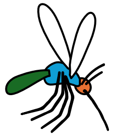
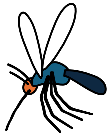
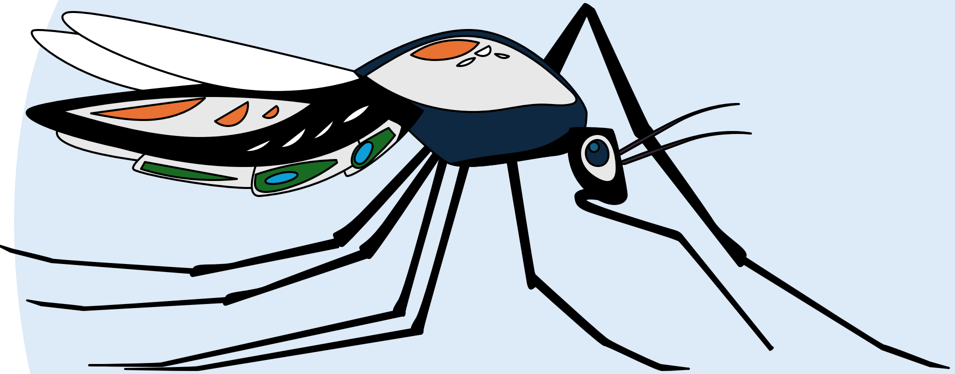
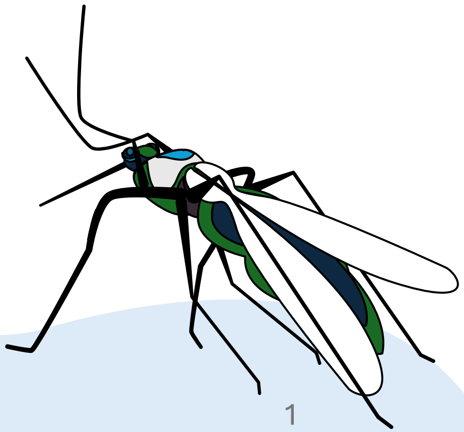


Characterizing the resting and flight behavior of *Aedes aegypti* to advance vector control

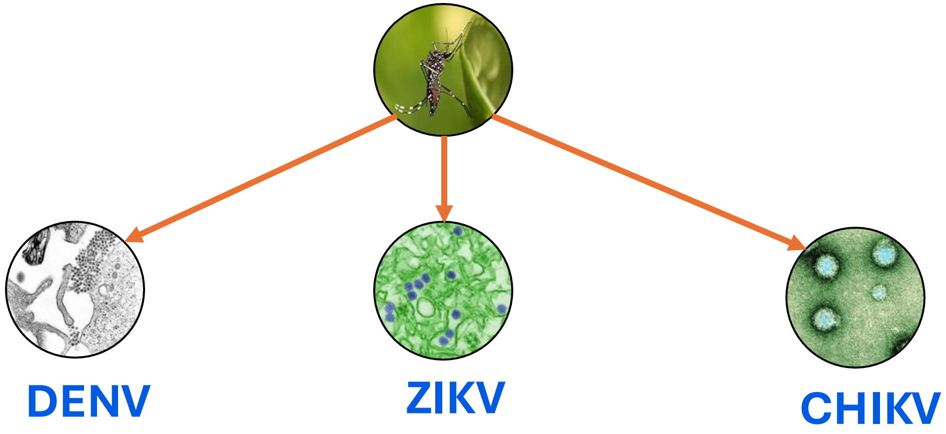


David Jimenez-Vallejo
PhD Candidate – Prokopec Lab, Emory University
Georgia Mosquito Control Association – 2024 Annual Meeting
October 17th, 2024





Aedes-borne diseases continue to pose a **significant burden** on humans worldwide



Aedes aegypti is the **primary vector** of **Dengue**, **Zika**, and **Chikungunya**

- **~280 thousand ZIKV** cases in 2019 (global)
- **~100 thousand CHIKV** cases in 2020 (the Americas)
- **~50-100 million DENV** cases per year (global)

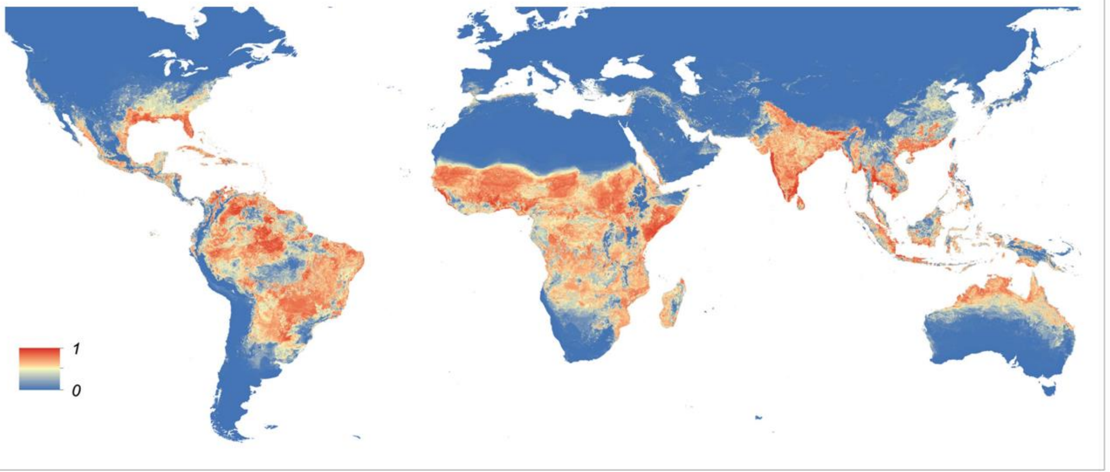


Figure 1. Global map of the predicted distribution of *Ae. aegypti*. The map depicts the probability of occurrence (from 0 blue to 1 red) at a spatial resolution of 5 km x 5 km.

Kraemer et al., 2015

HEALTH

Here's what to know about dengue, as Puerto Rico declares a public health emergency

MARCH 27, 2024 · 1:59 PM ET

By Joe Hernandez

Victoria Micieli, director and scientist at the Center for Parasitological and Vector Studies of the national scientific research institute CONICET, classifies different species of mosquitoes at a laboratory in La Plata, in Argentina's Buenos Aires Province, on Tuesday.

Luis Robayo/AFP via Getty Images

Selectively spraying insecticides according to the **behavior** of vector species can **improve their efficacy**

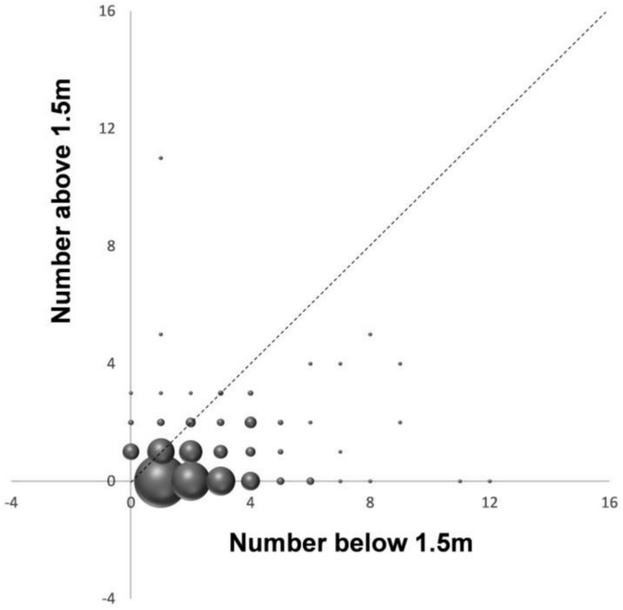


Fig. 1. Distribution of paired *Ae. aegypti* abundances inside houses stratified by collection height. Each symbol indicates an abundance occurrence (e.g., the point at [x = 12, y = 0] shows a house that had 12 *Ae. aegypti* below 1.5 m and none above 1.5 m). The size of the spheres is proportional to the number of houses with a given *Ae. aegypti* abundance above and below 1.5 m (e.g., the largest sphere indicates that 205 houses had the values [1,0], whereas the smallest spheres represent a single house). The dashed line indicates the point of indifference, where abundance is the same above and below 1.5 m.

