"Emerging Insights on *Anopheles* Mosquitoes and Malaria Risk in the United States"



Adult female *Anopheles quadrimaculatus*

Presented by: Subhika Rao

22 October 2026

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OUR TEAM

Vector Surveillance and Program Support Team (VSPST)

- **MISSION STATEMENT**
  - To enhance global and local public health by reinforcing capacity and transferring conventional and advanced expertise for malaria vector surveillance, monitoring, and control.



Overview

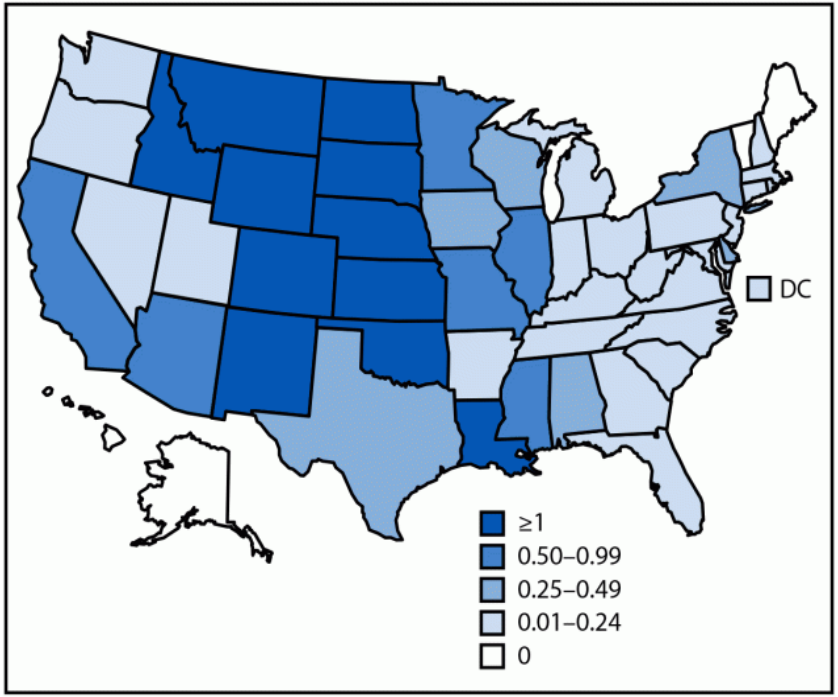
Work surrounding *Anopheles* spp. in the US:

1. Assessment of the utility of long-term bycatch data
2. Laboratory support to US states
3. Georgia mosquito control and surveillance programs
4. Additional projects
    1. Domestic malaria response (vector focus)
    2. *An. punctipennis* and *An. crucians* s.l. biology, ecology and population genetics

Arboviral Disease Burden

- **Arboviral diseases - major public health concern in the continental US**
  - Mosquitoes and ticks
- **Largely asymptomatic, but can cause neurologic illness and death**
- **Nationally reportable arbovirus morbidity and mortality, 2023**
  - 2,770 cases
  - 208 deaths

Incidence of confirmed and probable cases of neuroinvasive West Nile virus disease, by state – United States, 2023



Padda H, Jacobs D, Gould CV, et al. West Nile Virus and Other Nationally Notifiable Arboviral Diseases — United States, 2023. MMWR Morb Mortal Wkly Rep 2025;74:358–364. DOI:

Arboviral Vector Control

- **No treatment**
- **Vector control for managing disease transmission**
- **Vector surveillance**
  - Estimates species abundance and distribution
  - Basic assessment of disease risk
  - Provides guidance for vector control strategies

