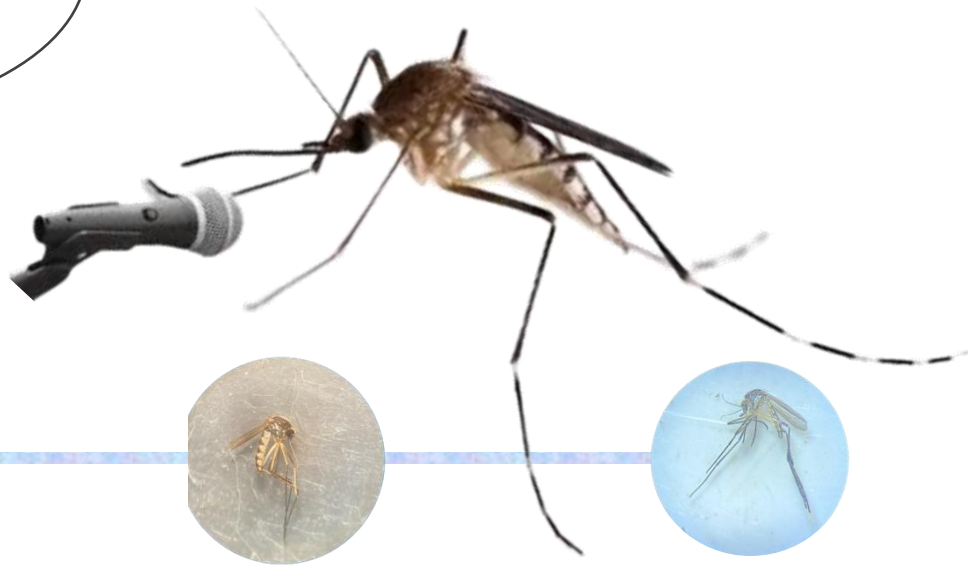
Evaluating bird-derived volatile organic compound blends for mosquito trap efficacy in the Savannah River Site

Nalany A. Richardson[1,2], Danica M. Shannon[1,2], Skyler Nichols[1,2], Mary Beard [1,2], Lia Hancock[1,2], Tiffany Mason[1,2], Taylor Fisher[2] and Daniel Peach[1,2]

[1]Savannah River Ecology Laboratory, University of Georgia, Aiken, SC, 29802, USA, [2]Department of Infectious Disease, University of Georgia, Athens, GA, 30602

Roadmap!





Rationale

EEEV and *Culiseta melanura*



Brief literature review

Bird-baited traps to synthetic odors



Aim 1:

Synthetic chicken blend in the field

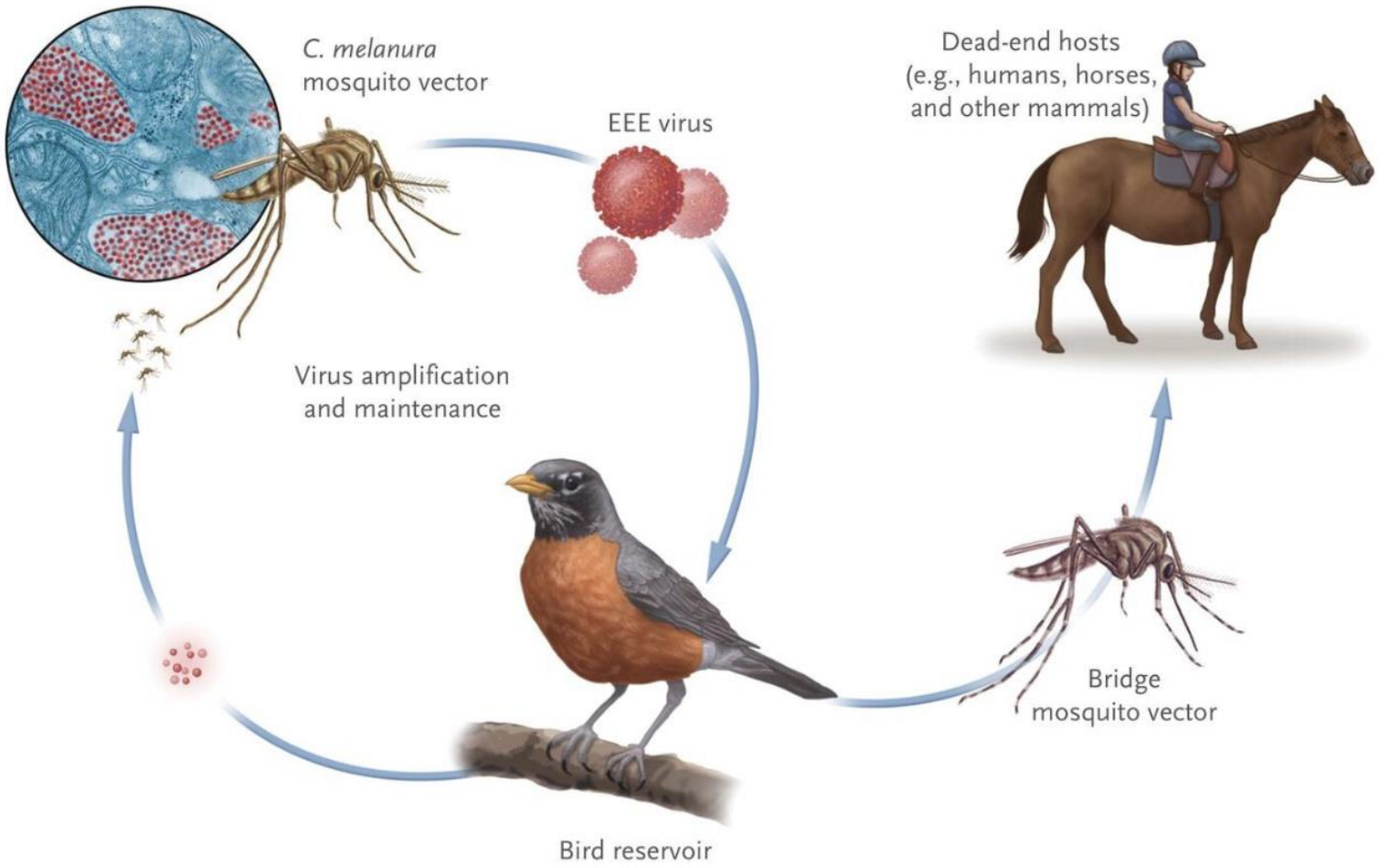
Aim 2:

Procuring our own passerine perfume!

Next steps

Lab assays, field trials…

EEEV Transmission Cycle



West *et al.* 2020 [1]

EEEV

- **Encephalitic alphavirus**
- **Select agent (BSL-3)**
- **<u>Highest case fatality</u> of known alphaviruses in U.S.**
- **No commercially available vaccine for humans**

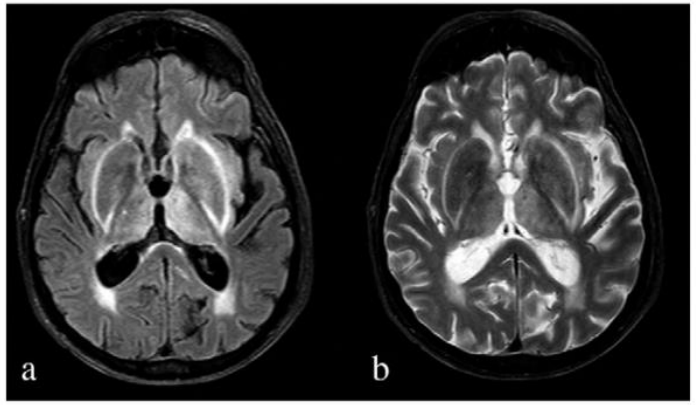


Fig. 1. T2 FLAIR (A) and T2-weighted (B) images from Subject 1 demonstrate T2 prolongation in the basal ganglia, thalami, and subinsular white matter with marked hyperintense signal in the external capsules bilaterally.

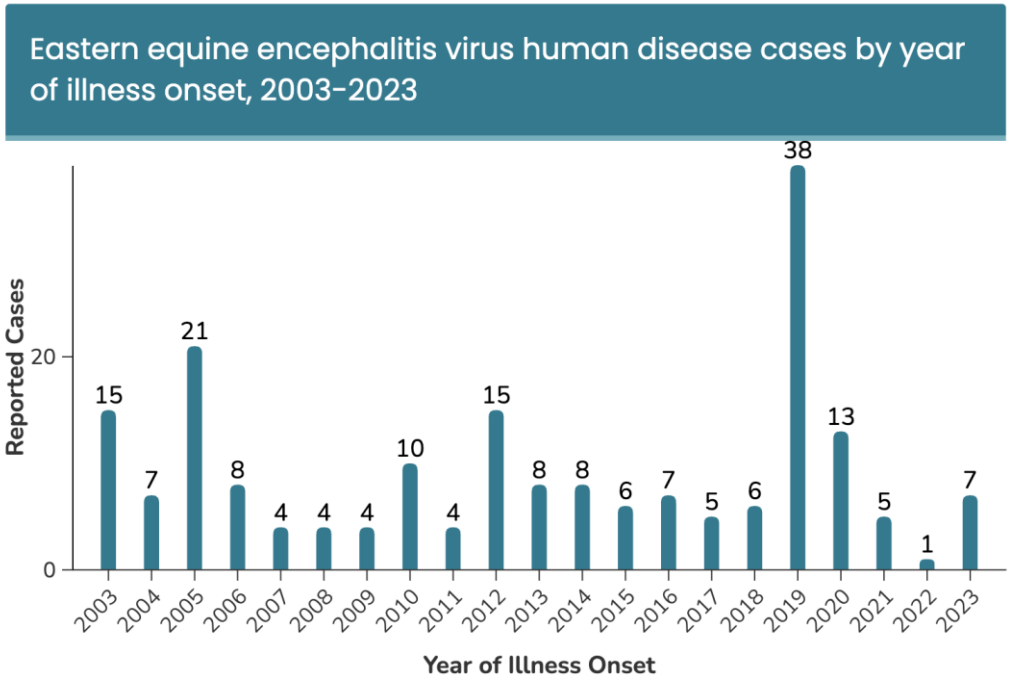


Image credit: CDC Historic Data, 2003–2024 [2]
Nickerson et al. 2016 [3]

EEEV

- **No commercially available vaccine for humans**
  - **Prestige 3 available for equids**