Dzul-Manzanilla et al., 2016

Insecticide Residual Spraying has evolved to be **“TARGETED”**; aka **TIRS**

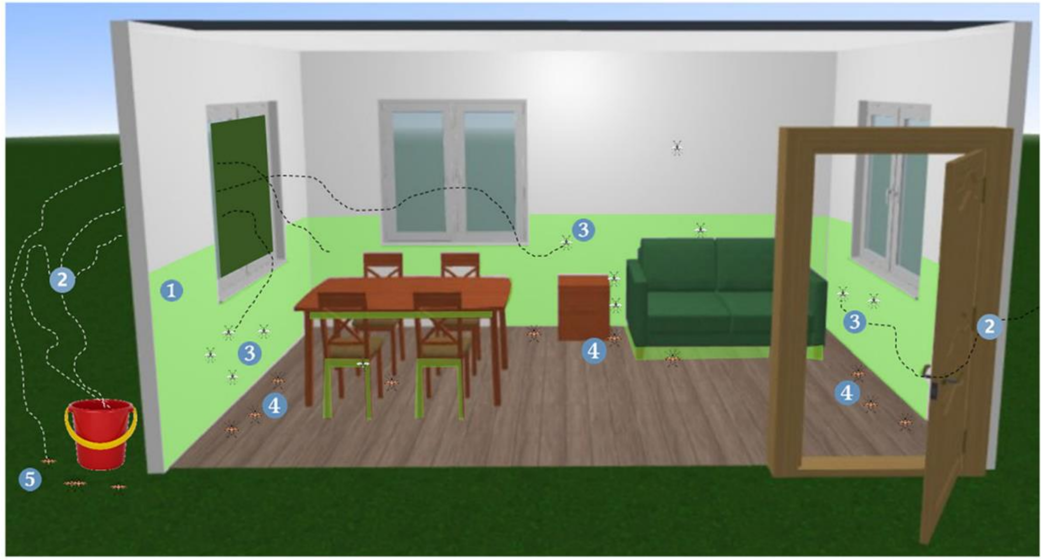
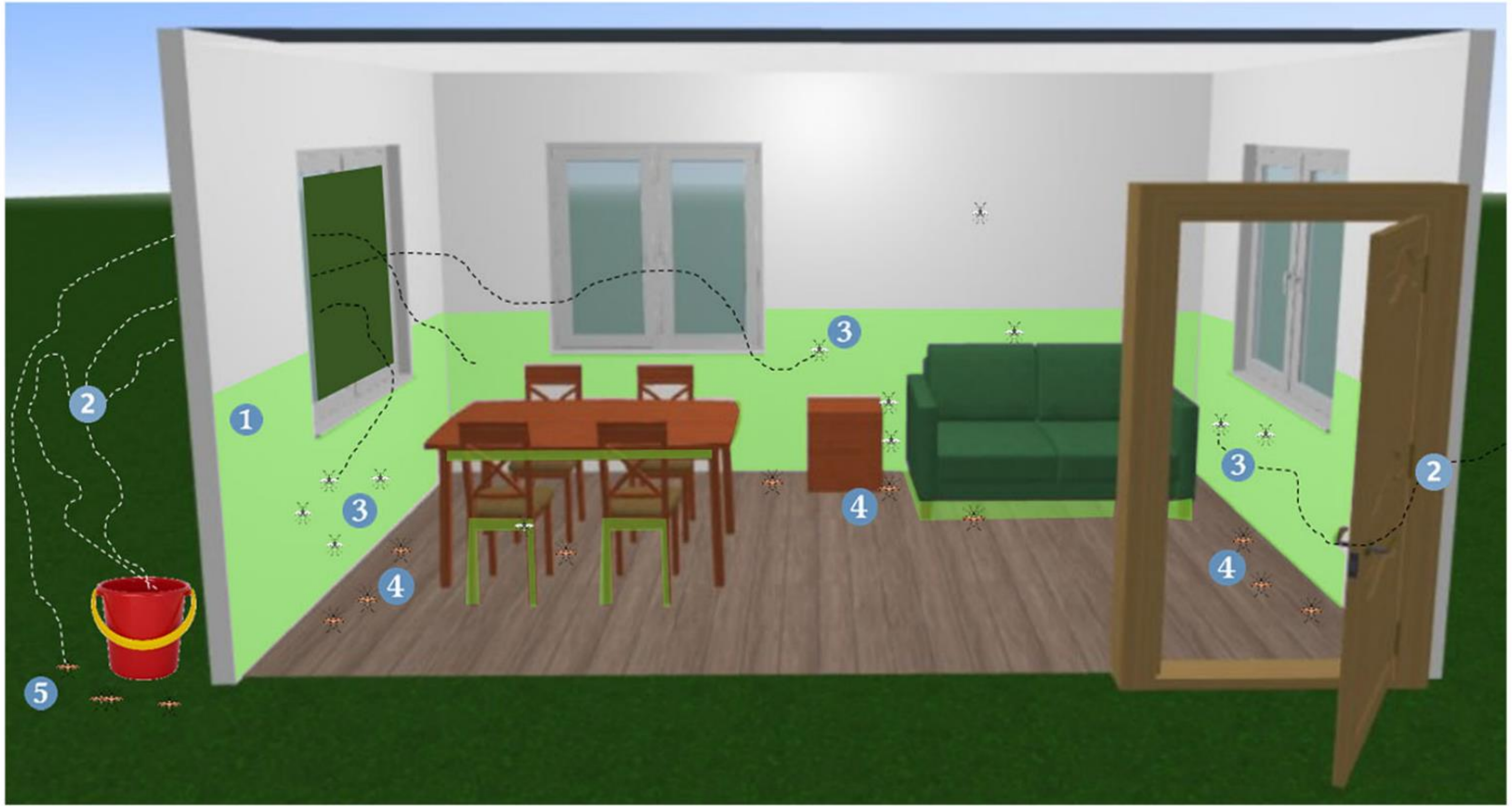


Fig. 1 Targeted indoor residual spraying (TIRS) to control *Ae. aegypti*. In urban environments, houses are primarily built of brick and cement, and *Ae. aegypti* rests preferentially below 1.5 m of height. Spraying residual insecticides in walls below 1.5 m and in key resting sites such as under furniture (#1 in figure, represented in green) will eventually kill *Ae. aegypti* that may be emerging from immature larval habitats outdoors (2) and rest indoors on treated surfaces (3). After exposure to the residual insecticide, mortality can occur immediately (4) or after several hours/days (5)

Manrique-Saide et al., 2020

Similar entomological **impact** (~70% reduction in adult abundance) using a **fraction** of **application time** (<18%) and **insecticide volume** (<30%)

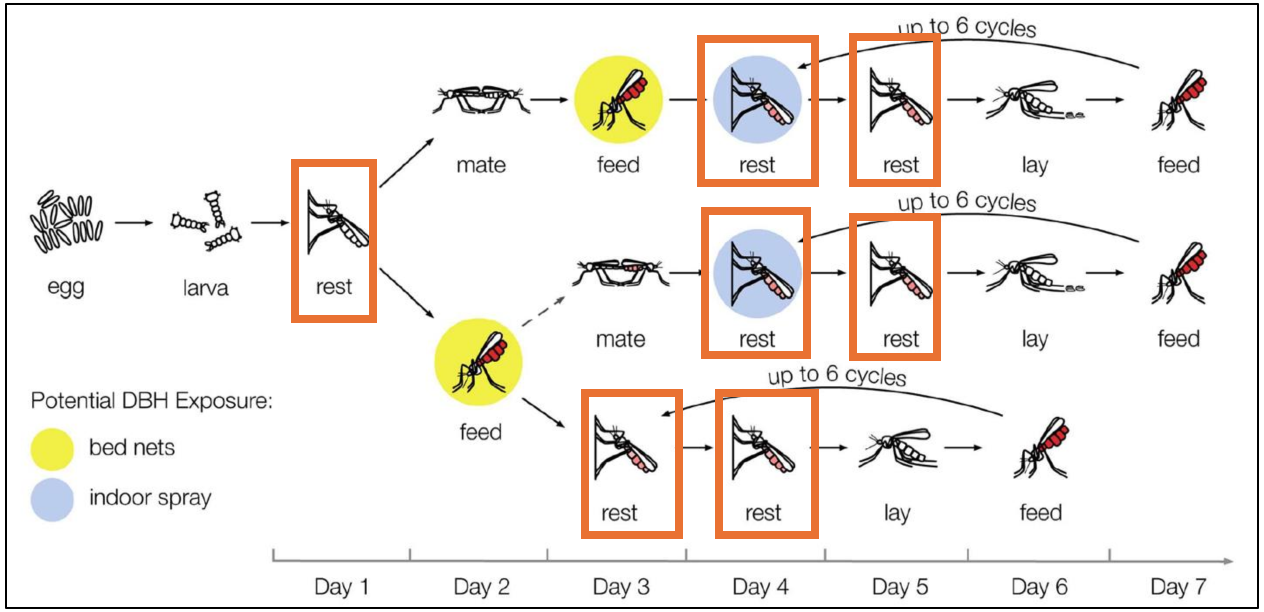
The **targeted focus** of TIRS **shifts** the **selective force** experienced by mosquitoes in **3D space**



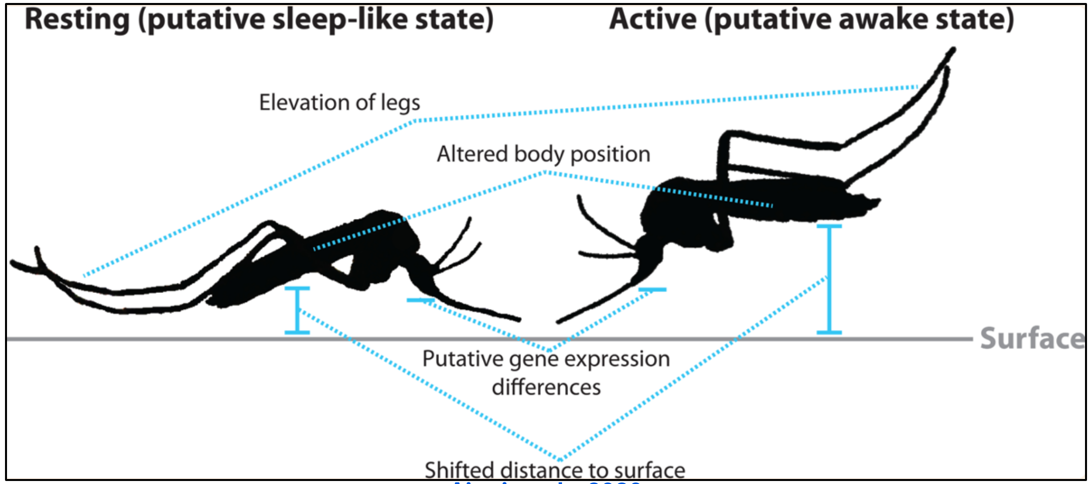
Manrique-Saide et al., 2020

- A **fraction** of mosquitoes are still choosing to **rest > 1m**
  - **Escape mortality**
    - Across scales component
  - **Selection** can **favor** this **fraction**
    - Behavioral resistance evolves
      - TIRS is **jeopardized**

Given **current knowledge**, it is **difficult** to **conclude** or **predict** if *Ae. aegypti* is **capable** of evolving **behavioral resistance**



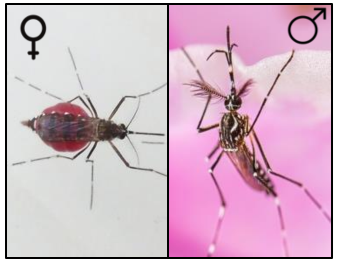
Childs et al., 2016

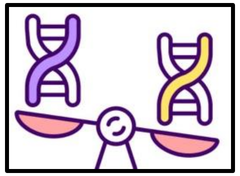


Ajayi et al., 2020

Pronounced gaps in what drives resting behavior

- Impact of microclimatic conditions?
- Does color attraction modulate behavior?
- Different resting strategies between sexes and feed status?
- Does a genetic basis exist for the behavior?
  - Gene x Environment interactions?

