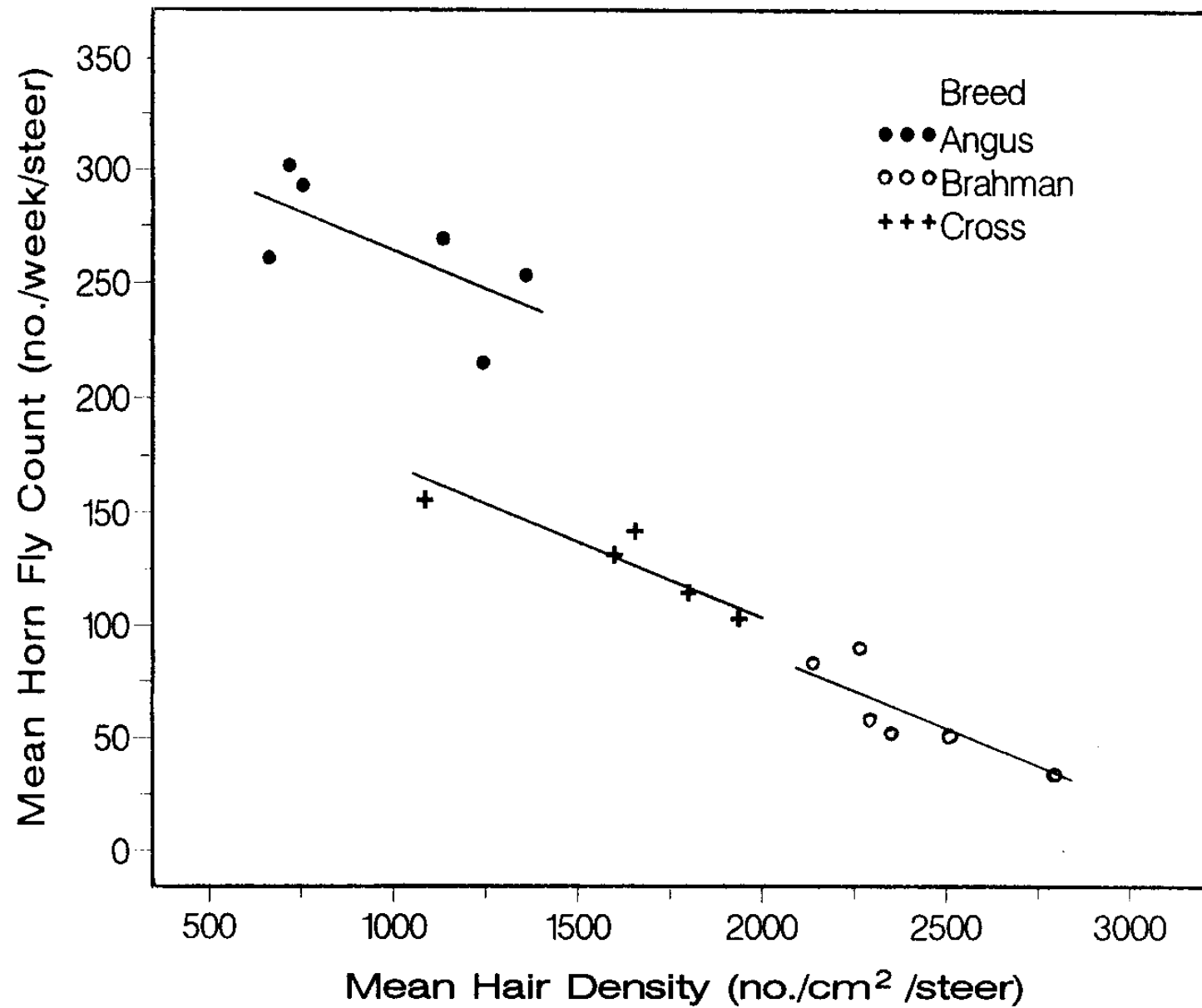
# **The effects of hair density of beef cattle on *Haematobia irritans* horn fly populations**

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**Fig. 2.** Regression of mean hair density on mean horn fly numbers for the three breeds of cattle at Booneville, Arkansas. Estimated slopes and intercepts for the fitted lines are given in Table 2.