Meme credit: HippoLogic – Wordpress.com

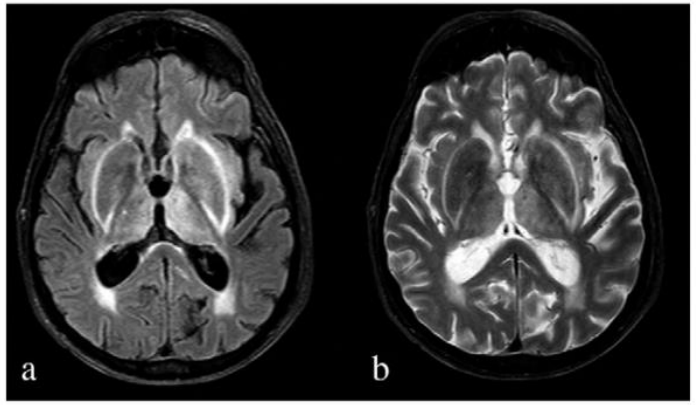


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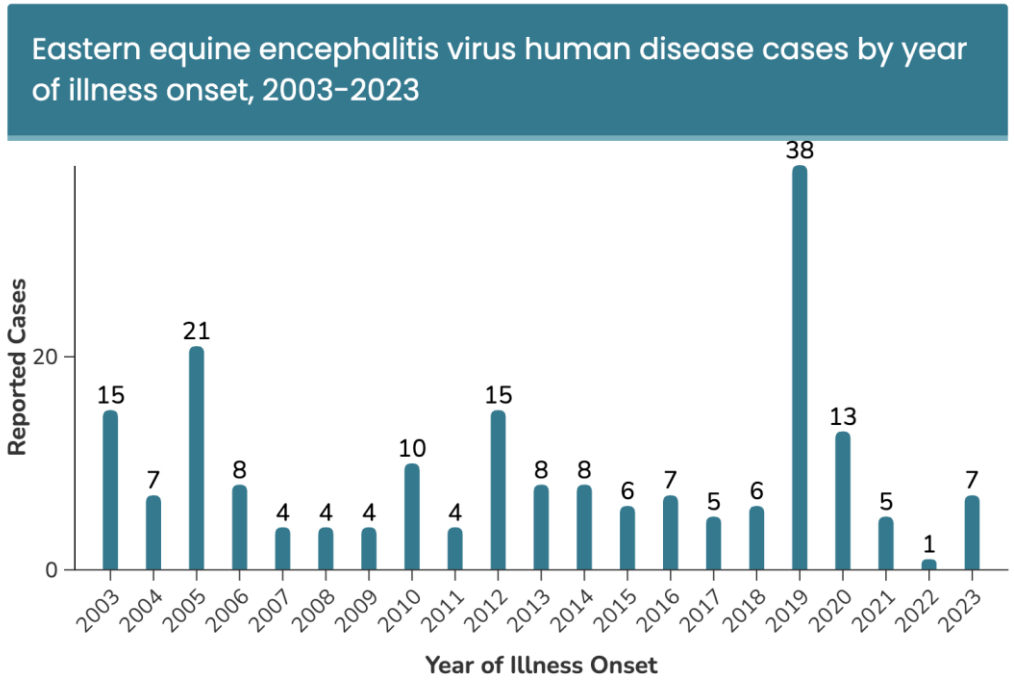


Image credit: CDC Historic Data, 2003–2024 [2]
Nickerson et al. 2016 [3]

EEEV by the Numbers

~30%-75%

case fatality in severe (neuroinvasive) disease

CDC [4]

>50%

of survivors have lasting physical or neurologic effects

CDC [4]

38

U.S. human cases in 2019

CDC [2]; Lindsey et al. 2020 [5]

95%

of 2024 cases began July–September

Mace et al. 2026 [6]

2024: 19 cases, all neuroinvasive, all hospitalized; 5 deaths (26%).

CDC clinical signs [4]; CDC historic data [2]; Lindsey et al. 2020 [5]; Mace et al. 2026 [6]

EEEV in South Carolina

1996–98

Statewide surveillance

EEEV found in mosquito pools from 4 of 8 Carolina bays surveyed, all in the Atlantic Coastal Plain

Wozniak et al. 2001 [7]

Vectors

Positive pools in SC

An. crucians complex (14 pools), *Cq. perturbans* (4), *Cx. erraticus*, *Cs. melanura*, *An. punctipennis*, *An. quadrimaculatus*

Wozniak et al. 2001 [7]

2025

First SC death in >20 years

SC DPH confirmed the state's first human EEE death in more than 20 years (Beaufort County, Sept. 2025)

SC DPH 2025 [8]

Wozniak et al. 2001 [7]; SC Department of Public Health 2025 [8]

Who Carries EEEV?

ENZOOTIC

Culiseta melanura

- Feeds *nearly* exclusively on birds
- Keeps virus circulating among songbird

BRIDGE AND SUPPORTING VECTORS examples (birds → mammals… like us)

Culex erraticus	84% disseminated infection in the lab; vectorial capacity 44% of *Cs. melanura* at an Alabama site [10]
***An. crucians* complex**	EEEV-positive pools in Carolina bays(14 pools) [7]
Coquillettidia perturbans	EEEV-positive pools in SC [7]; known bridge vector

Molaei et al. 2006 [9]; Bingham et al. 2016 [10]; Wozniak et al. 2001 [7]

Culiseta melanura

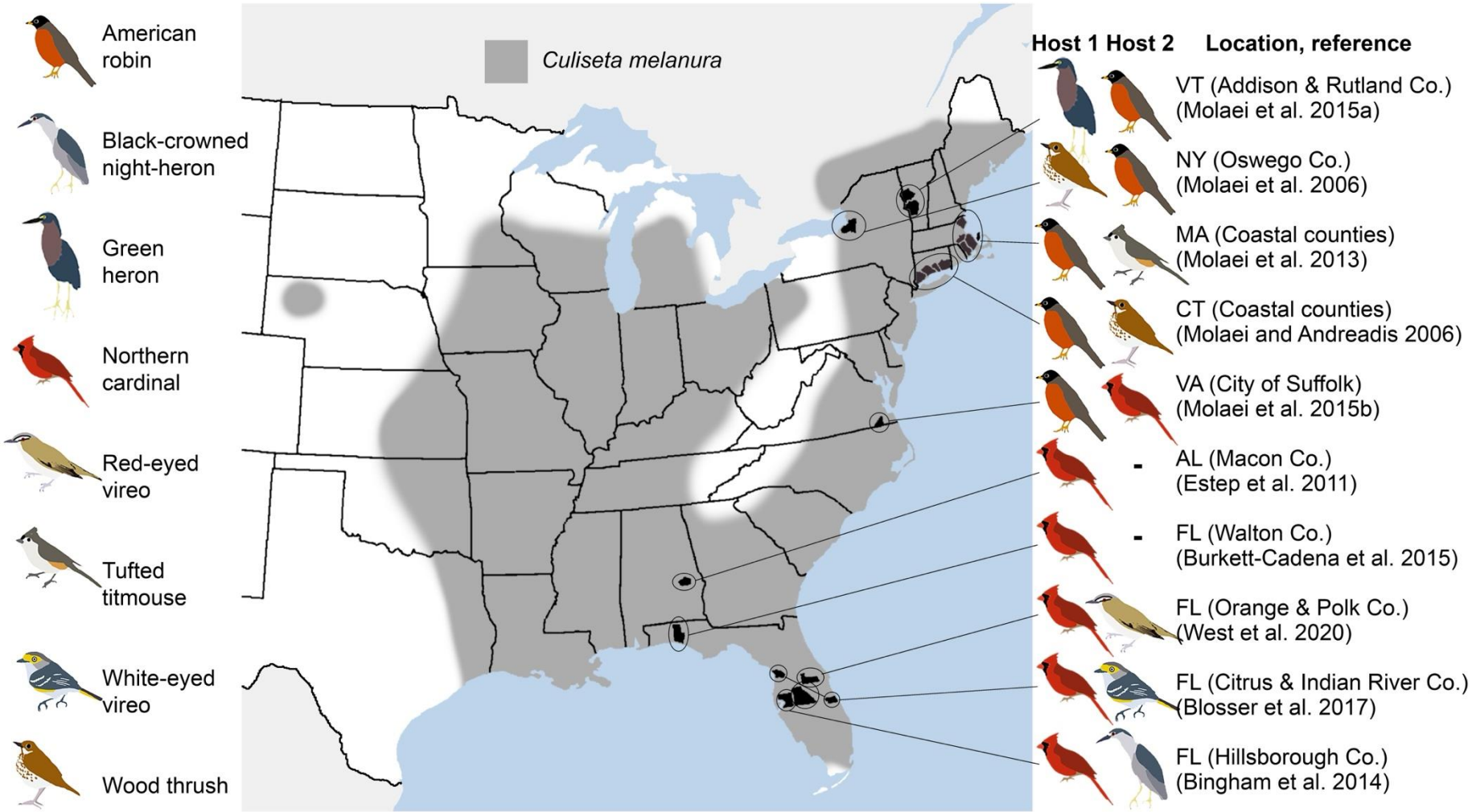
- Primary hosts = songbirds (passerines)
  - Ornithophilic
- Primary vector of Eastern Equine Encephalitis Virus (EEEV)
- Significant vector competence
- Surveillance shows early buildup of virus in environment





Top image credit: CDC Public Health Image Library
Bottom image: Nalany Richardson

Culiseta melanura: Range



West *et al.* 2020 [1]

Alternatives

- **Sentinel chickens**
  - **Cost-prohibitive**
  - **Require husbandry, permits, and training**
- **Bird-scented traps**
  - **Less financial burden**
  - **Use in conjunction with traditional trap methods**



Sentinel chicken program logistics: McIntire et al. 2021 [11]

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Sentinel chicken program logistics: McIntire et al. 2021 [11]. Image credit to Clarke Mosquito Control.