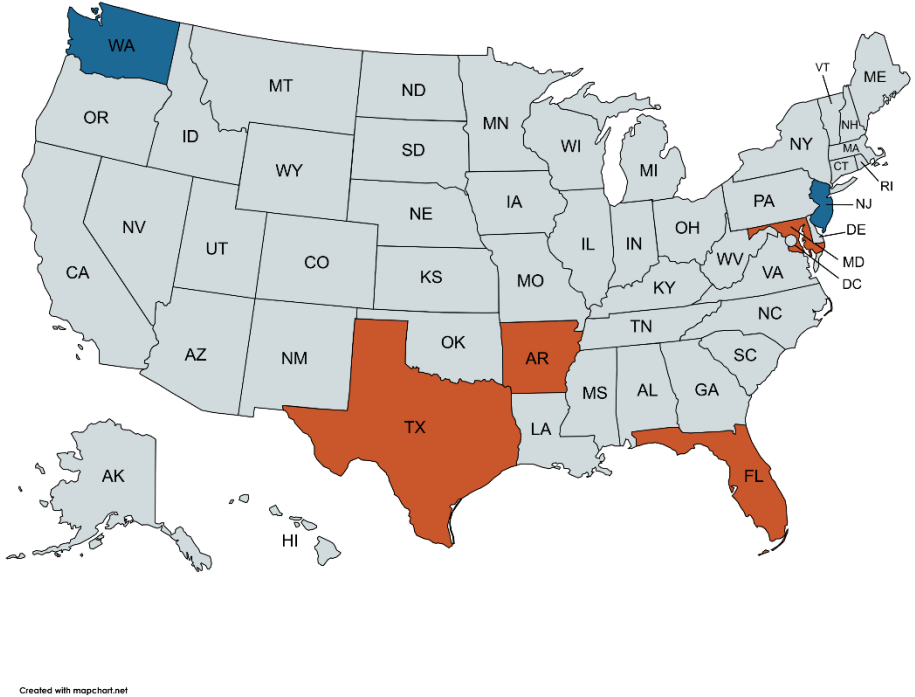


Adult female *Culex quinquefasciatus*

Original Investigation | Infectious Diseases

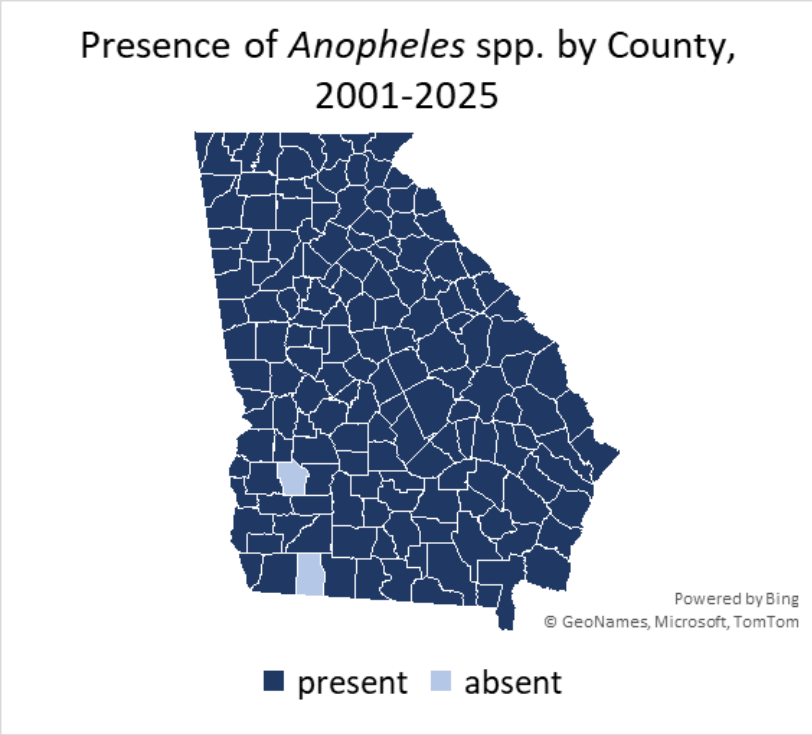
Public Health Response to the First Locally Acquired Malaria Outbreaks in the US in 20 Years

Timothy N. DeVita, MD[1,2,3]; Andrea M. Morrison, PhD[4]; Danielle Stanek, DVM[4]; et al



Anopheles spp. Presence in Georgia

- **2001 West Nile outbreaks spurred *Culex* surveillance**
- **Malaria eliminated from US in 1951, but malaria vectors (*Anopheles* mosquitoes) persist**
- ***Anopheles* spp. in *Culex* surveillance bycatch**
  - No reports of *Anopheles* spp. in Terrell County and Grady County
- ***Anopheles* bycatch may help assess malaria risk by establishing a baseline**