# 20123623 Example 1, right side

245 horn flies



Original



Annotated

20123623 example 2, left side

385 horn flies



Original



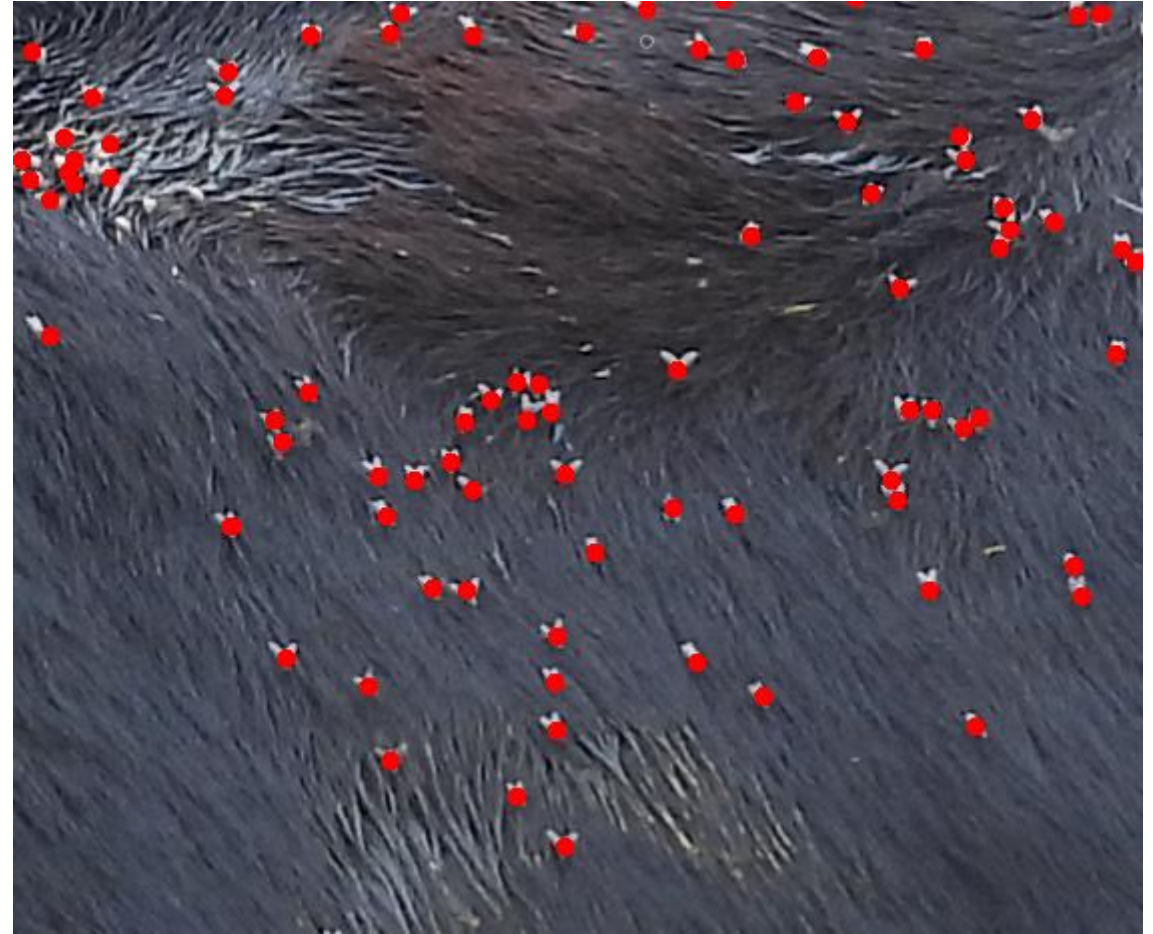
Annotated

# Multiple pictures of one animal on both sides

<b>Cow 20123623</b>	<b>Side of Cow</b>	<b>Annotated Count</b>	<b>Time of Picture</b>
Example 1	Right	245	8:28 A.M.
Example 2	Left	385	8:42 A.M.
Example 3	Right	385	9:29 A.M.
Example 4	Left	367	9:33 A.M.
Example 5	Left	679	9:39 A.M.