Mosquito attraction is multi-modal & synergistic

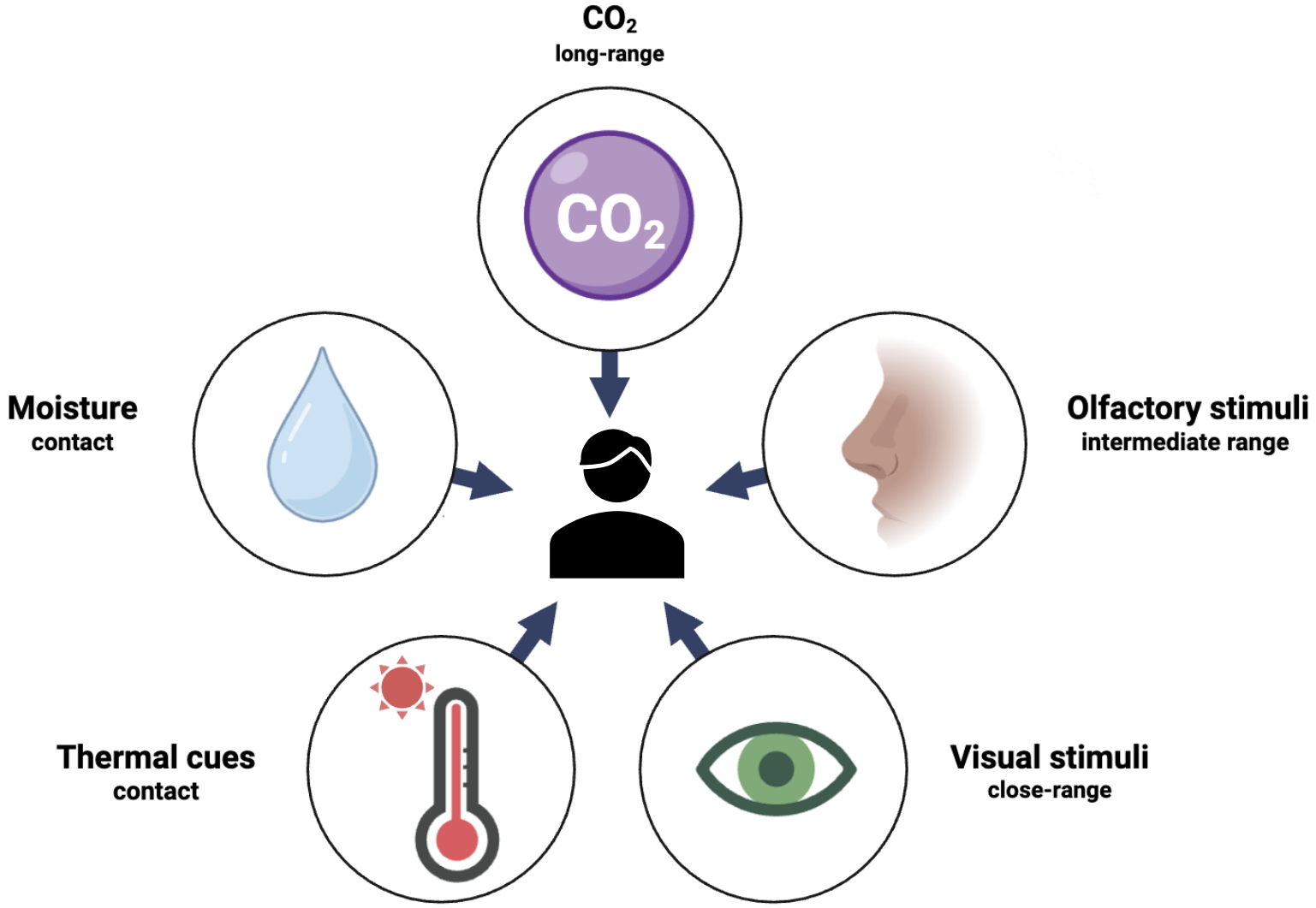


Image created with Biorender

Mosquito attraction is multi-modal & synergistic

- **Ornithophilic**
  - **"bird loving"**

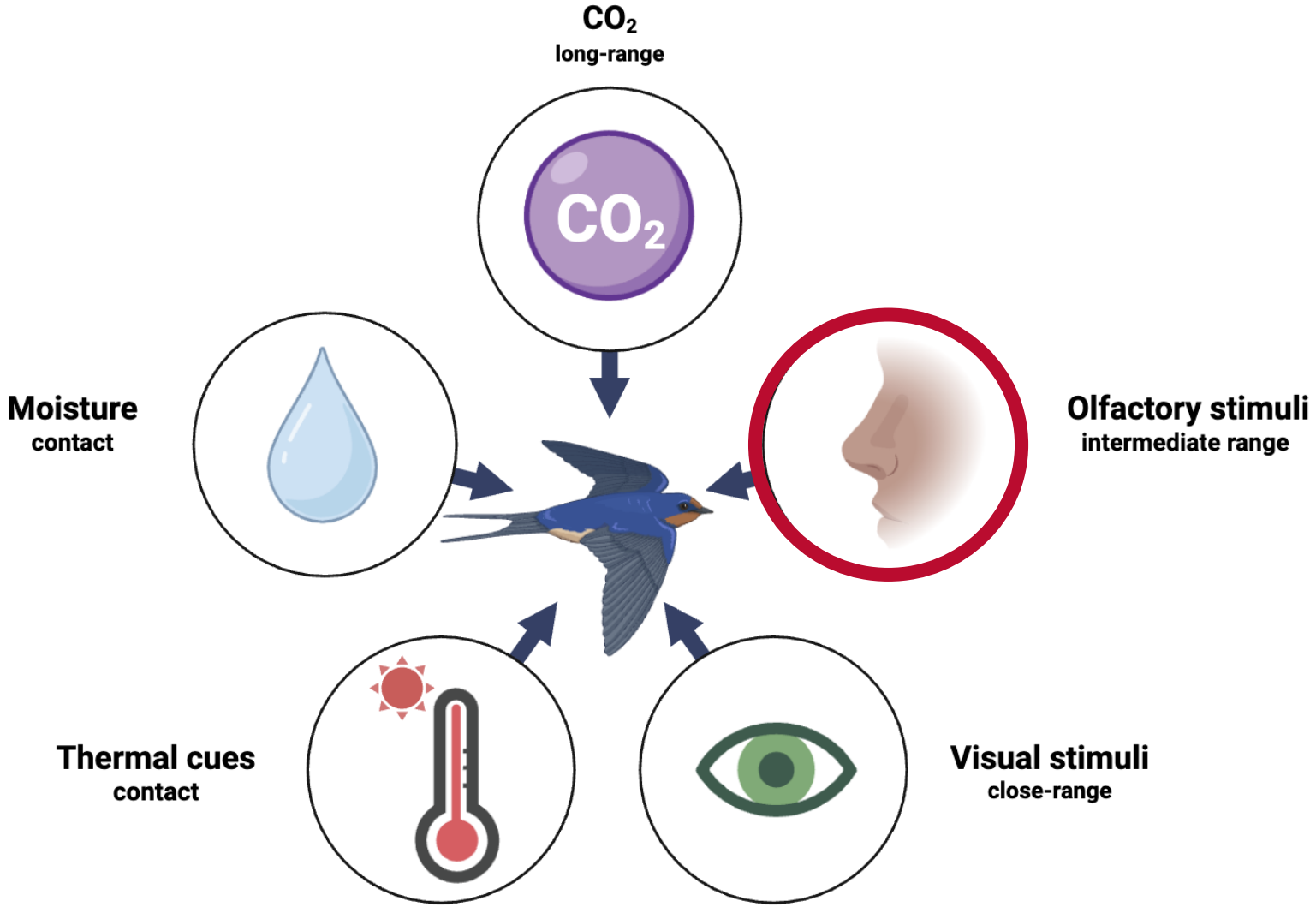


Image created with Biorender

Bird-Baited/Scented Traps: What We Know

2003

Williams et al.

South Australia

Bait: Chicken vs./and guinea pig

Two *Cx. annulirostris* populations chose different hosts. Odor chemistry, not CO_2, likely drove the choice.

2006

Darbro & Harrington

New York

Bait: Chicken vs. house sparrow

Both birds caught similar numbers. Canopy traps (~9 m) caught more than ground traps (~1.5 m).

2010

Russell & Hunter

Ontario

Bait: Chicken vs. guinea pig (no light, no CO_2)

Chicken-baited traps were preferred. More *Cx. pipiens* at 5 m than 1.5 m.

2016

Victoriano Llopis et al.

Italy

Bait: 8 bird species, incl. raptors

Cx. pipiens made up 84% of the catch and favored large raptors.

Williams et al. 2003 [12]; Darbro & Harrington 2006 [13]; Russell & Hunter 2010 [14]; Victoriano Llopis et al. 2016 [15]

From Live Birds to Bird Odor: Lab and Field

1

Whole chicken

55–74% of *Culex* responded, vs. <25% to a human arm

Allan et al. 2006

Attractive

2

Feathers & hexane extracts

Attractive; ether extracts of the same feathers were not

Allan et al. 2006

Attractive

3

Headspace volatiles

Chicken & pigeon odor + CO_2 beat CO_2 alone for *Cx. quinquefasciatus*

Spanoudis et al. 2020

Needs CO_2

4

Uropygial secretions

No effect on *Cx. pipiens* choice between sparrow age classes

Garvin et al. 2018

No effect alone

5

Single compounds

Isolated feather compounds failed; nonanal + CO_2 increased *Culex* trap catch

Allan et al. 2006; Syed & Leal 2009

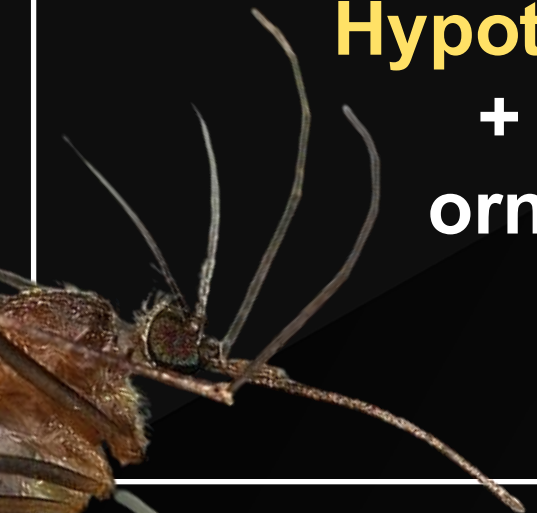
Mixed

Attraction comes from the blend, not a single compound, and often depends on CO_2.

Allan et al. 2006 [16]; Spanoudis et al. 2020 [17]; Garvin et al. 2018 [18]; Syed & Leal 2009 [19]

Aim 1: Does a synthetic chicken odor blend draw more mosquitoes into traps than a solvent control?