Bycatch Data

Current Surveillance Methods

- **Surveillance conducted by:**
  - Two GDPH entomologists
  - Environmental Health Specialists
  - Vector Surveillance Coordinators (2016-2020)
- **Trapping sites selected based on:**
  - Presence of West Nile cases
  - Nuisance complaint locations
  - Proximity to people





Distribution of Local Mosquito Control Programs (2017 Survey)

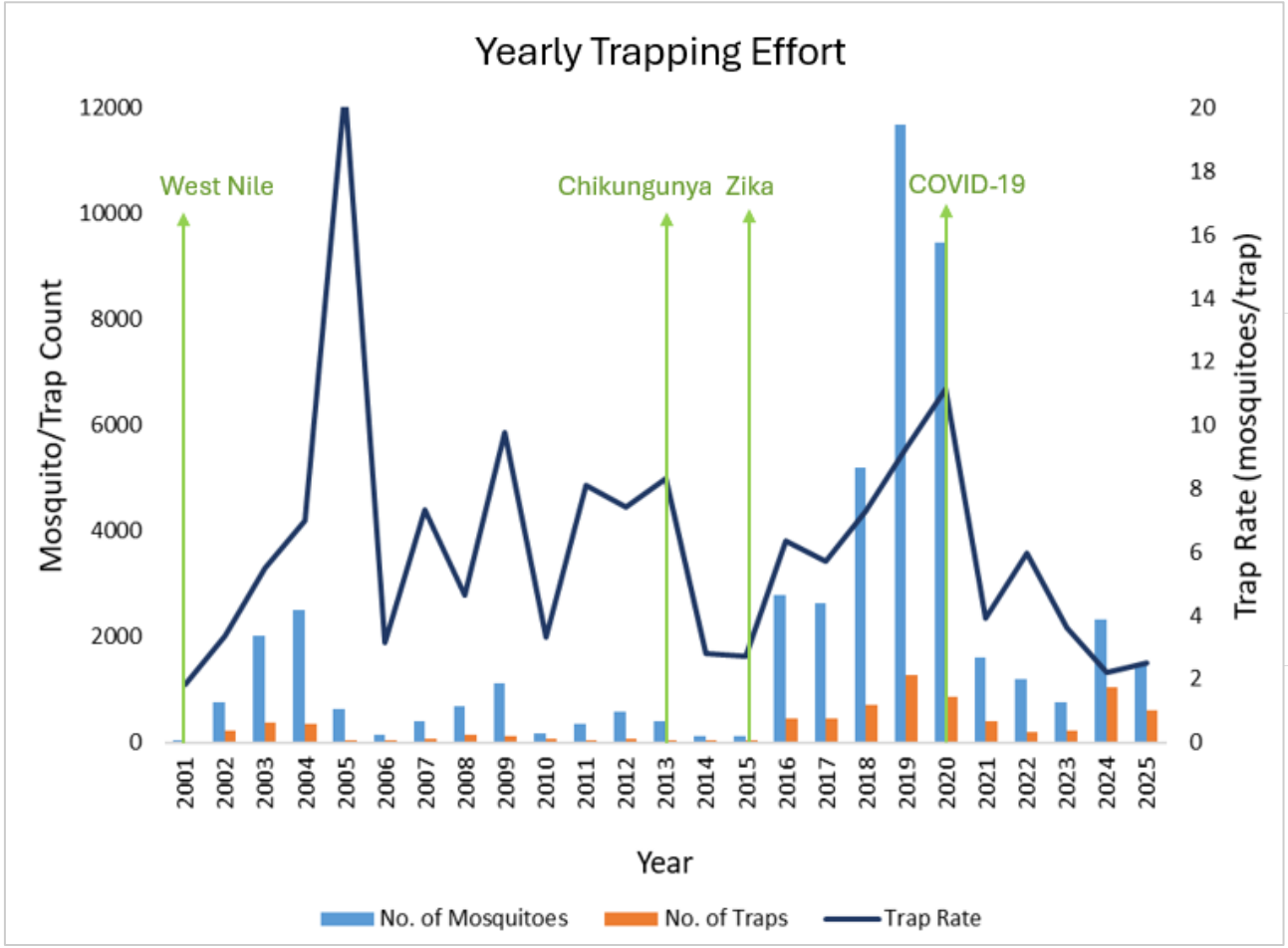
DPH