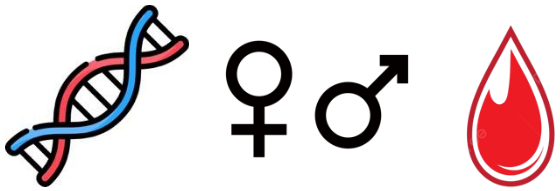




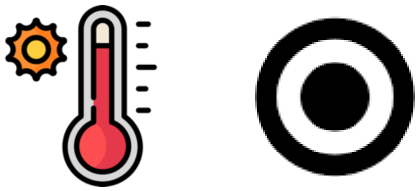
Aim 1: **disentangle** the individual/combined **influence** of **intrinsic and extrinsic** factors driving **innate resting** behavior

- **Hypothesis**
  - The **innate resting** behavior of *Ae. aegypti* is **driven by microclimate**, with the number and color of resting “targets” only modulating mosquito arrangement in flight

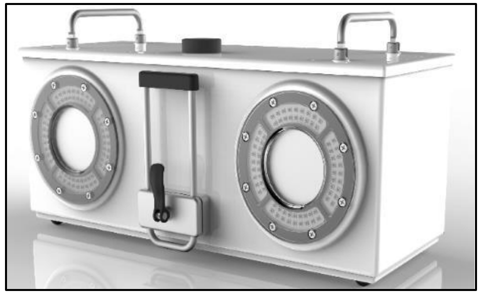
- **Intrinsic** factors
  - Strain
  - Sex
  - Physiological status

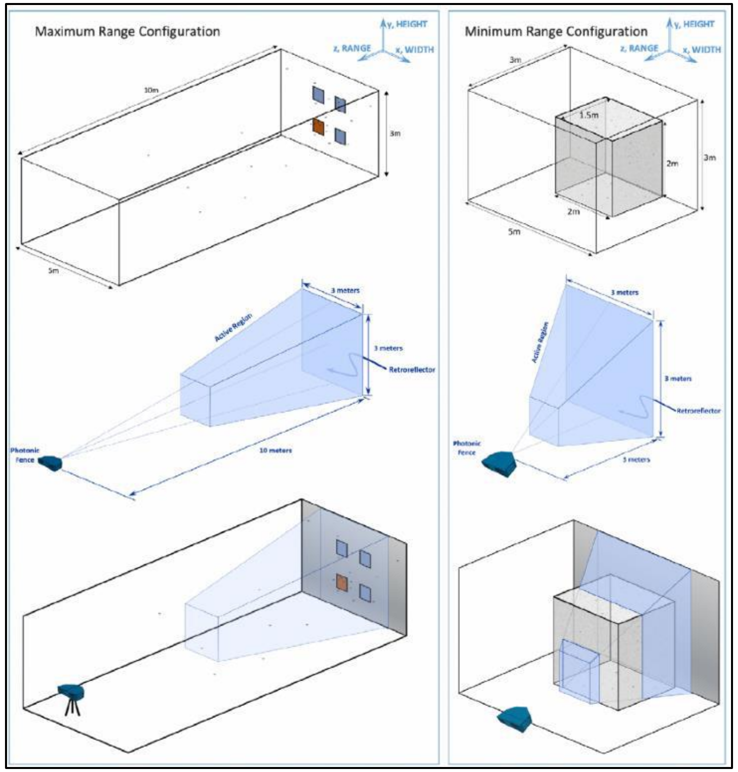


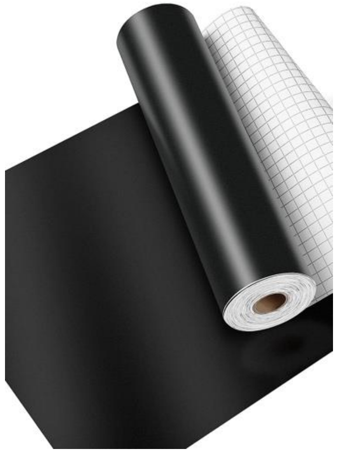
- **Extrinsic** factors
  - Microclimate
  - Color attraction



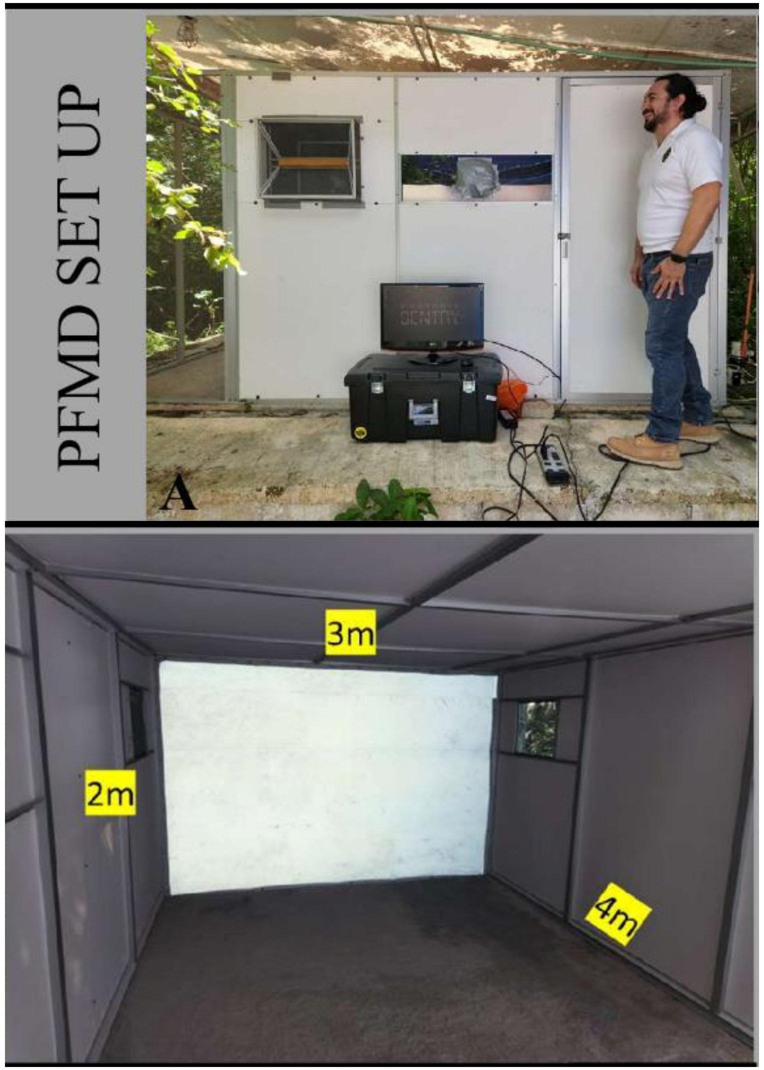
Experimental field huts, the **Photonic Fence Monitoring Device**, and **sticky traps** are at the **core** of the experimental design