Hypothesis: Traps baited with synthetic chicken odor + CO_2 will catch more mosquitoes, especially ornithophilic species, than pentane + CO_2 traps.



Field Site

- Carolina bay at the Savannah River Site
- Paired trap deployment
- Pairs 5-10ft apart
- (2) Sub-sites separated by approx. 100ft







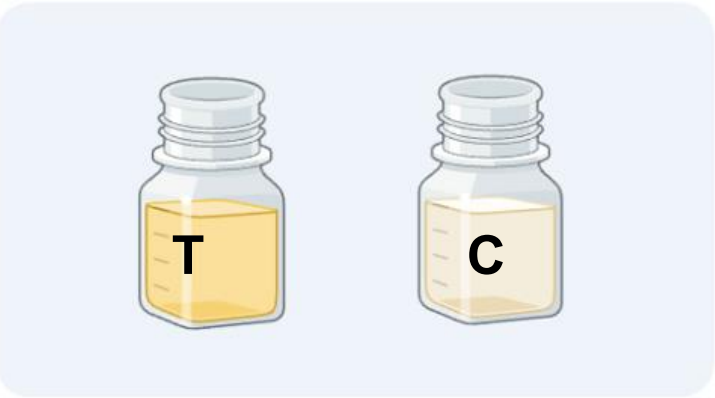
SRS image credit: Clemson Index Map and Study Sites (https://cecas.clemson.edu/geolk12/scmaps/maps/Chapters/5/srstopo.html)
Photographs by Nalany Richardson

Experimental Design

Both traps baited with CO_2 (dry ice)

Overnight

Chicken + Pentane Pentane







Produce chemical blends from the literature (e.g., chicken odors)

Deploy treatment (blend) and control (pentane) trap to field sites

Retrieve traps the next morning. Freeze samples.

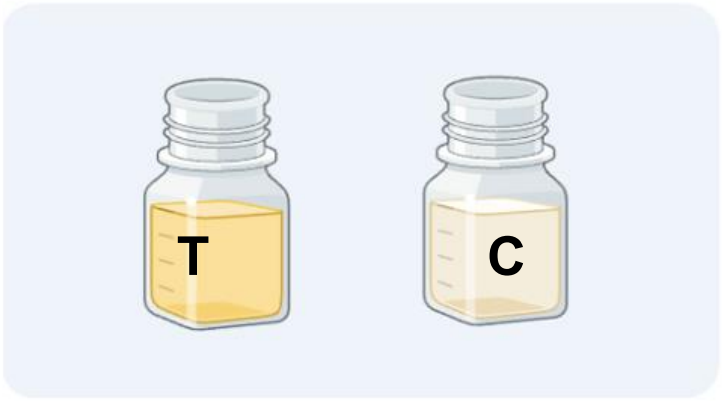
Spanoudis et al. 2022 [20]; Allan et al. 2006 [16]

Graphics created with Biorender
Photographs by Nalany Richardson

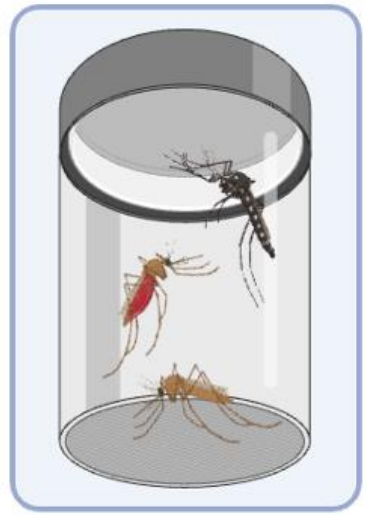
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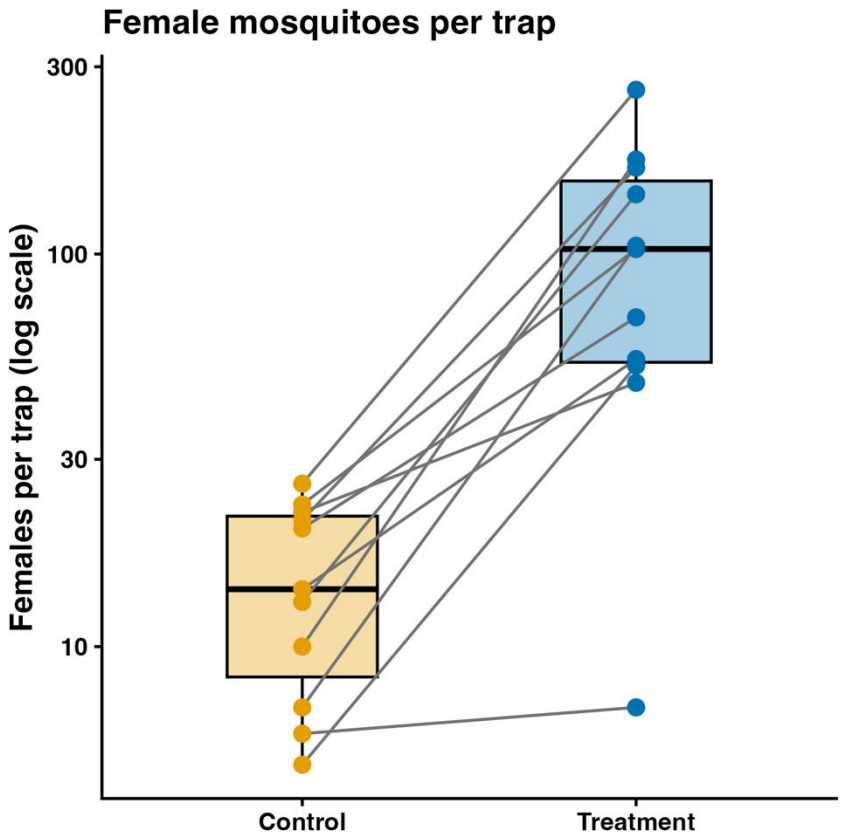
Assess capture rates and morphologically ID samples

Spanoudis et al. 2022 [20]; Allan et al. 2006 [16]

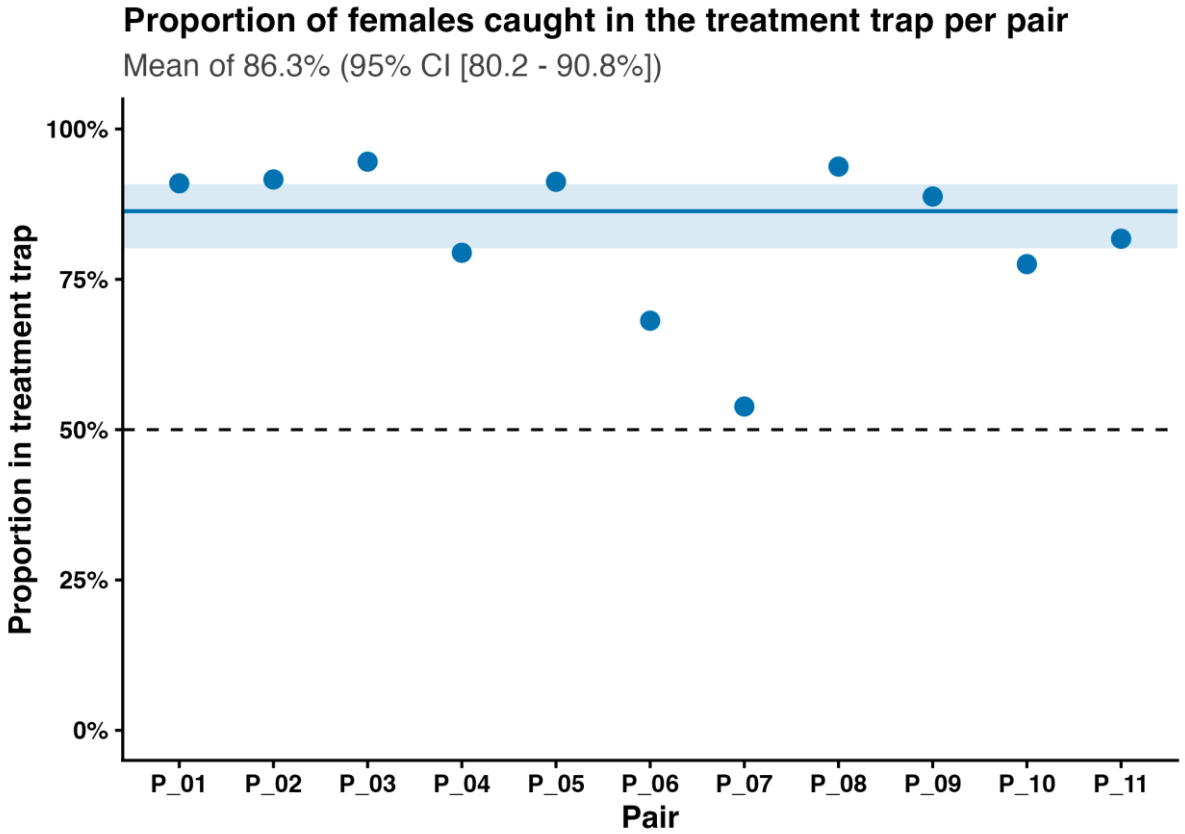
Graphics created with Biorender
Photographs by Nalany Richardson

Results

- **Traps baited with treatment received >50% of response for every pair.**
- **Mean response of 86.3% (95% CI: 80.2-90.8%)**



Box plots of treatment and control catch.



Scatterplot of response rate per pair. Dash line at 50% represents cutoff for 'no preference'.