Georgia Department of Public Health

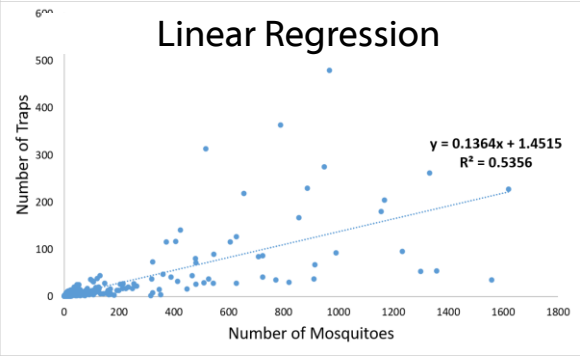




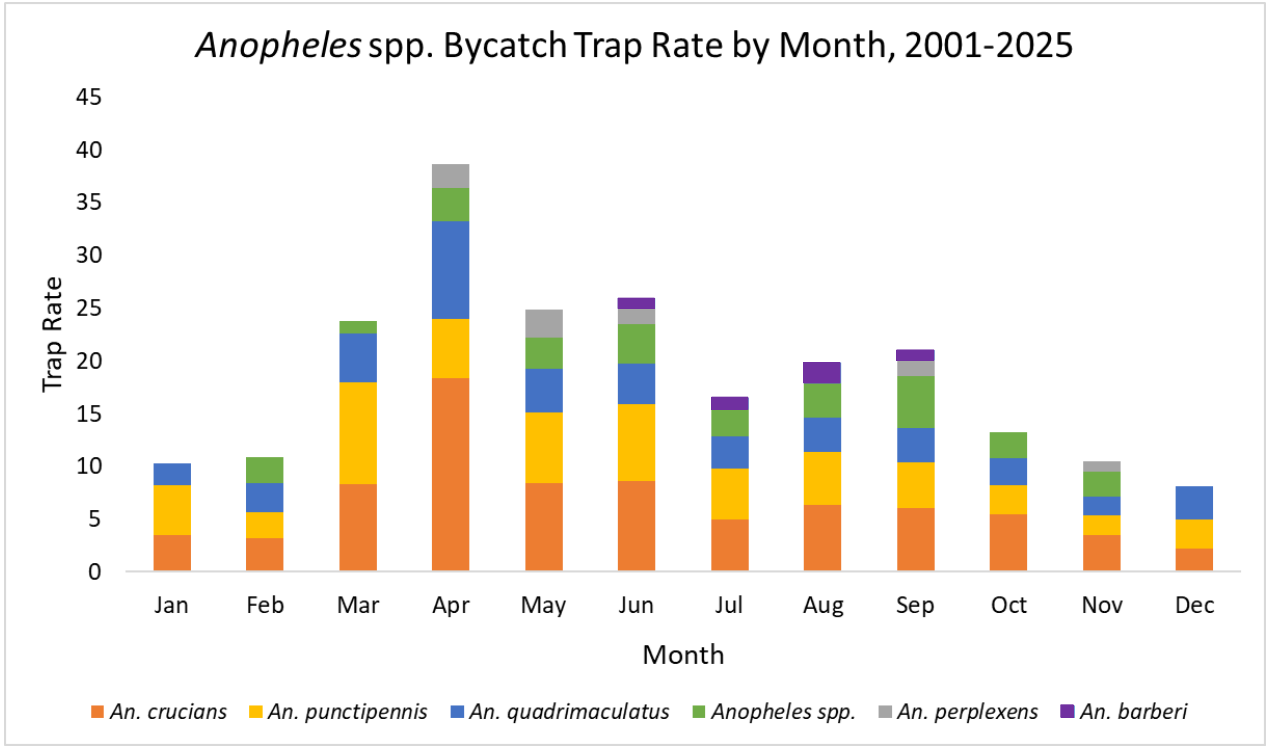
Anopheles spp. Bycatch Overview

- **40,095 *Anopheles* spp. mosquitoes captured**
  - 39,840 females (99.36%)
  - 255 males (0.64%)
- **5 species identified**
  - *An. crucians* s.l.
  - *An. punctipennis*
  - *An. quadrimaculatus* s.l.
  - *An. perplexens*
  - *An. barberi*
  - Unknown *(Anopheles* spp.)