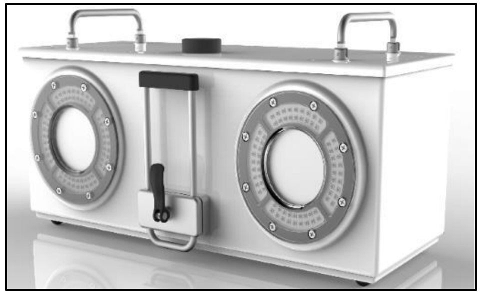


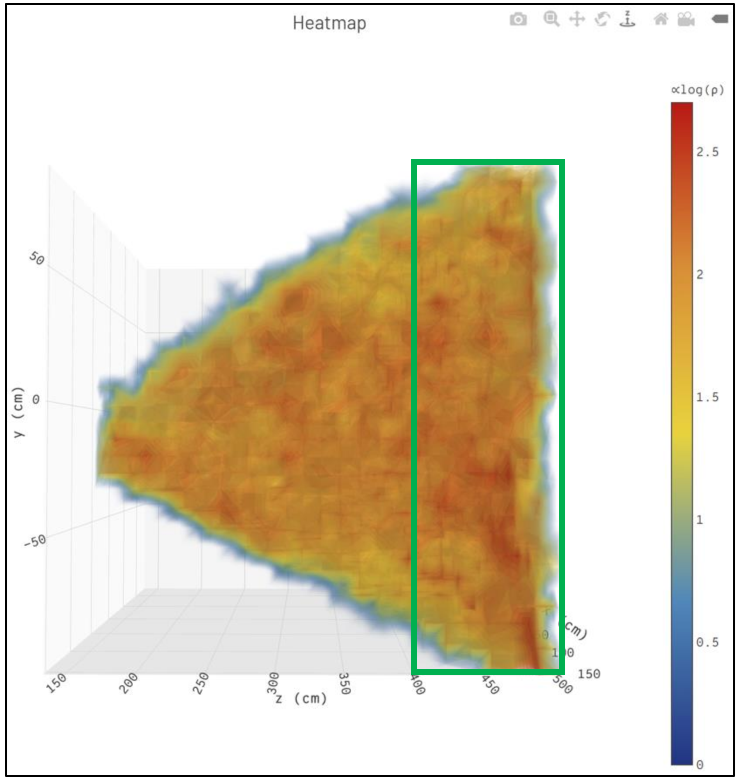


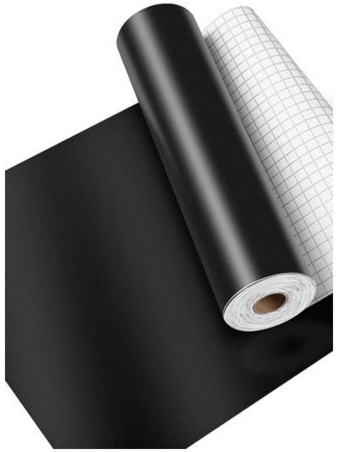


Experimental field huts, the **Photonic Fence Monitoring Device**, and **sticky traps** are at the **core** of the experimental design





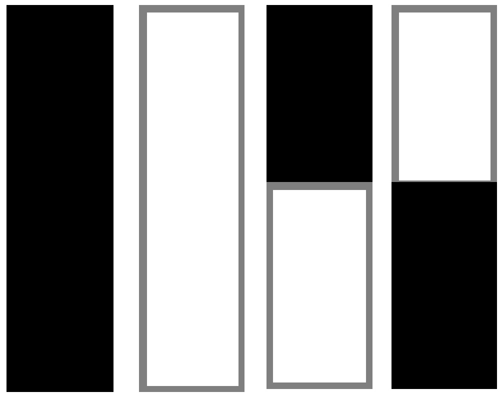




Continuous sticky **traps** sampled resting mosquitoes across all possible heights, while **accounting** for **color** cues

- Previous studies have typically used **categorical sampling**
  - > 1m vs < 1m
  - A 2-meter sheet allows continuous sampling

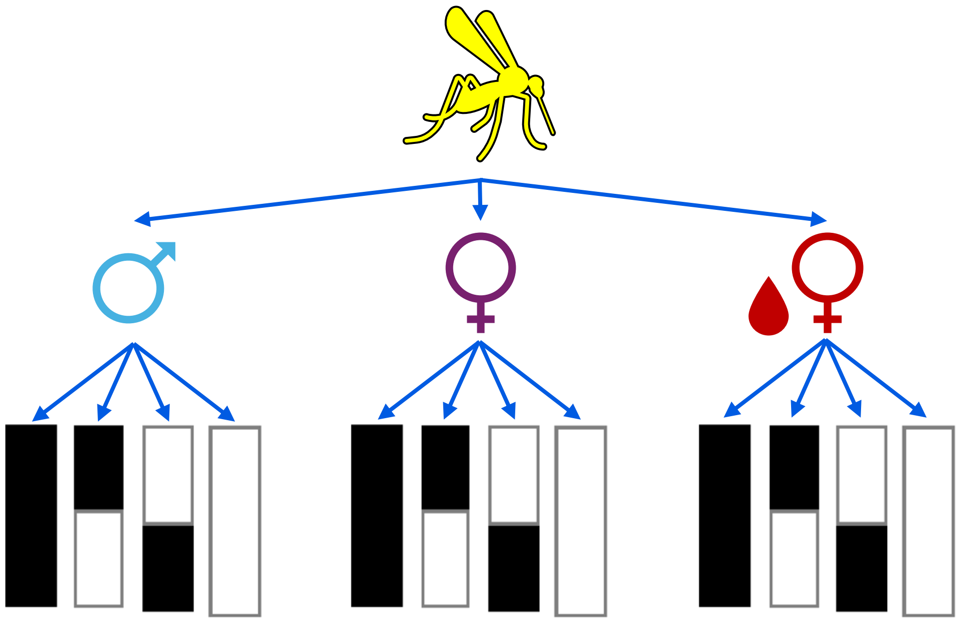
Sticky sheet treatments



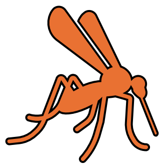
Experimental field huts, the **Photonic Fence Monitoring Device**, and **sticky traps** are at the **core** of the experimental design

Three experimental **groups** from **two strains** were tested under each color treatment

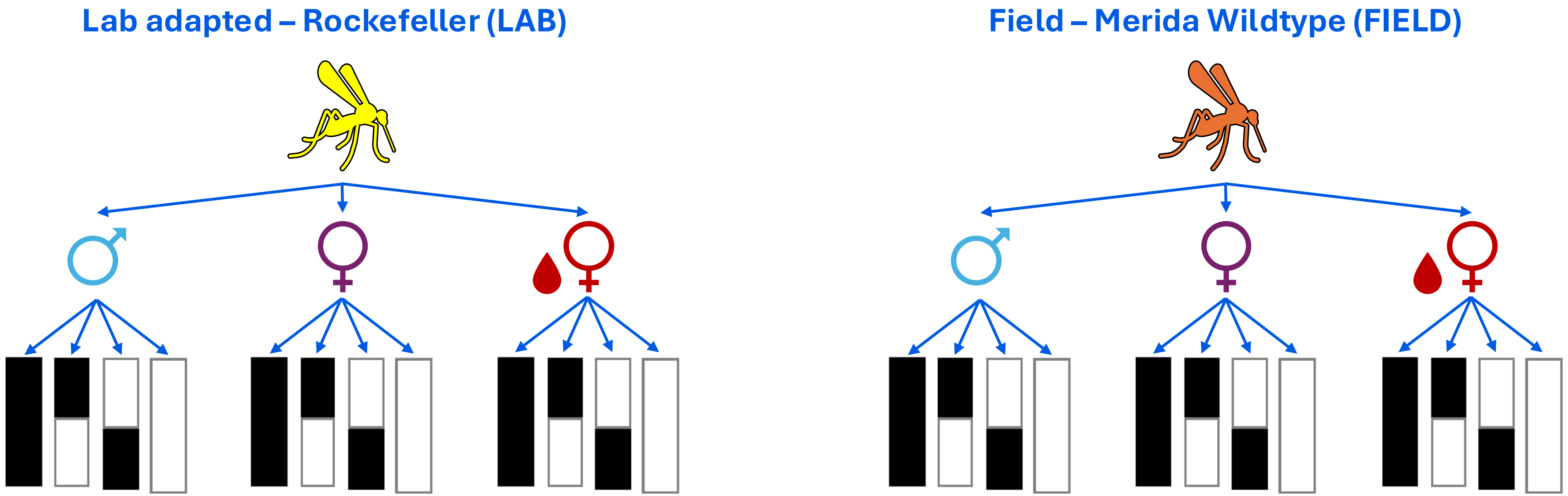
Lab adapted – Rockefeller (LAB)



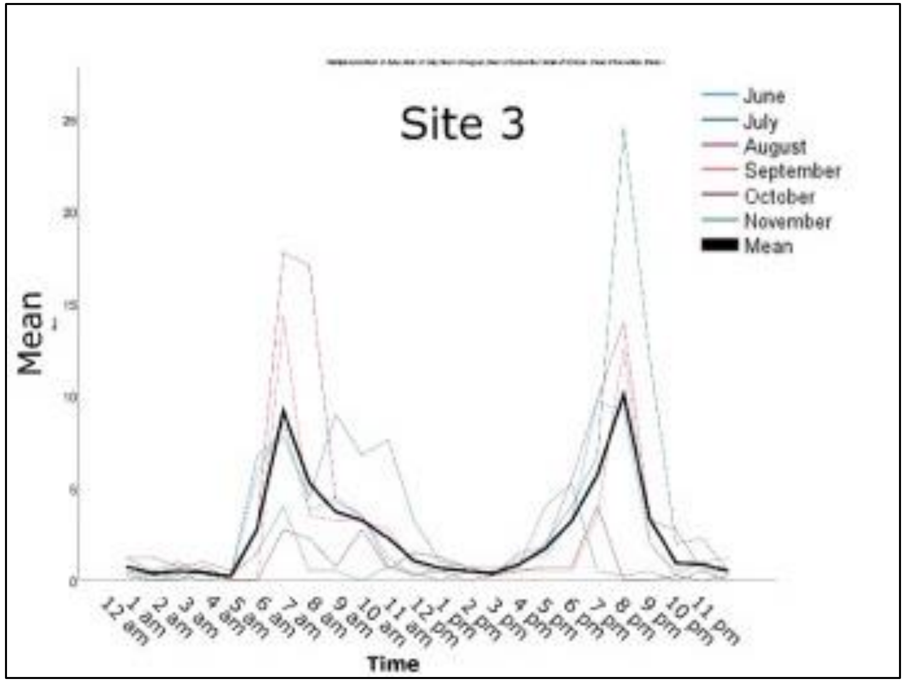
Field – Merida Wildtype (FIELD)