Results

- ***Anopheles spp.*** **are the most abundant genus followed by *Aedes*.**
  - **Morphological identifications ongoing.**

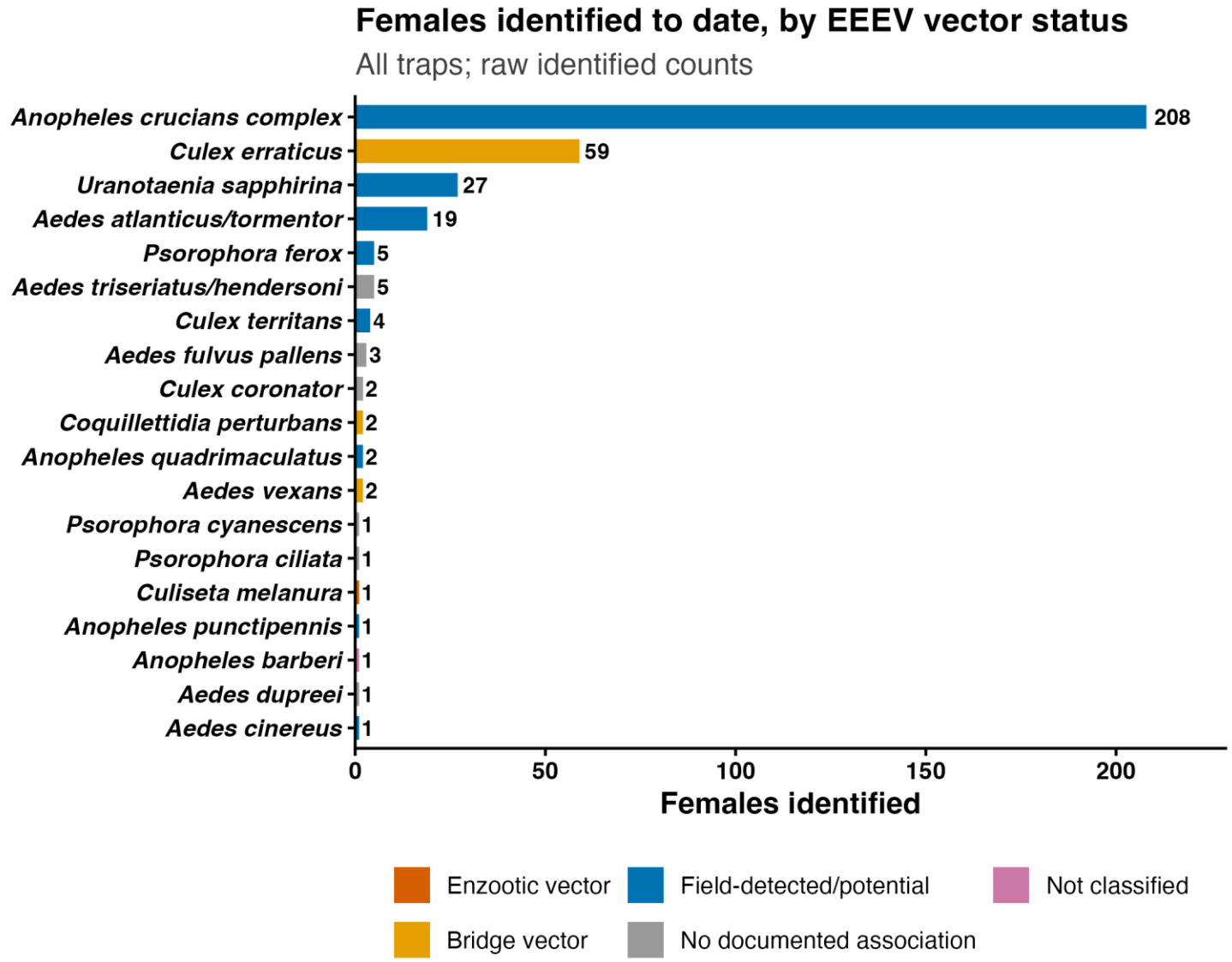
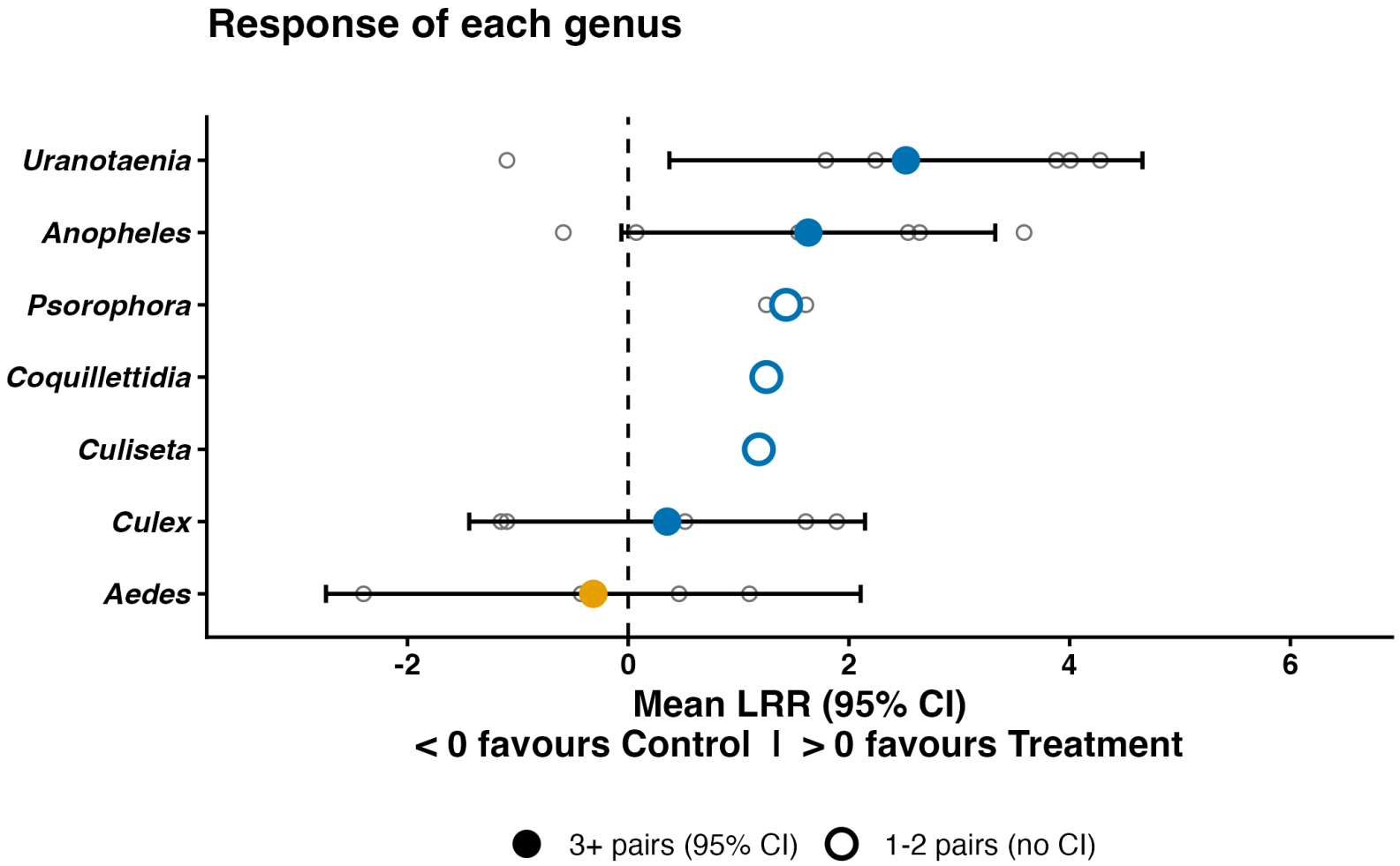


Fig. 3: Bar graph of identified mosquitoes by vector status

Results

- Attraction did not vary significantly by subsite
- Predominantly opportunistic catch
- Bridge vectors show preference for chicken odor over pentane solvent



Our Results vs. the Literature

	Literature	Our paired trials
Overall attraction	Blend + CO_2 caught more than CO_2 alone or controls (Spanoudis et al. 2022)	**Same trend noted**
Anopheles	Increased with blend + CO_2 in Greece (Spanoudis et al. 2022). *An. crucians* complex was EEEV-positive in SC Carolina bays (Wozniak et al. 2001)	**Most abundant genus so far Remember, our traps are at a Carolina Bay!**
Uranotaenia	More *Ur. sapphirina* in blend-only and cyclopentanone traps (Spanoudis et al. 2022)	**Catching a fair number of females… and predominantly males!**
Culiseta	Increased in Greece with blend + CO_2 (Spanoudis et al. 2022). CO_2 reduced *Cs. melanura* catch in NJ (Fagre et al. 2024)	**Low numbers, can't make a fair comparison**

Preliminary notes

Spanoudis et al. 2022 [20]; Wozniak et al. 2001 [7]; Fagre et al. 2024 [21]

Aim 1: Do synthetic bird-derived odor blends increase trap attraction rates?

Preliminary results: Synthetic whole-body chicken odor attracted significantly more mosquitoes than the pentane solvent control.





Aim 2: What passerine-derived volatiles attract *Cs. melanura* to avian hosts?

Hypothesis: Synthetic odor blends derived from whole-body odors of host species will elicit greater attraction than both (or either) traditional trapping methods or partial/whole-body blends from non-target birds.

Aim 2: Why Host-specific Odor is Desirable

Molecular identification of blood-meal sources in Culiseta melanura and Culiseta morsitans from an endemic focus of eastern equine encephalitis virus in New York

Goudarz Molaei [1], Joanne Oliver, Theodore G Andreadis, Philip M Armstrong, John J Howard

Affiliations + expand

PMID: 17172382

Laboratory Evaluation of Avian Odors for Mosquito (Diptera: Culicidae) Attraction

S. A. ALLAN, U. R. BERNIER, AND D. L. KLINE

Center for Medical, Agricultural and Agricultural Entomology, USDA–ARS, 1600/1700, 23rd Drive, P.O. Box 14565, Gainesville, FL 32608

The chemical code for attracting *Culex* mosquitoes

Christos G. Spanoudis[1], Betelehem Wondwosen[2], Elin Isberg[3], Stefanos S. Andreadis[3,4], Daniel L. Kline[5], Göran Birgersson[3] and Rickard Ignell[3]*

Seasonal Changes of Host Use by *Culiseta melanura* (Diptera: Culicidae) in Central Florida

Richard G West, Derrick K Mathias, Jonathan F Day, Carolina Acevedo, Thomas R Unnasch, Nathan D Burkett-Cadena ✉

Journal of Medical Entomology, Volume 57, Issue 5, 1 September 2020, Pages 1627–1634, https://doi.org/10.1093/jme/tjaa067