Yearly Trapping Effort
West Nile
Chikungunya
Zika
COVID-19
Mosquito/Trap Count
Trap Rate (mosquitoes/trap)
Year
No. of Mosquitoes
No. of Traps
Trap Rate


Linear Regression
y = 0.1364x + 1.4515
R² = 0.5356
Number of Traps
Number of Mosquitoes

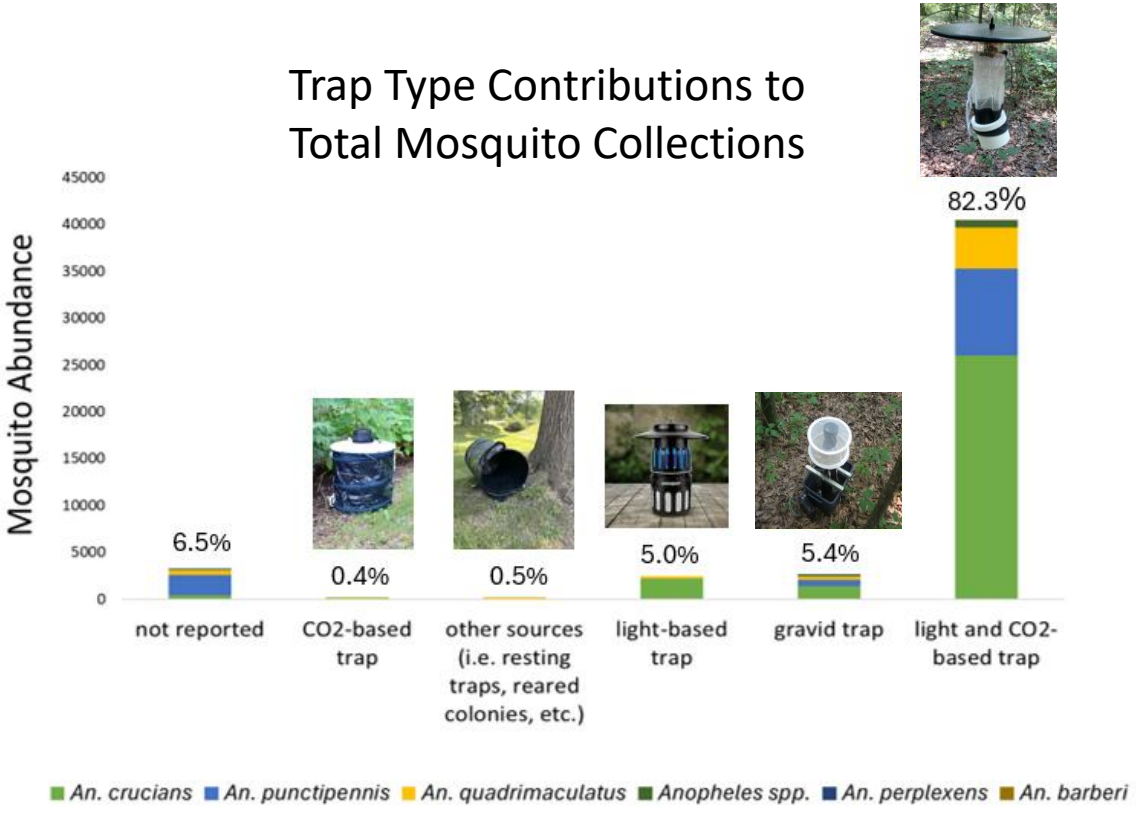