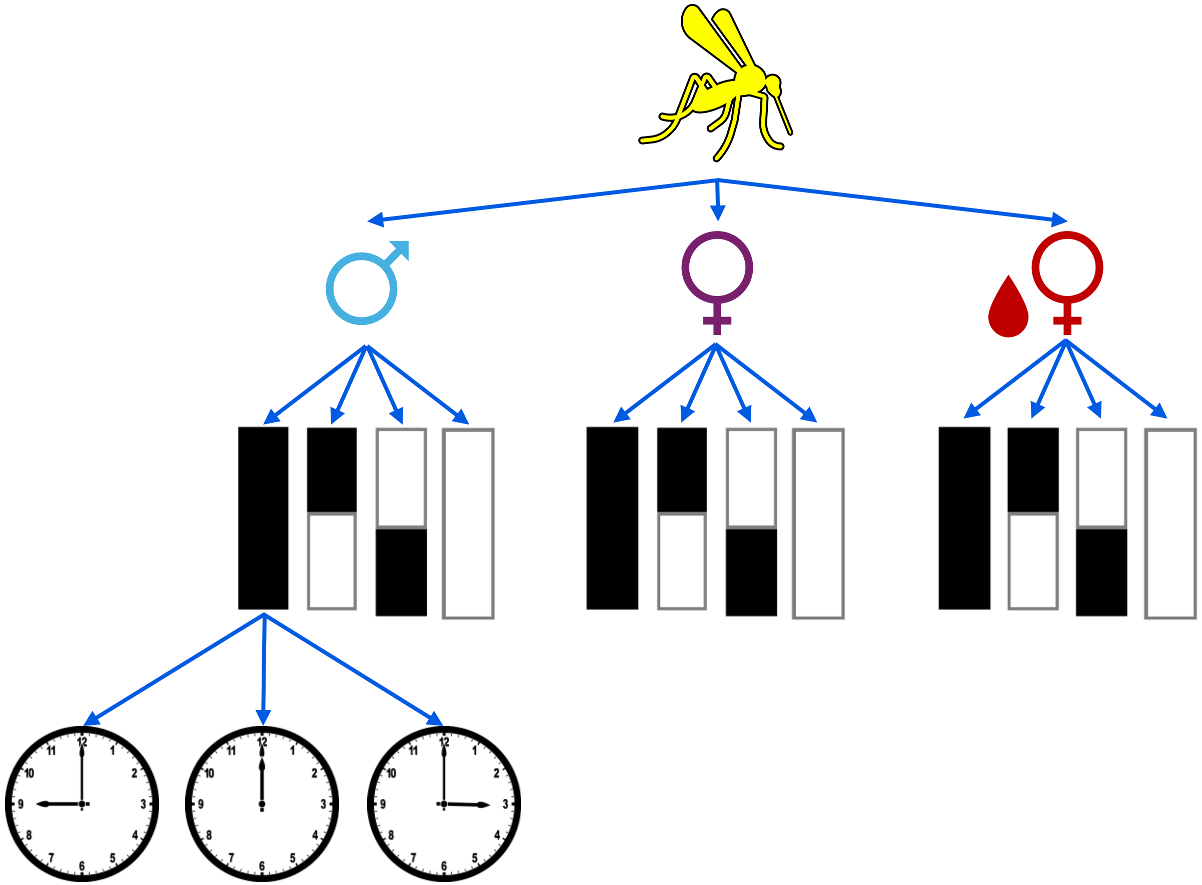
Three experimental **groups** from **two strains** were tested under each color treatment



A **latin-square** was designed to ensure **each** experimental **group** was **assessed** at **three** different **diel time points**

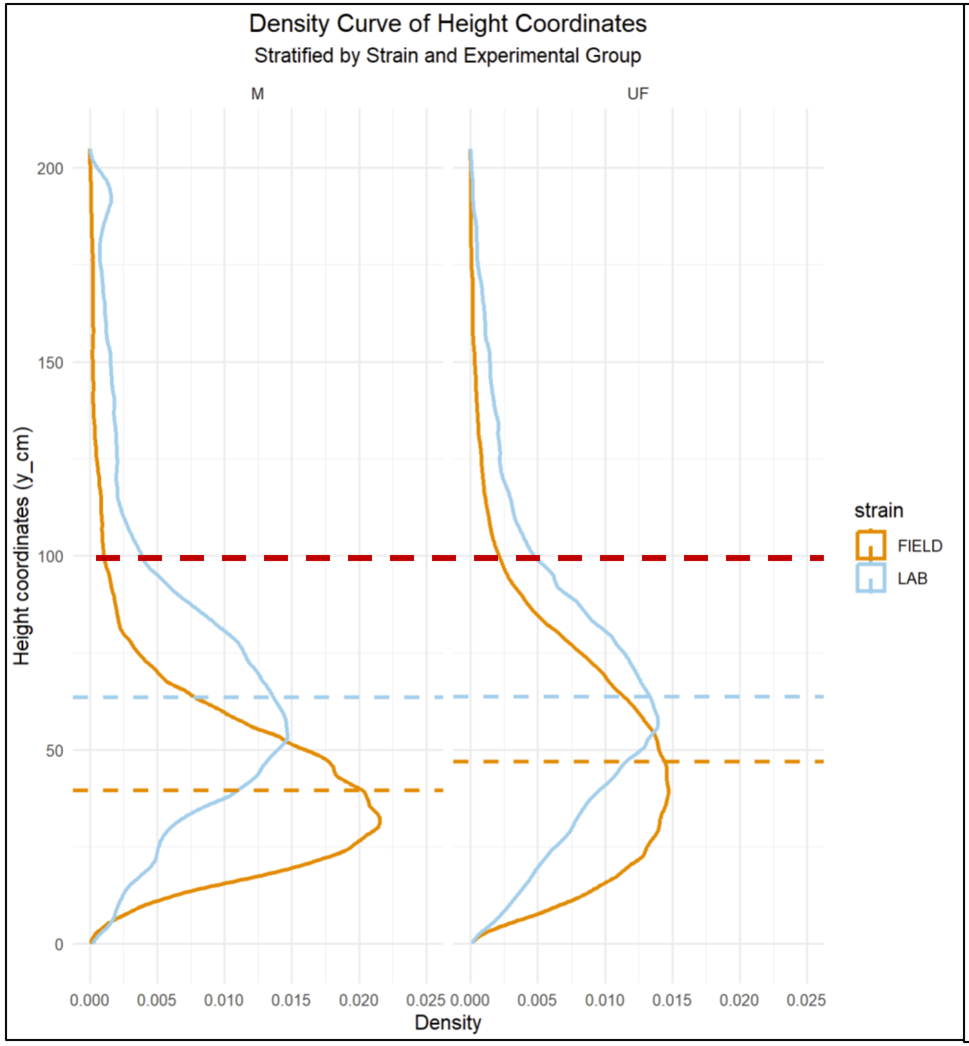


	Day 1	Day 2	Day 3
9AM	M	UF	BF
12PM	UF	BF	M
4PM	BF	M	UF

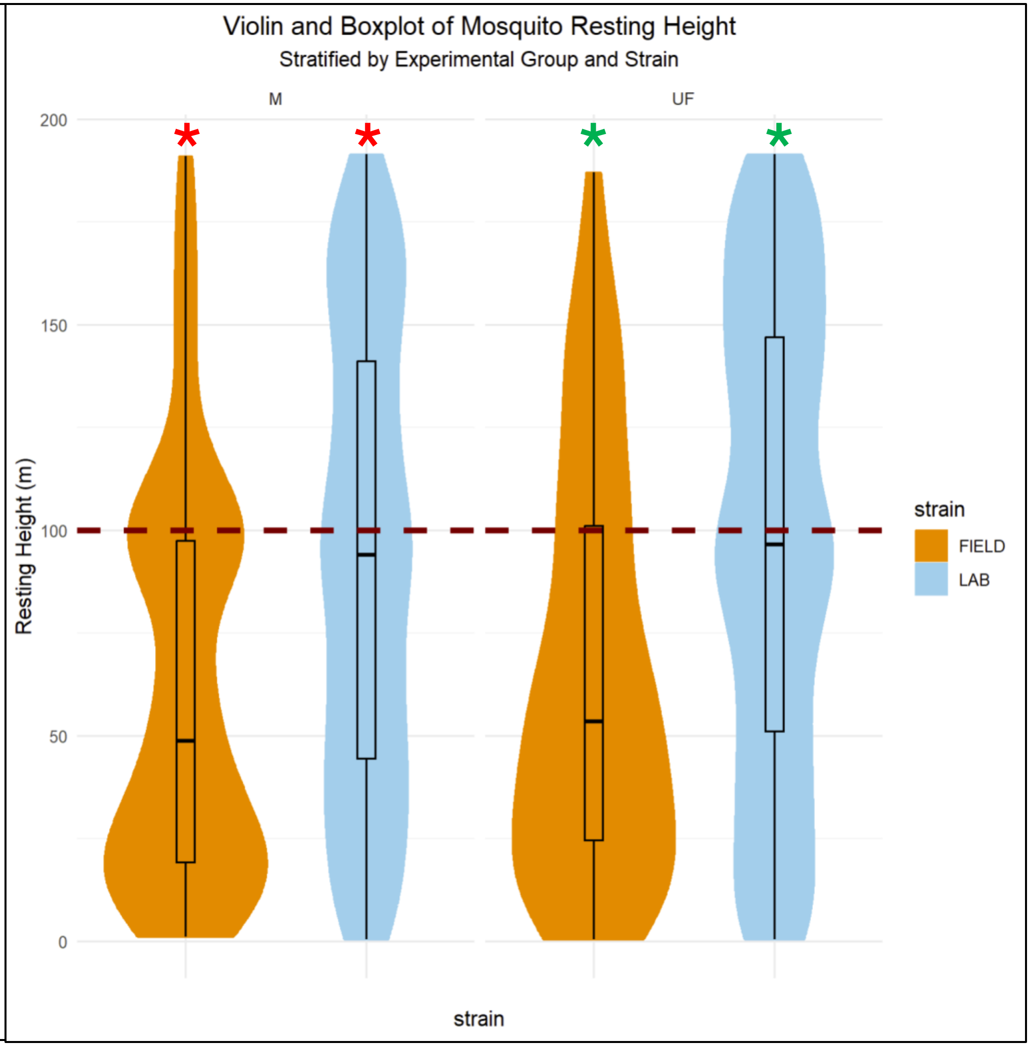


Though **both strains** are primarily **flying low**, only the **FIELD** strain shows a pronounced **preference** to **rest** at a much **lower** height