Mist-netting



Image credit: NC Arboretum

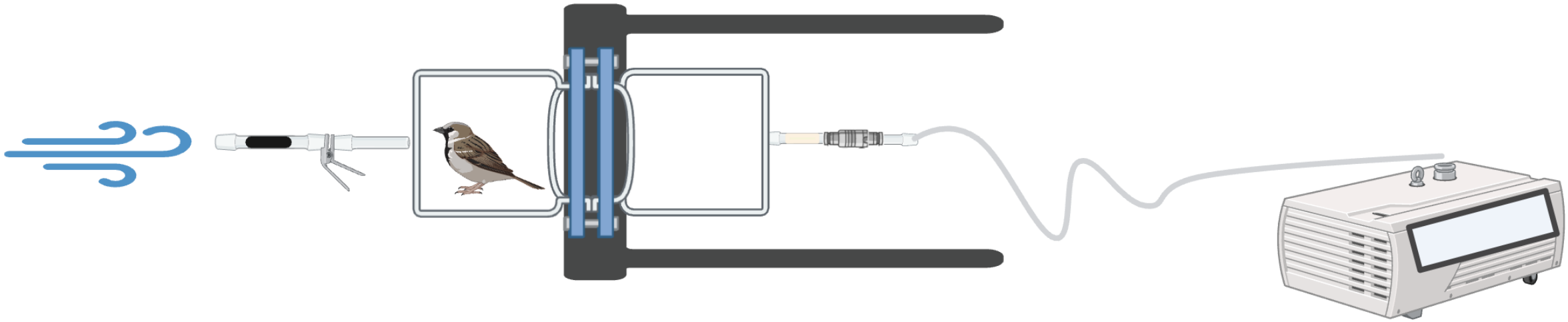
Mist-netting



Image credit: NC Arboretum

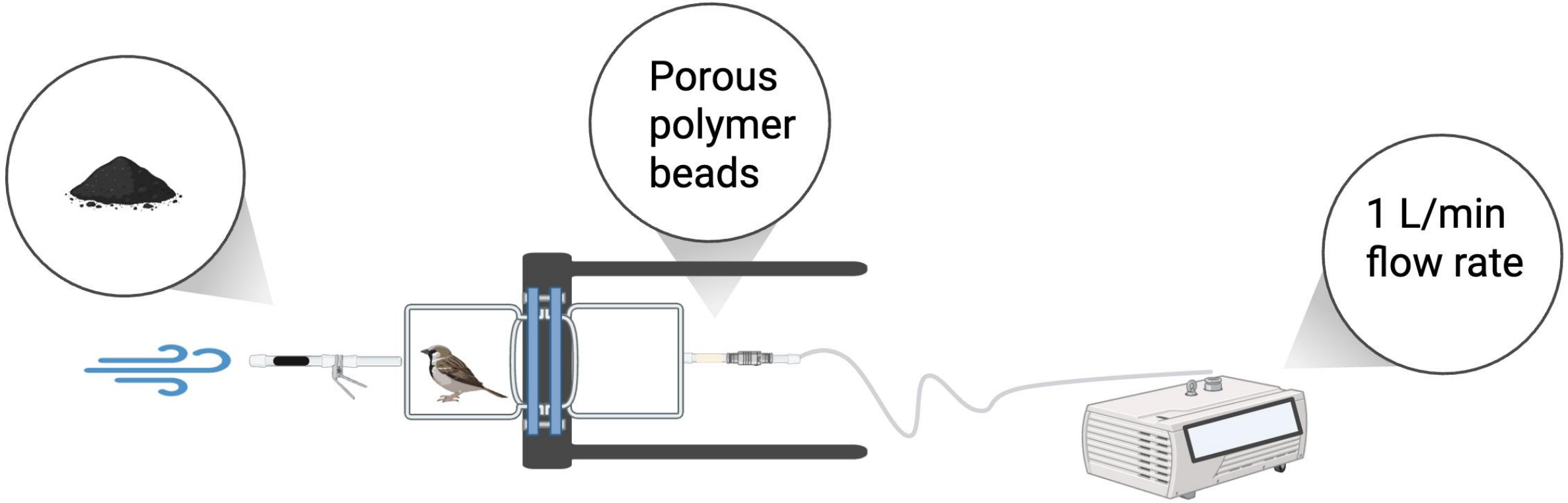
Dynamic Headspace Aeration (DHA)

- 1.5-2.0-hour aerations at ~ 1L/min flow rate
- Porapak adsorbent with charcoal filter
- Samples desorbed with 600 uL pentane



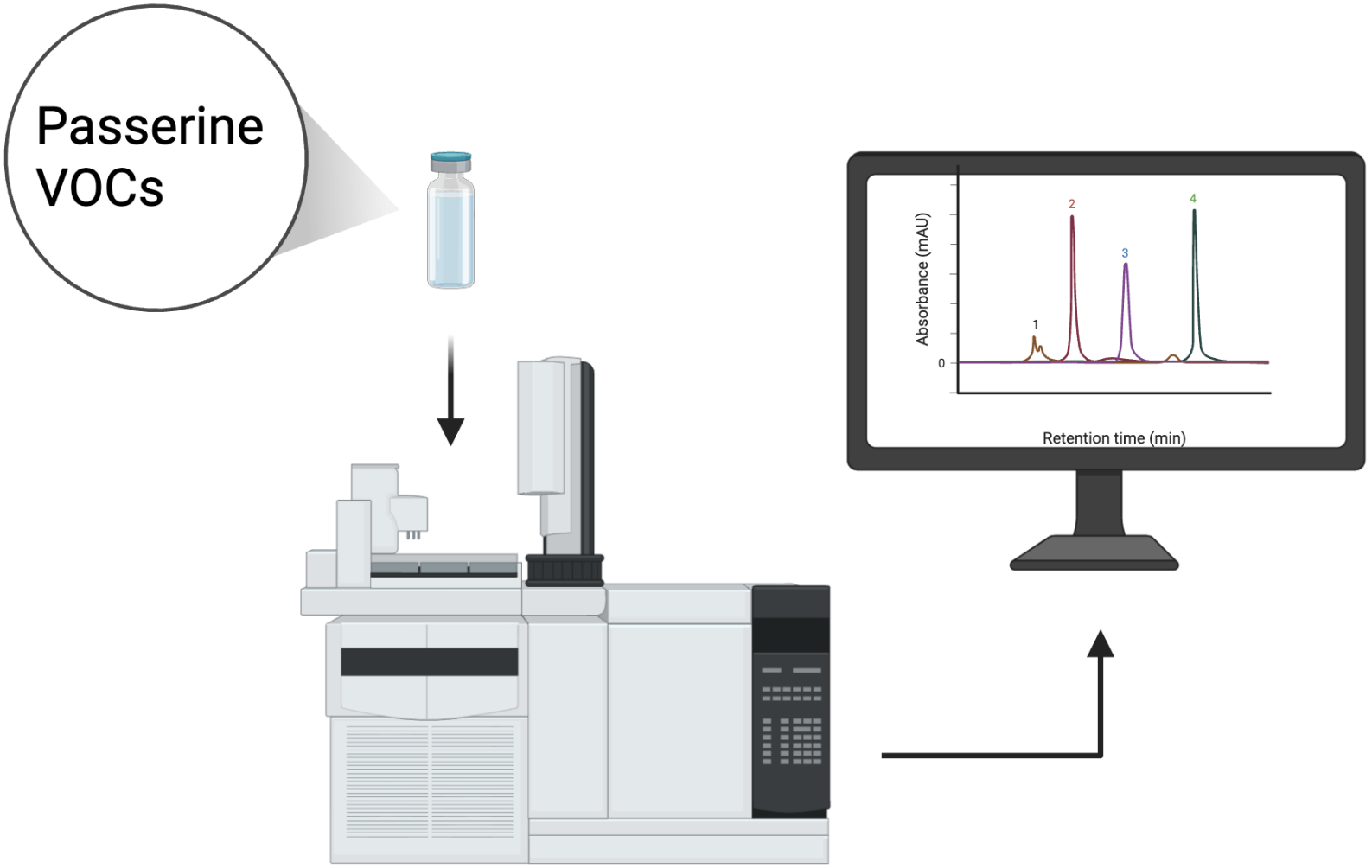
Graphic created in Biorender

Dynamic Headspace Aeration (DHA)