Seasonality Differs Between Species

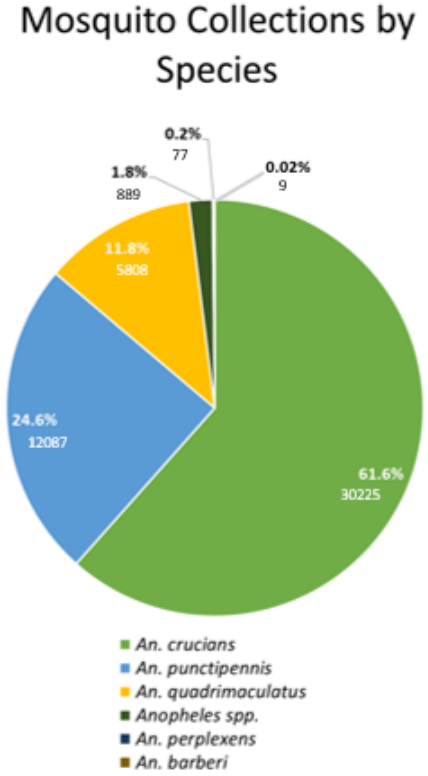


Peak abundance

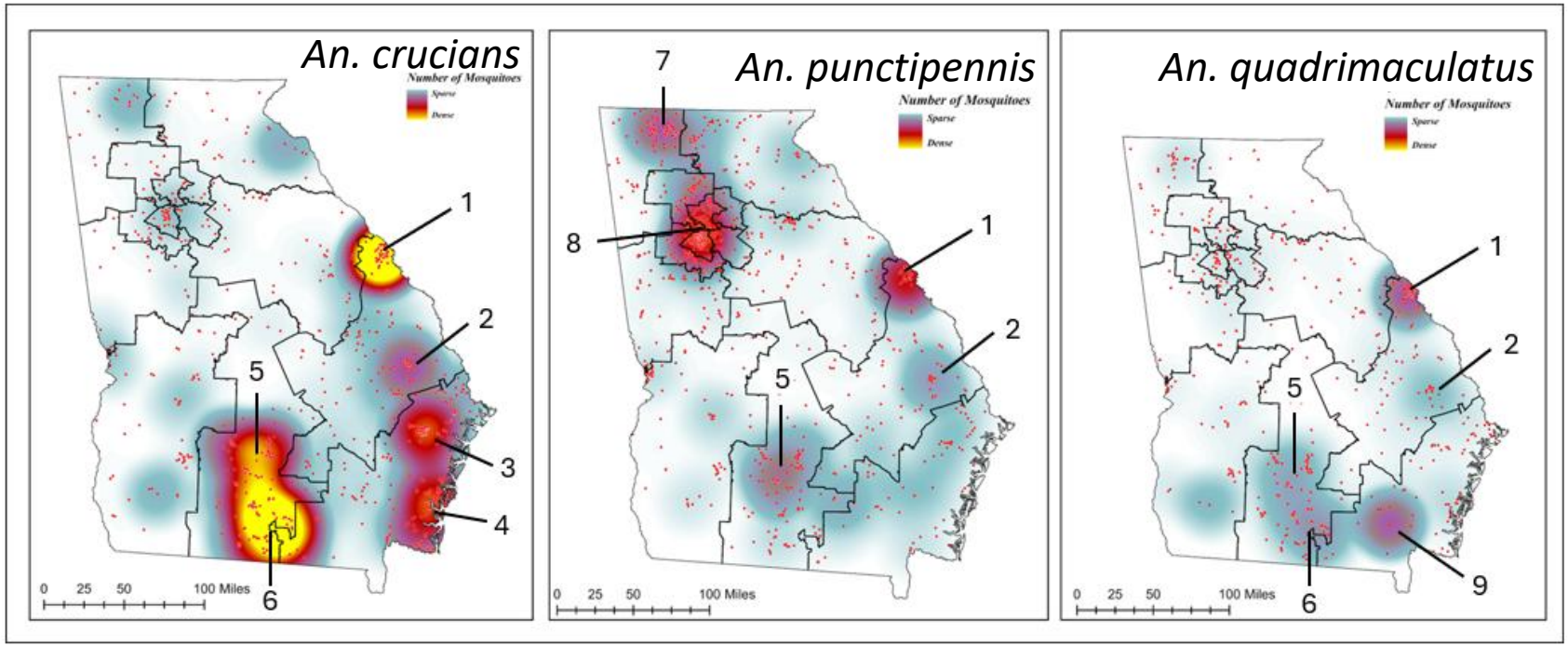
- *An. crucians* – April
- *An. punctipennis* – March
- *An. quadrimaculatus* – April
- *Anopheles* spp. – September
- *An. perplexens* – May
- *An. barberi* - August