FLIGHT



RESTING

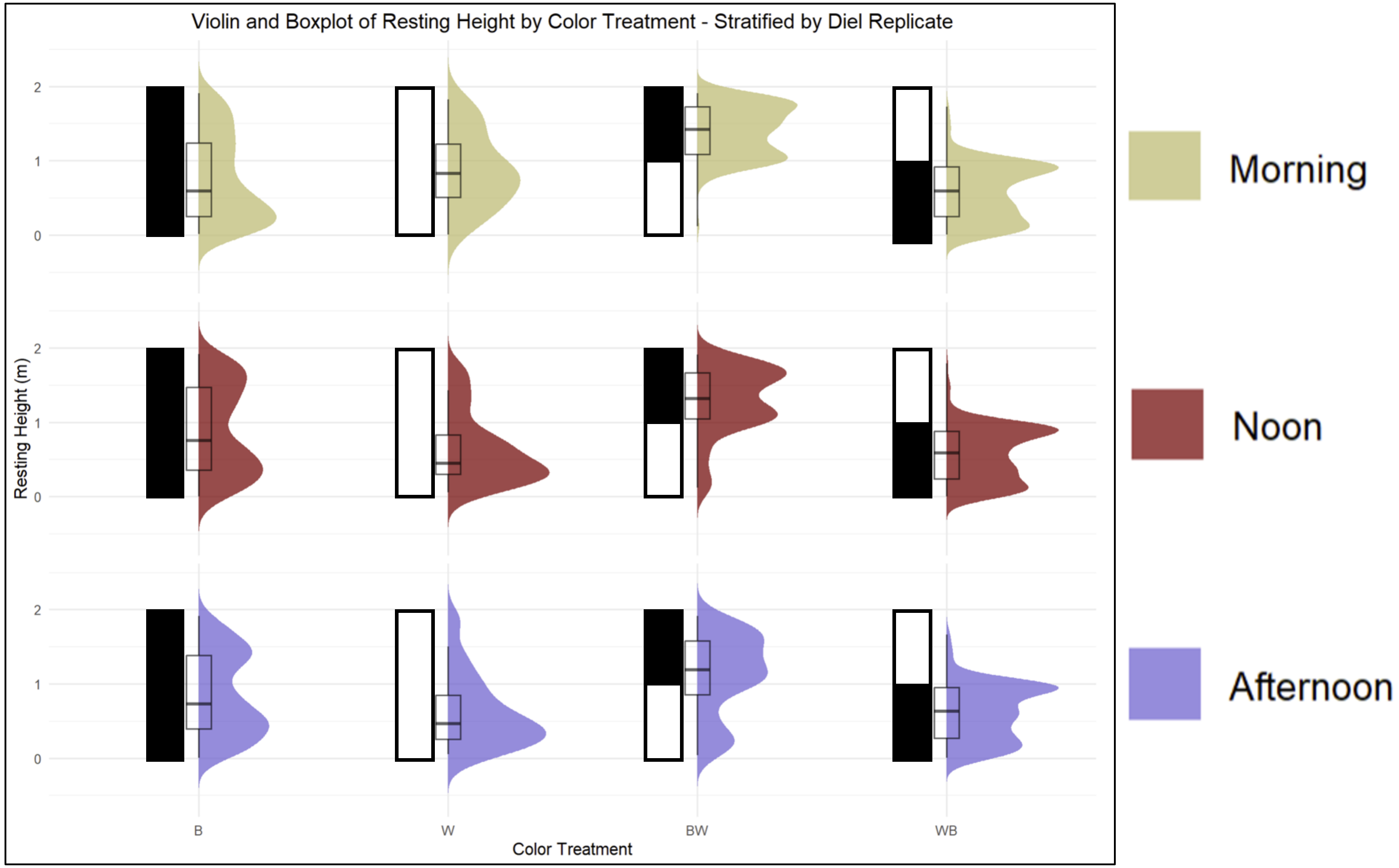


Beta-Family GLMM Results	
Outcome Variable	Resting height
Fixed effects	Strain + Sex
Random effects	Replicate
Significant effects	**Strain - FIELD**
AIC	-684
Marginal R^2	0.01
Conditional R^2	**0.05**

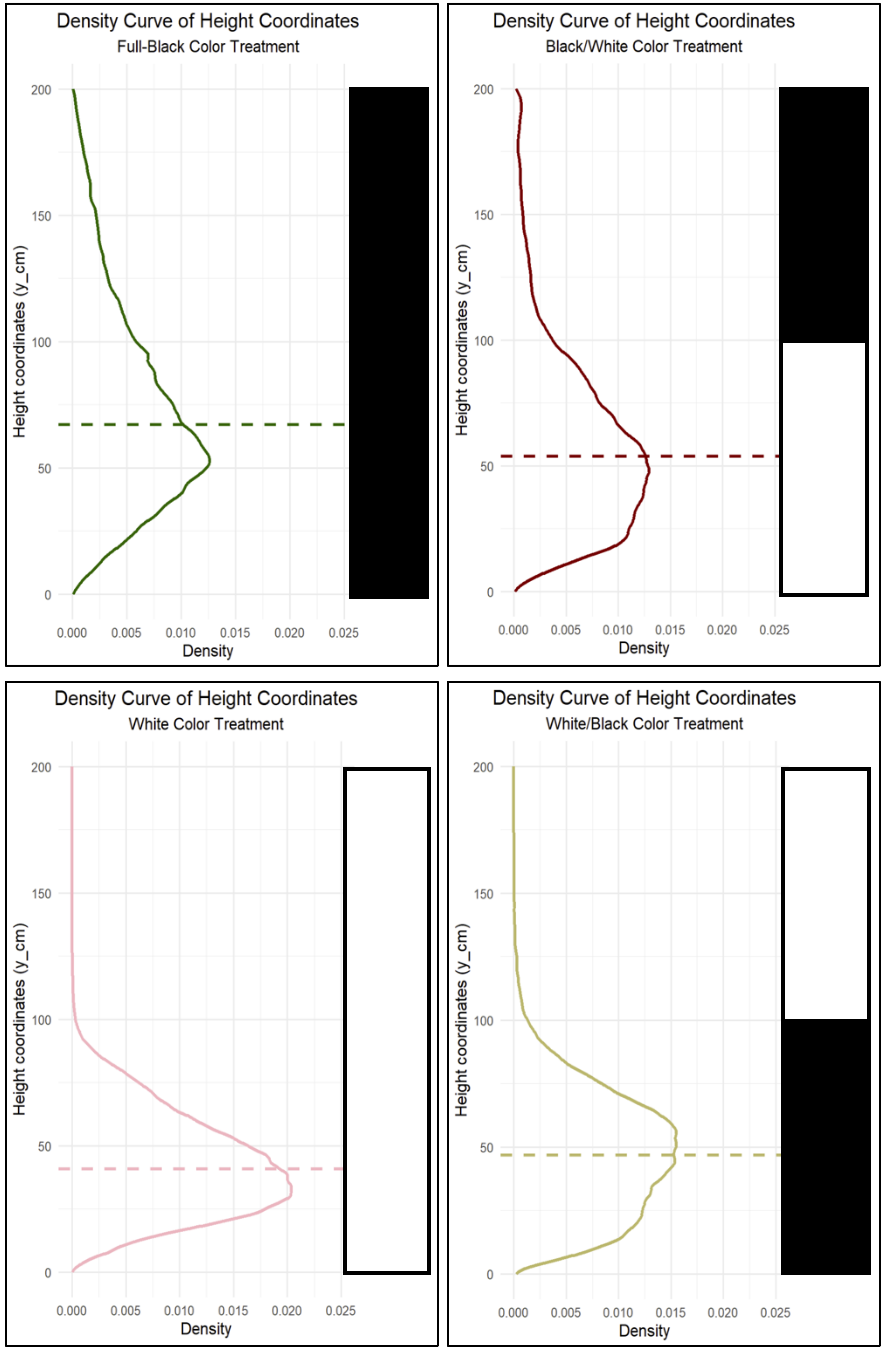
ONLY CONSIDERING INTRINSIC FACTORS

If **color** is **modulated** by **height**, mosquitoes **prefer** to **rest** on **black regardless** of **diel** time point