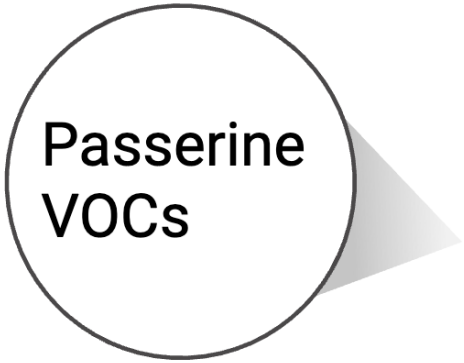
Graphic created in Biorender

Next Steps: GC-MS

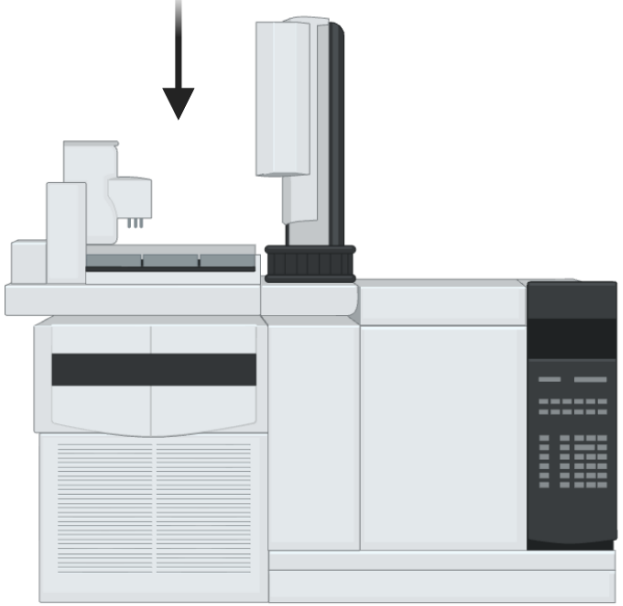


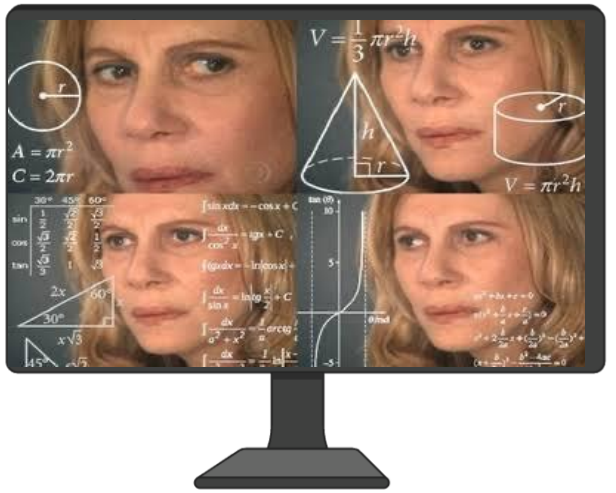
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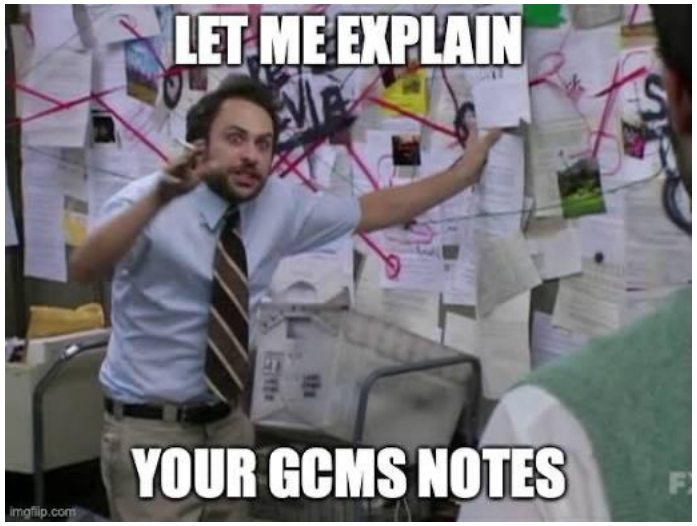
Next Steps: GC-MS





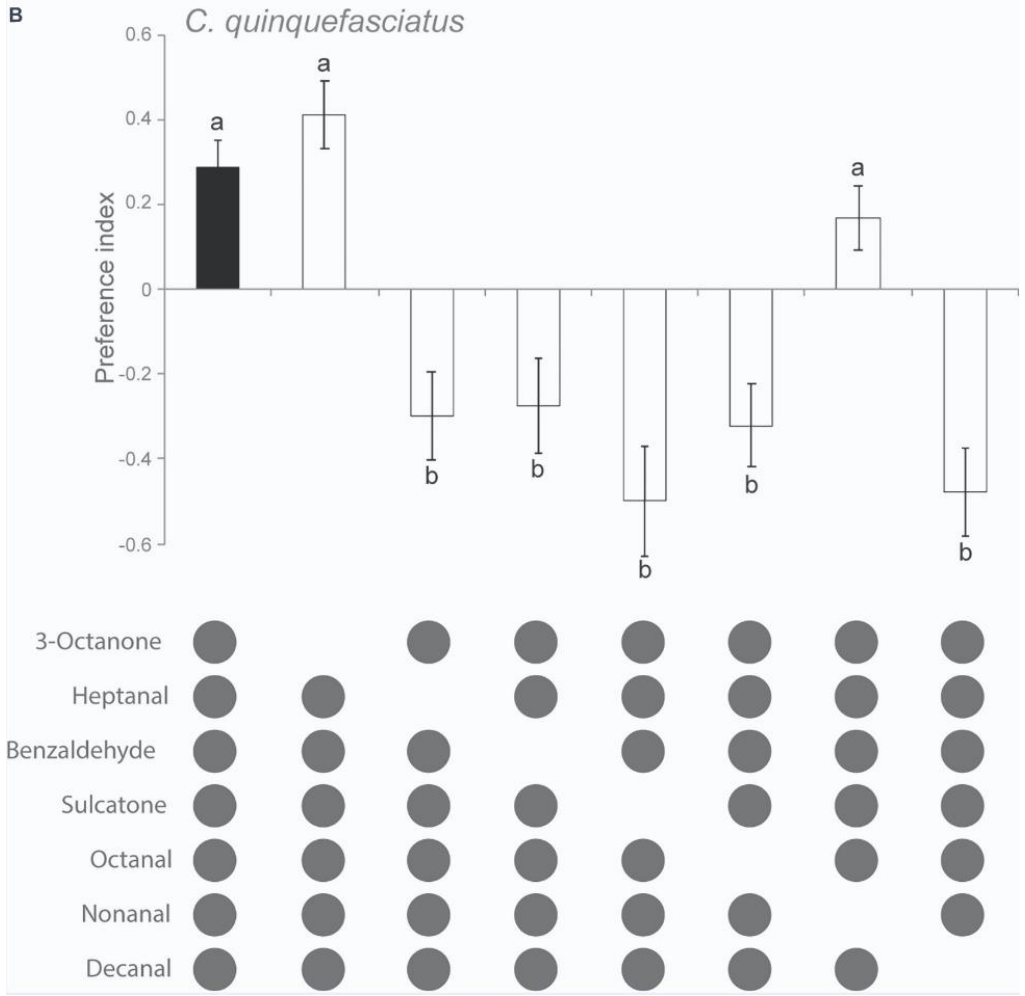






Graphic created with Biorender

Next Steps: Laboratory Assays



Spanoudis et al. 2022 [20]

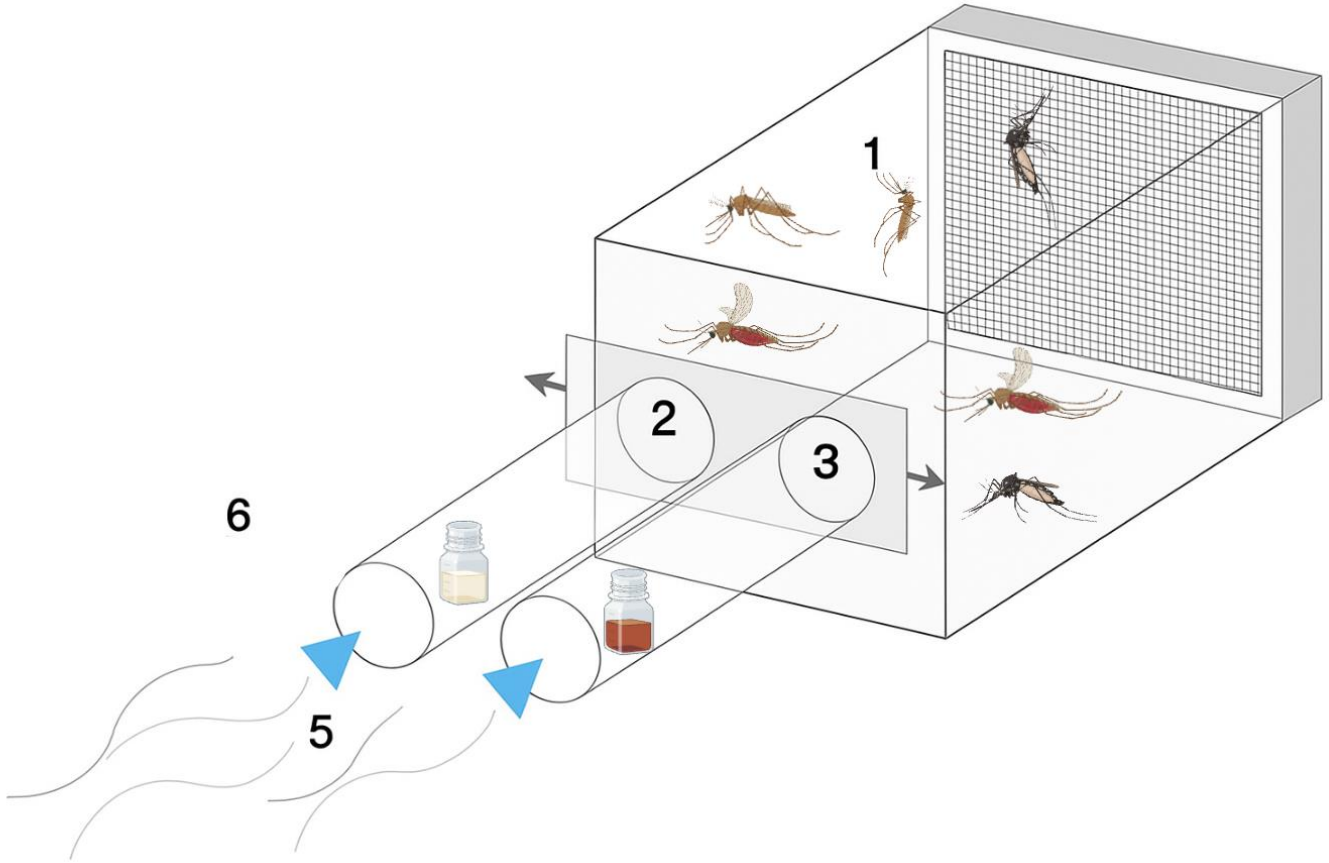


Image adapted from Fikrig et al. 2023 [24]

Next Steps: Field Work



Image adapted from Fikrig et al. 2023 [24]

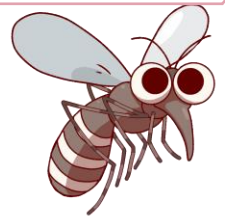
Next Steps: Field Work







Image adapted from Fikrig et al. 2023 [24]



Conclusions



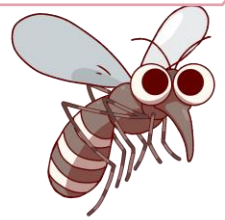
- Synthetic chicken odor **out-caught the pentane solvent control in all 11 pairs**
- So far, the catch is mostly **opportunistic feeders**; ornithophilic species are a minority
  - *Cs. melanura* catch is low
- **A host-specific (passerine) blend** could improve surveillance for ornithophilic mosquitoes

Acknowledgments

- **The Peach Lab**
- **Mist-netting**
  - **Caryn Ross**
- **Committee members**
  - Dr. Travis DeVault and Dr. Melinda Brindley

Contact @ Nalany.richardson@uga.edu

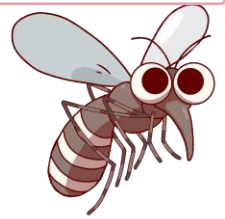

Thanks for listening ☺
Nalany.Richardson@uga.edu



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8. South Carolina Department of Public Health. DPH confirms first human eastern equine encephalitis death in South Carolina in more than 20 years. https://dph.sc.gov (19 September 2025).
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Dynamic Headspace Aeration (DHA)