# 385 horn flies







# Stringency of neural network effect on number of horn flies detected per cow

Stringency	Mean number of horn flies detected
0.3	462
0.5	191
0.7	160

The higher the stringency, the fewer incorrect or false fly detections and more flies are missed or not detected.

# Effect of stringency of horn fly detection on estimates of heritability and proportion of permanent environment

Source of Variation	Neural Network Stringency		
	0.7	0.5	0.3
Additive Genetic	0.146±0.029	0.158±0.030	0.020±0.016
Permanent Environment	0.201±0.029	0.213±0.030	0.038±0.018
Temporary Environment	0.652±0.014	0.629±0.014	0.942±0.011

8,524 pictures of 2,978 cows. Cows are crossbreds from 18 breeds, 3 composites and Angus. Neural network trained from 291 annotated pictures.



Proportion of variation attributable to genetic and environmental effects based on manual annotation of horn flies.

Source of Variation	Estimate±SE
Additive Genetic	0.135±0.094
Permanent Environment	0.356±0.093
Temporary Environment	0.509±0.029

1,523 pictures of 727 cows. Cows comprise 18 breeds, 3 composites and Angus.

# Heritability and Genetic and Environmental Correlations

	Hair (10 sons)	Fly (10 sons)	Log <sub>10</sub> No Flies
Hair	0.757±0.214	0.825±0.196	-0.514±4.609
Fly	-0.496±0.722	0.712±0.223	0.062±4.761
Log <sub>10</sub> No. Flies			0.186±0.063

If we had one observation on the herd sire then what would the heritability be?

Hair Follicle Density Score = 0.95

Fly Score = 0.79

# Sources of variation for $\log_{10}$ of horn fly counts

Source of Variation	$\log_{10}$ fly count	Percentage of Variance
Additive Genetic	0.03519±0.01406	30.87±10.47
Dominance	0.01550±0.02121	13.60±18.23
Permanent Environment	0.01037±0.02182	9.10±19.46
Temporary Environment	0.05294±0.00221	46.44±4.13

1,465 pictures from 165 animals at Livestock Arthropod Pest Research, Kerrville, Texas between 2002 and 2005; Pia Olafson and John Pruett. There were between 6 and 19 pictures per animal; most animals (124 out of 165) had 8 pictures. Most of the calves were sired by 2 genetically identical Simmental x Red Poll bulls produced by embryo transfer. The embryos split naturally; they were not engineered to do that.

# Conclusions and future Research

- Genetic differences in cattle for susceptibility to horn flies; carrying capacity of horn flies
- Multiple possible mechanisms of genetic variation in horn fly carrying capacity. Most likely polygenic.
  - Host pathogen interaction between horn fly thrombostasin and bovine blood clotting system; thrombin and other proteins in pathway.
  - Hair follicle density and possibly sebaceous glands
  - Coat color and color pattern
  - Hair shedding
- Data collection at USMARC
  - Took ~10,000 pictures of over 2,000 cows in 2019.
  - 1,500 pictures of 727 cows annotated to improve training of neural network
  - Genotypes and haplotype data on most GPE and SFA population

# Feasibility of selection for resistance to horn flies in registered cattle

- Exploit large database of pedigree and SNP genotypes
- Take pictures of horn flies on cattle geographically distributed across the United States.
- Estimate heritability, breeding values and genetic and environmental correlations with production traits.
- Identify Chromosomal or gene associations with horn fly resistance.
- Amazon Mechanical Turk and crowd sourcing to annotate horn flies on images.
- Annotations to train a neural network to rapidly automate fly counting on images that haven't been annotated.
- Benefit of a properly trained neural network would be reducing the amount of manual annotation required. 1 or 2 seconds per fly for manual annotation.
- More skilled photographers in the world than skilled entomologists.

# Thanks!

- Summer Interns
  - Shanon Park, Texas A&M at Commerce
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  - Emma Rients, Southern University of Illinois
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- Becky Trout Fryxell, University of Tennessee
- Dave Taylor, ARS, Lincoln NE
- Kristina Friesen, ARS, Lincoln NE