FLIGHT

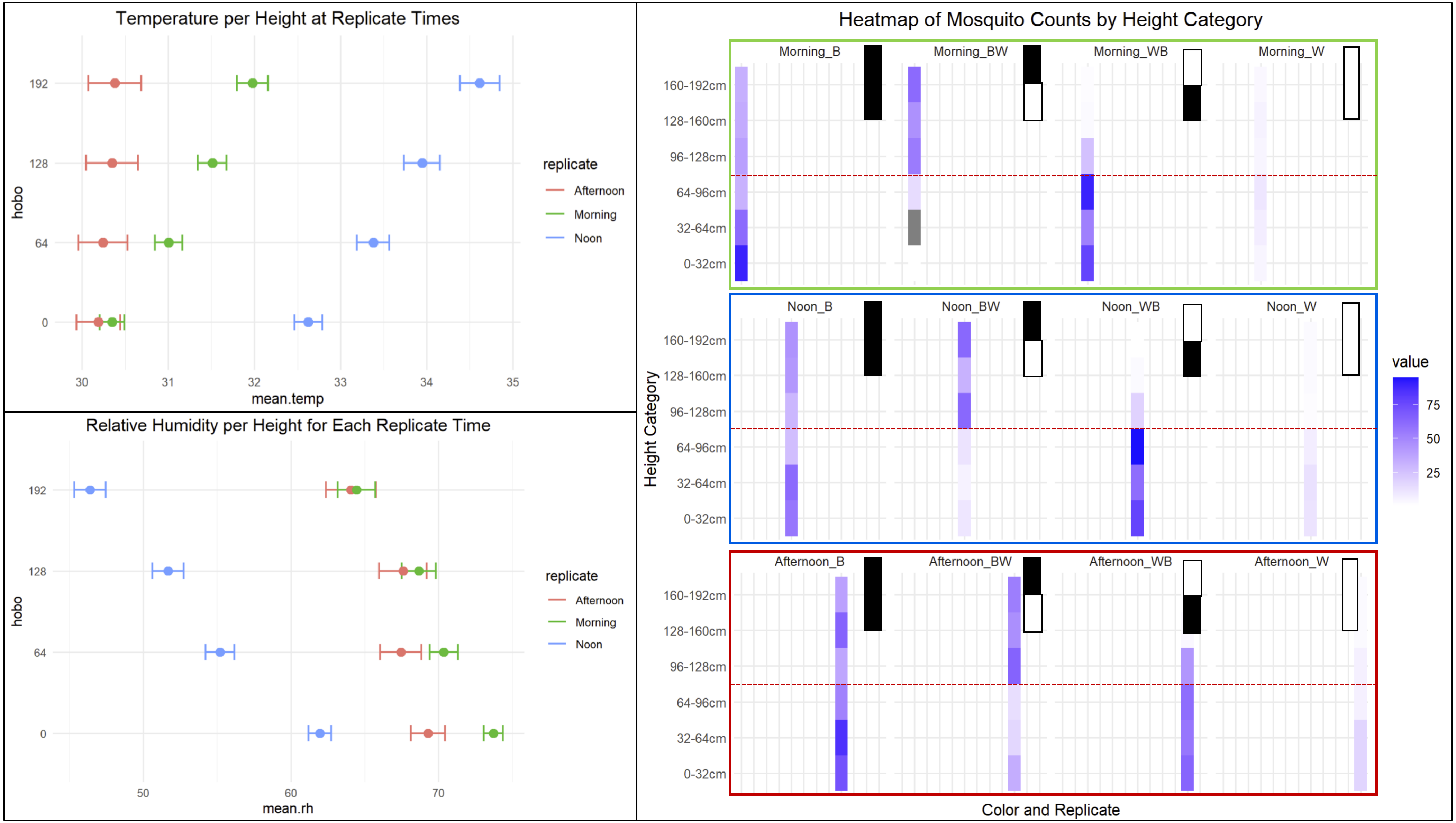


RESTING



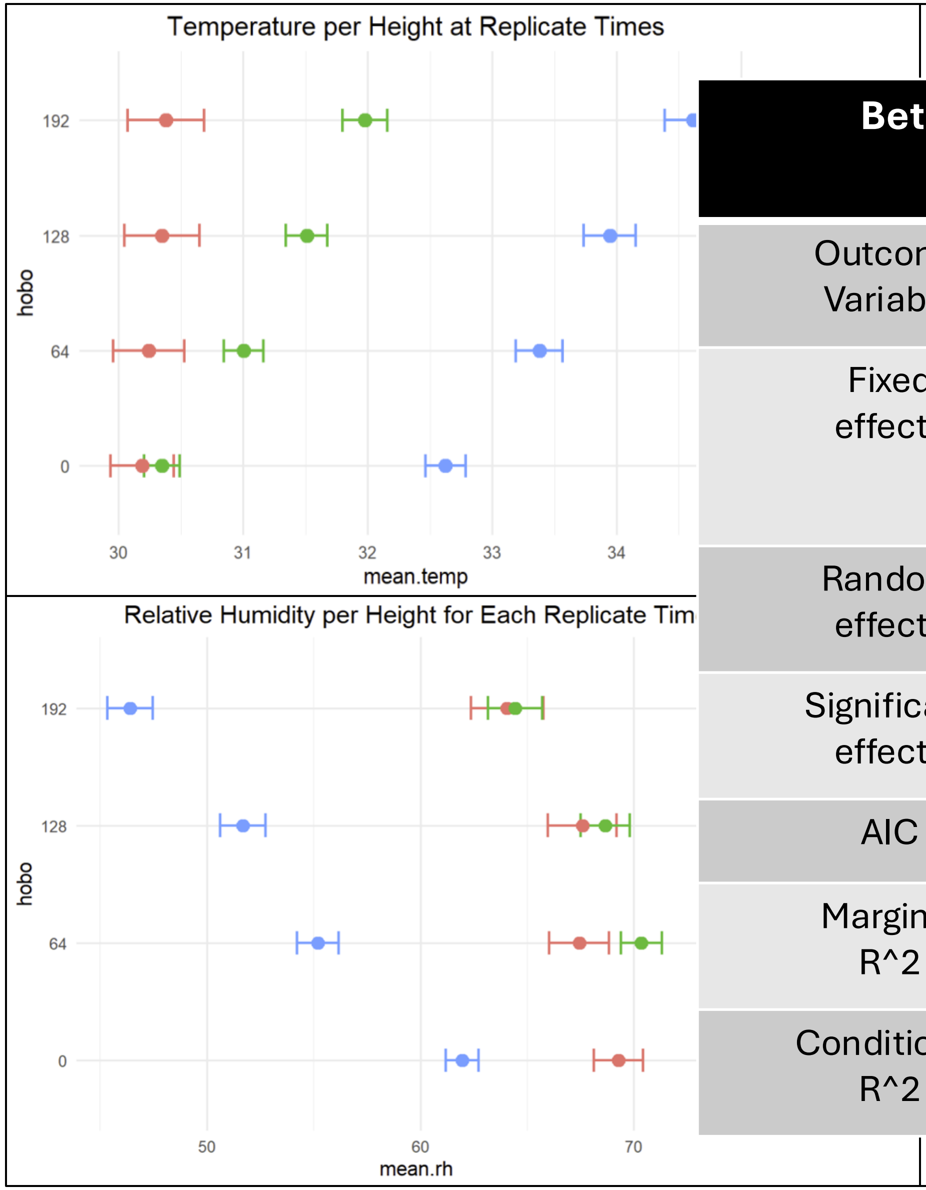
ONLY CONSIDERING EXTRINSIC FACTORS

However, **mosquitoes** are willing to **disregard** these **conditions** and **track black** when **color** attraction is **modulated** by **height**