Anopheles spp. Bycatch by Trap Type and Species





Distributions Differ Between Species, 2001-2025



1 Augusta
2 Statesboro
3 Hinesville
4 St. Mary's/Brunswick
5 Tifton
6 Valdosta
7 Dalton
8 Atlanta
9 Waycross

Conclusions

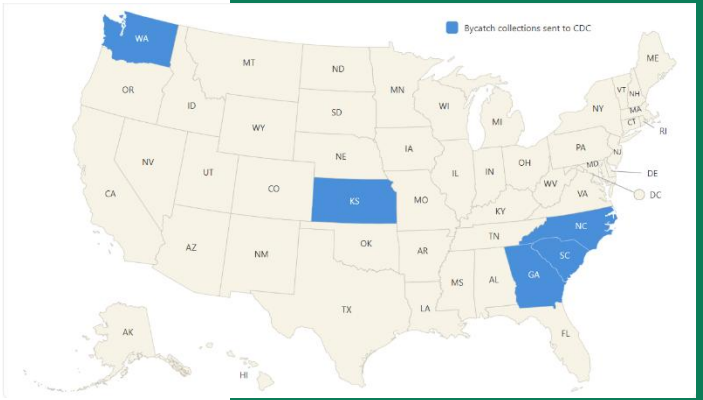
- Increases in sampling effort correlate to increases in mosquito abundance and may be influenced by different public health events
- Distributions across Georgia differ over time and between species
- CDC light traps capture a majority of *Anopheles* spp. bycatch
- *An. crucians* is the most abundant *Anopheles* spp.

Partnership with States

Laboratory support to US states

DOMESTIC *ANOPHELES* BYCATCH

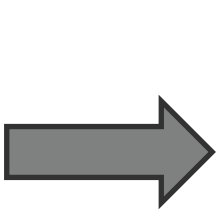
Molecular Laboratory support to US State Programs

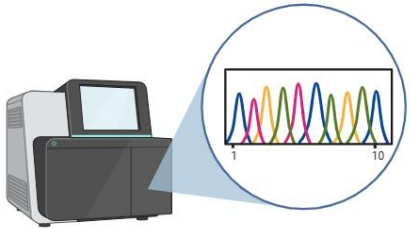


- We have partnered with several US state mosquito control programs and leveraged *Anopheles* bycatch from existing *Culex* surveillance to characterize malaria vectors.
- Mosquito programs send mosquito collections to the CDC for molecular species identification confirmation.









PARTNERSHIP WITH GADPH CHATHAM CO. MOSQUITO CONTROL

Determining distribution of *Anopheles crucians* complex by molecular confirmation

- Adult *Anopheles* mosquito bycatch from Chatham County Mosquito Control were collected in Chatham Co., GA and Jasper Co., SC between September and November 2025.
- A total of 372 adults were sent to CDC for morphology and molecular species confirmation.
- All samples were confirmed morphologically and approximately 25% of the samples were analyzed using molecular methods.



Collection

- 372 *Anopheles* collected as bycatch during routine WNV surveillance (2025-2026) in southern Georgia and Jasper County, SC.

Morphological Identification

- Specimens identified to species or species complex using morphological keys (e.g. *An. crucians* complex, *An. atropos*).