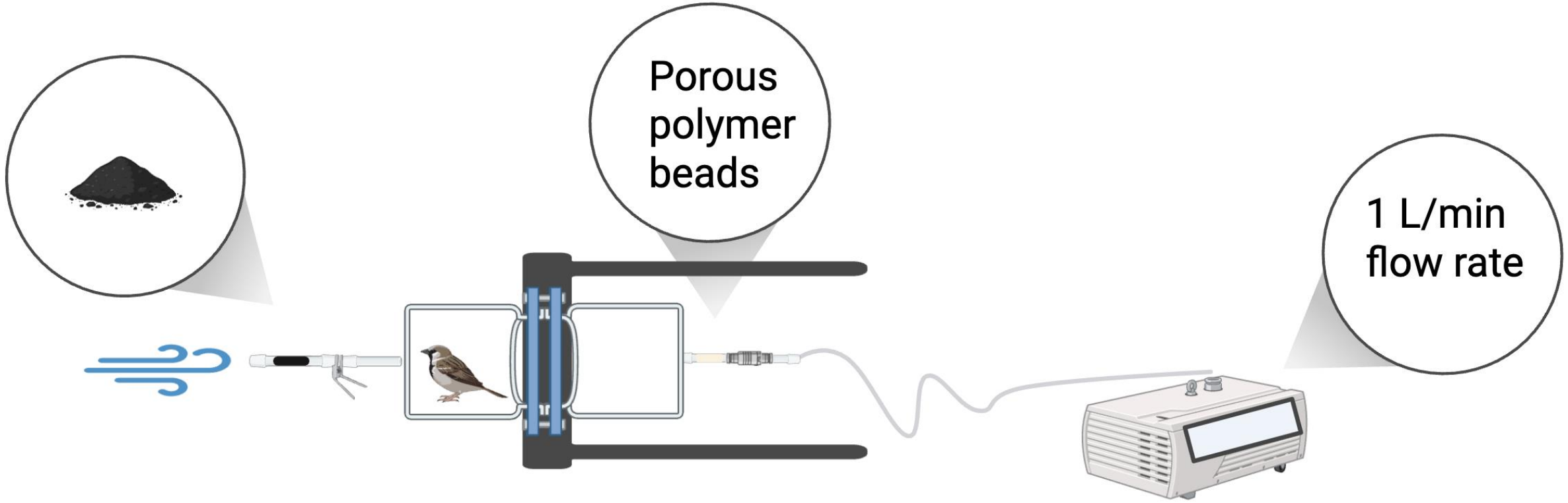
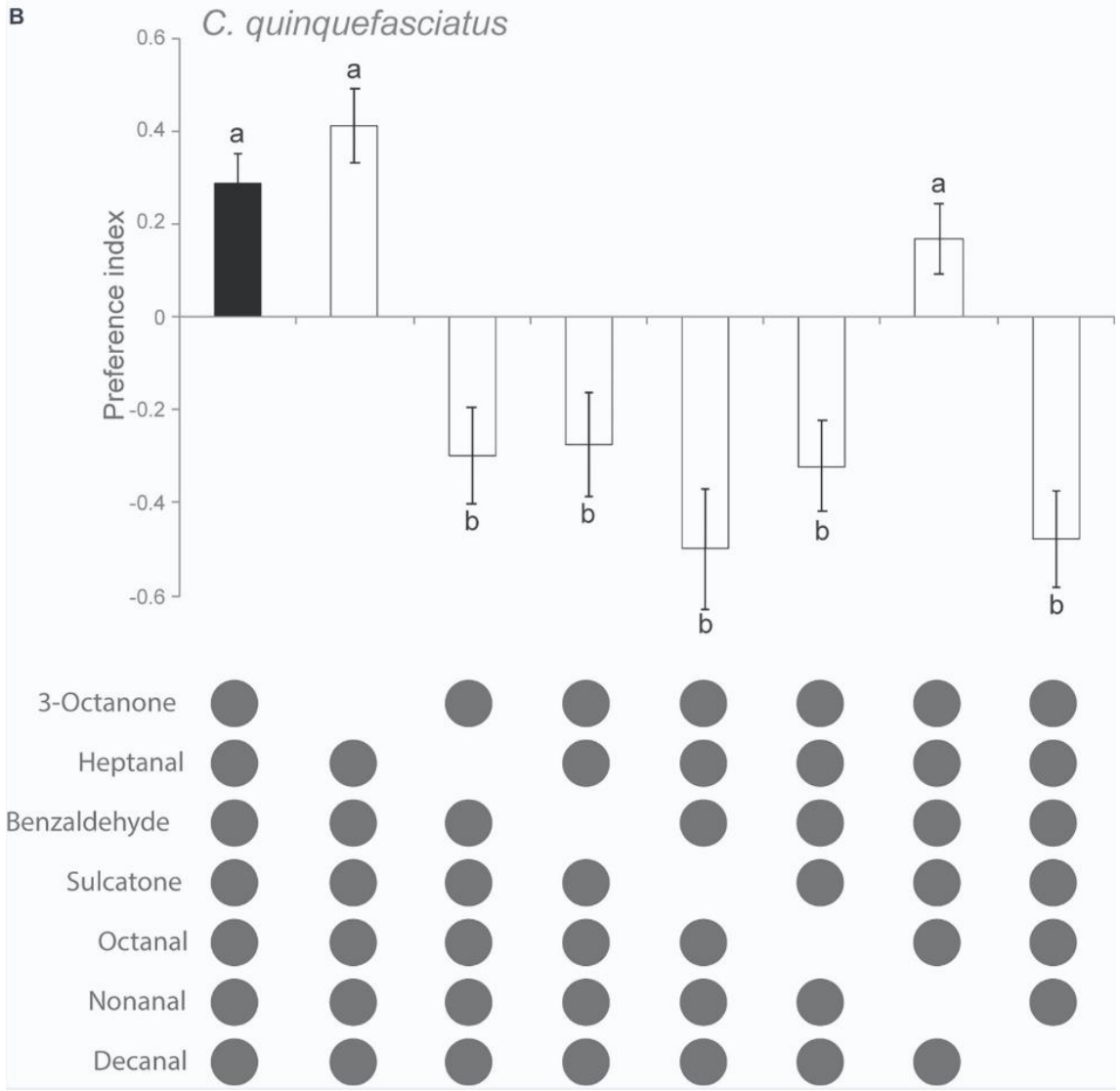


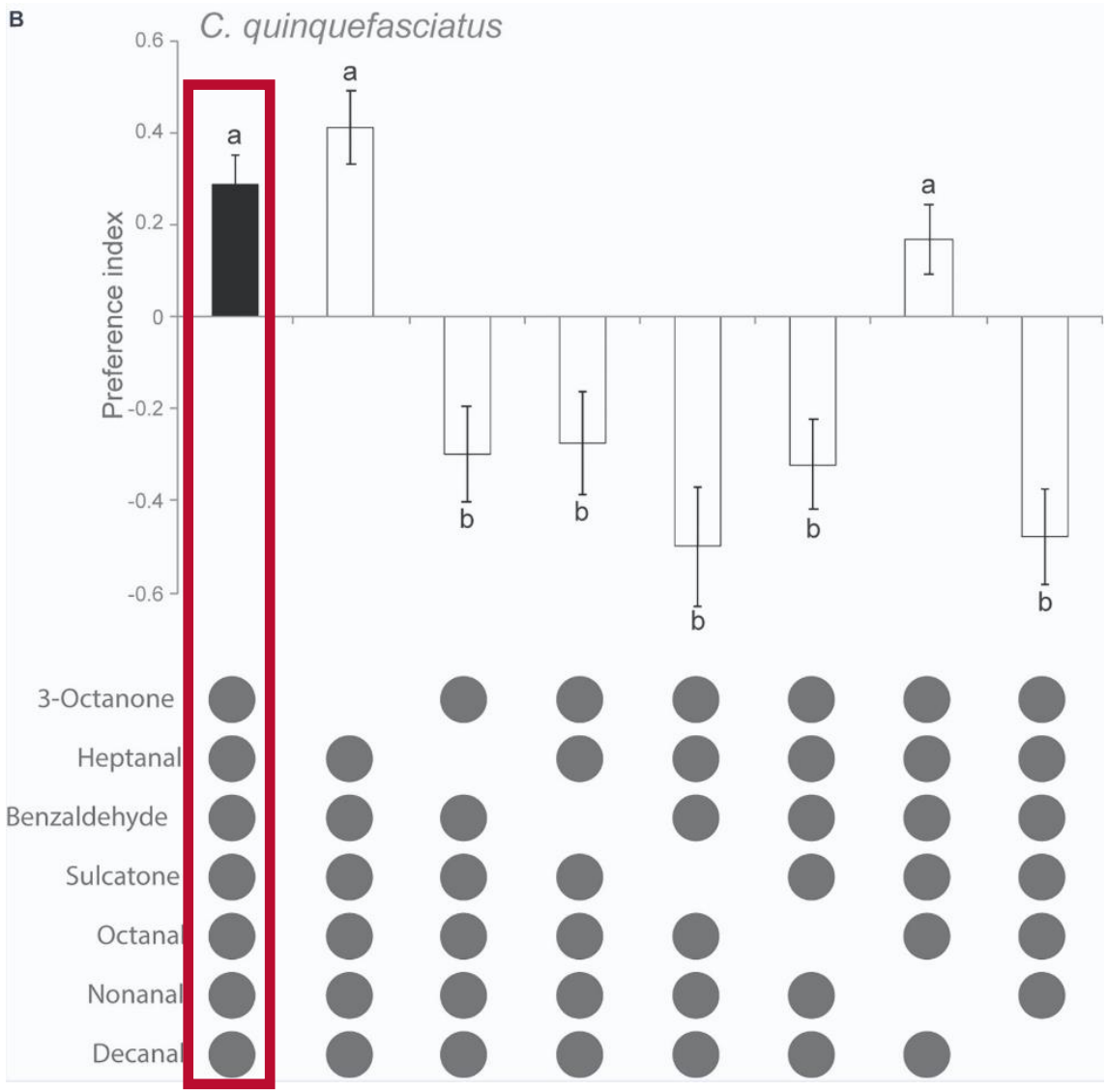
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Subtractive assay for chemical blends



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