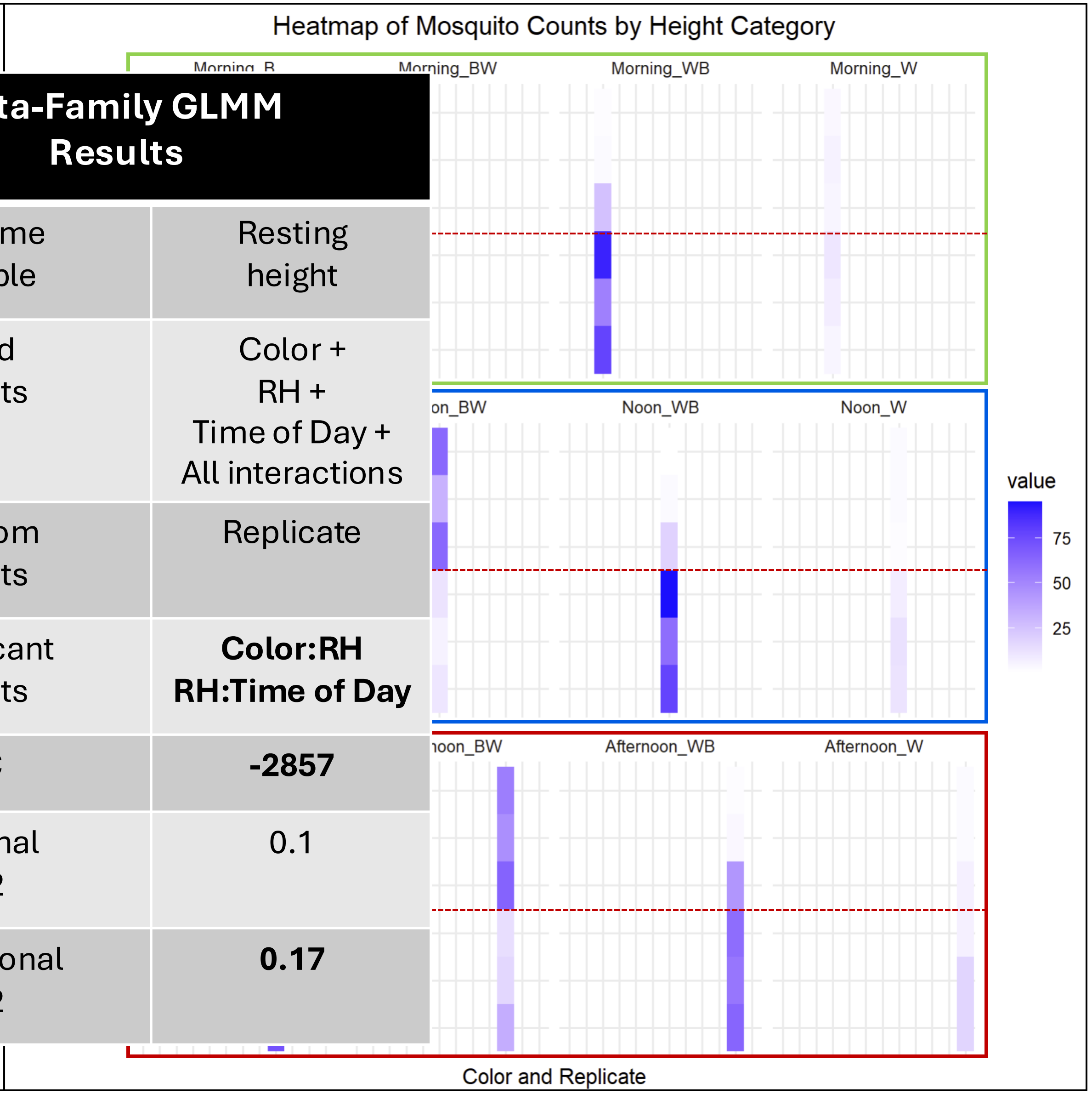


ONLY CONSIDERING EXTRINSIC FACTORS

However, **mosquitoes** are willing to **"give up"** these **conditions** and **track black** when **color** attraction is **modulated** by **height**

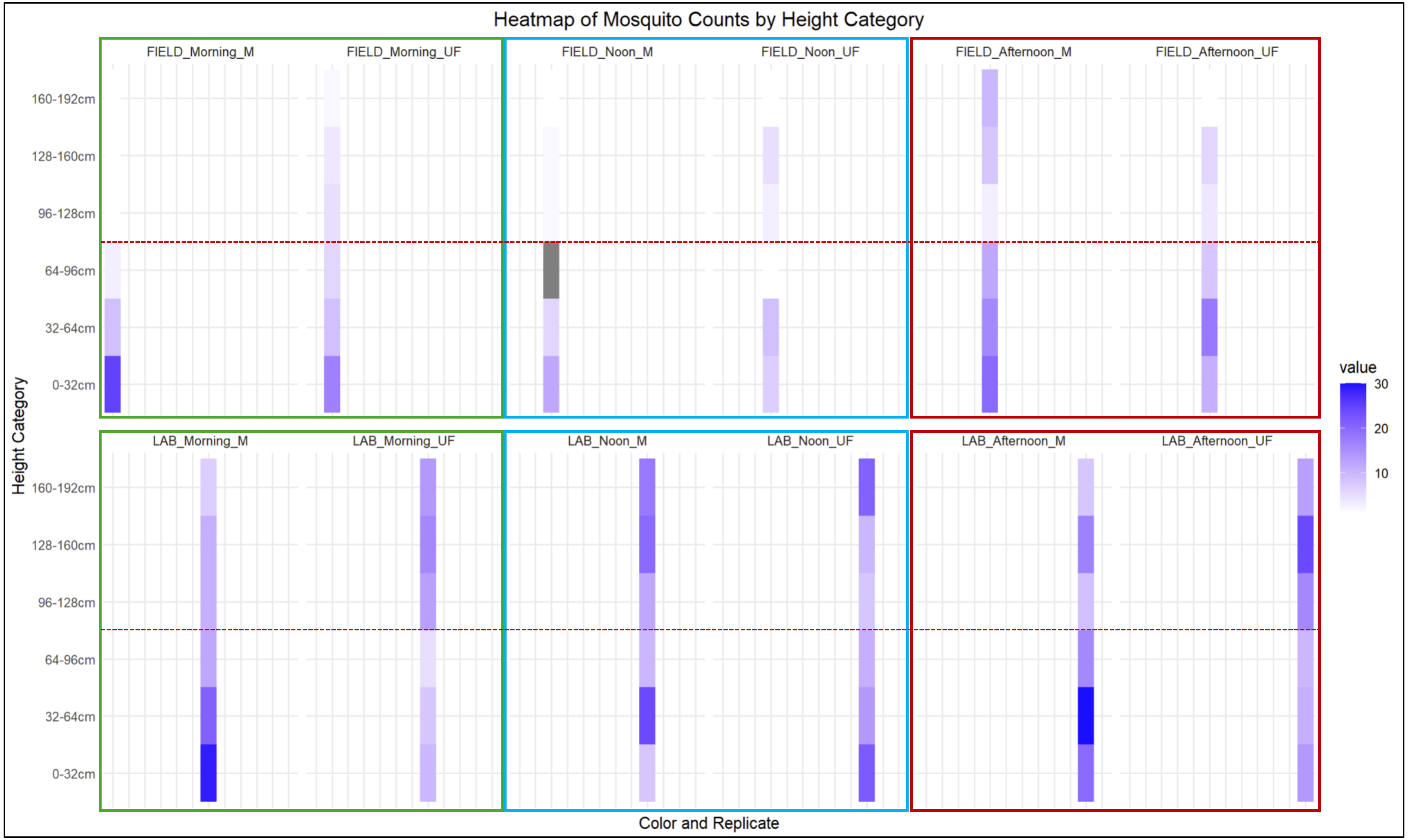


Beta-Family GLMM Results	
Outcome Variable	Resting height
Fixed effects	Color + RH + Time of Day + All interactions
Random effects	Replicate
Significant effects	**Color:RH RH:Time of Day**
AIC	**-2857**
Marginal R^2	0.1
Conditional R^2	**0.17**



ONLY CONSIDERING EXTRINSIC FACTORS

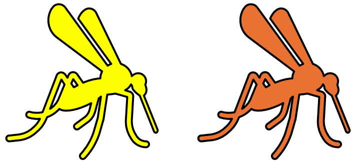
Though **FIELD** has **slight differences** between **Males and Females**, their patterns are **more consistent** across **diel** time in **comparison** to **LAB** mosquitoes



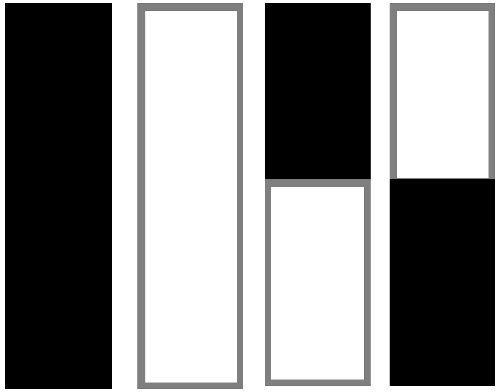
CONSIDERING INTRINSIC + EXTRINSIC FACTORS

Primary conclusions to this point

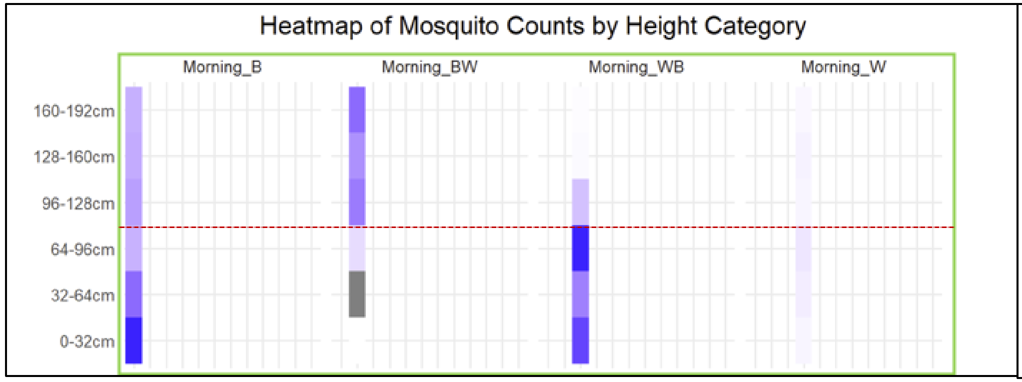
PFMD performs in semi-field

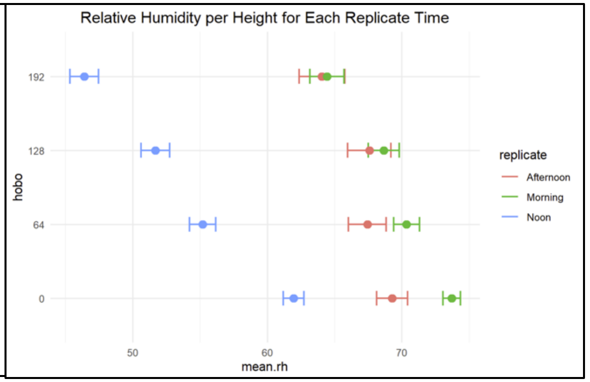


FIELD rests lower than LAB
Possible strain/genetic differences



Preference for Black over White





Microclimatic gradients differ between Noon and Morning/Afternoon;
More tolerable conditions preferred until color is modulated by height

Acknowledgements

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- Dr. Rosemarie Kelly

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- Jerry Byrd and Melissa Ivey

Dissertation Committee

- Dr. Levi Morran, Dr. Dave Civitello, Dr. Lance Waller, Dr. Pablo Manrique-Saide, Dr. Gonzalo Vazquez-Prokopec

GDBBS, IDASTP