Molecular Characterization

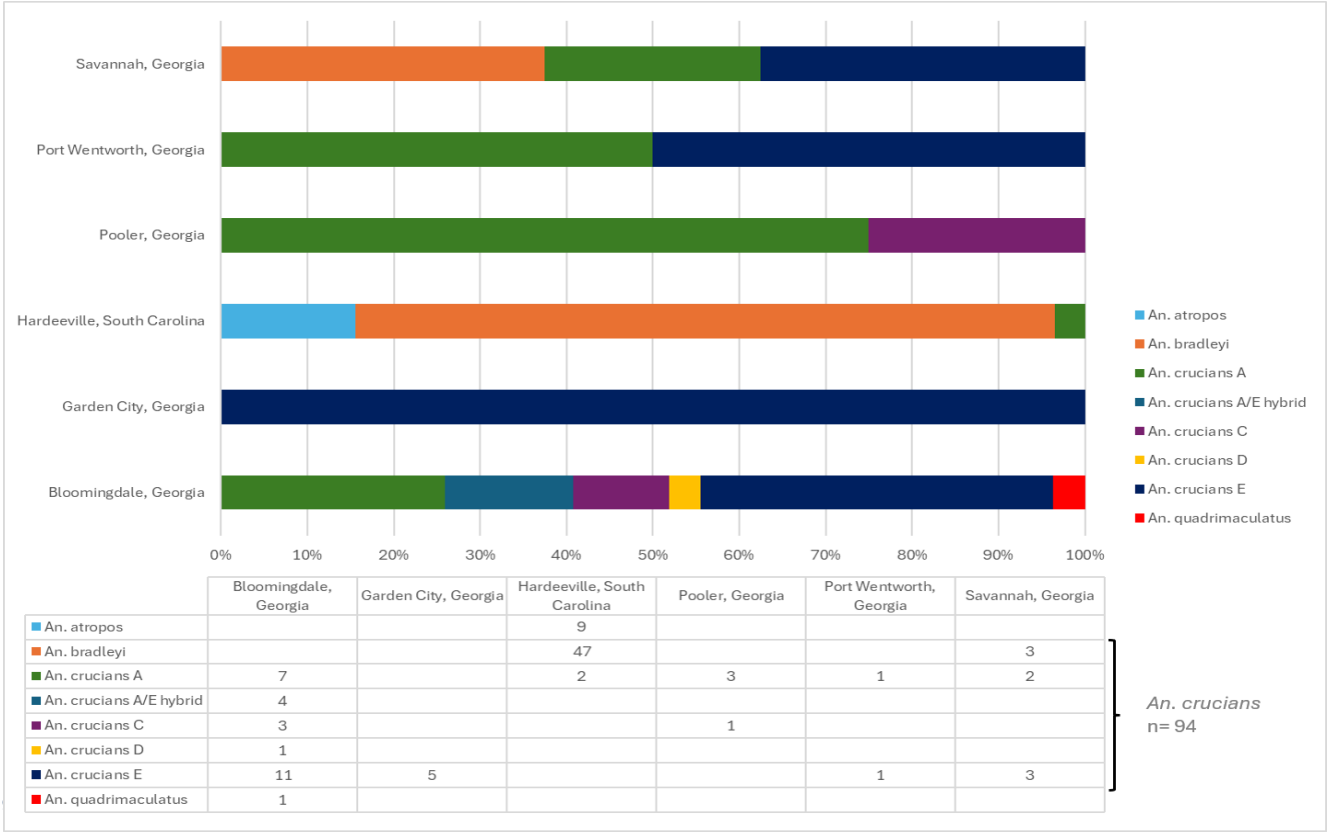
- Subset of specimens (n+104) underwent ITS2 sequencing to resolve species within complexes.

Additional Analysis

- Nine *An. atropos* specimens characterized using morphology, sequencing, and COI-based phylogenetic analysis to establish a molecular reference.

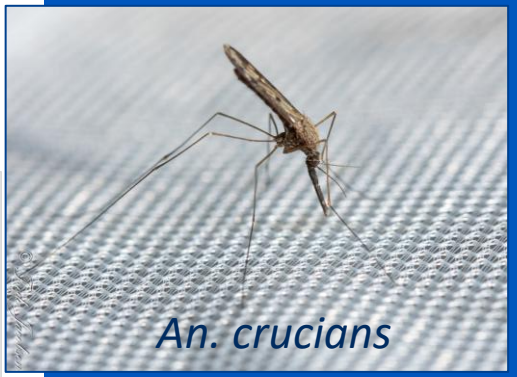
PARTNERSHIP WITH GADPH CHATHAM CO. MOSQUITO CONTROL

Results



	Bloomingdale, Georgia	Garden City, Georgia	Hardeeville, South Carolina	Pooler, Georgia	Port Wentworth, Georgia	Savannah, Georgia
An. atropos			9			
An. bradleyi			47			3
An. crucians A	7		2	3	1	2
An. crucians A/E hybrid	4					
An. crucians C	3			1		
An. crucians D	1					
An. crucians E	11	5			1	3
An. quadrimaculatus	1					

An. crucians
n= 94



Conclusions

Confirmations of *An. crucians* complex species can provide species-specific information, allowing a program to develop a targeted response.

Molecular confirmation of cryptic species like *An. atropos* is significant and new molecular data has been added to the NCBI genbank database.

Routine molecular confirmation of bycatch collections can help track species distribution and ecological changes and adaptability.

Molecular data of species complexes can inform new tool development that support state lab capacity strengthening.



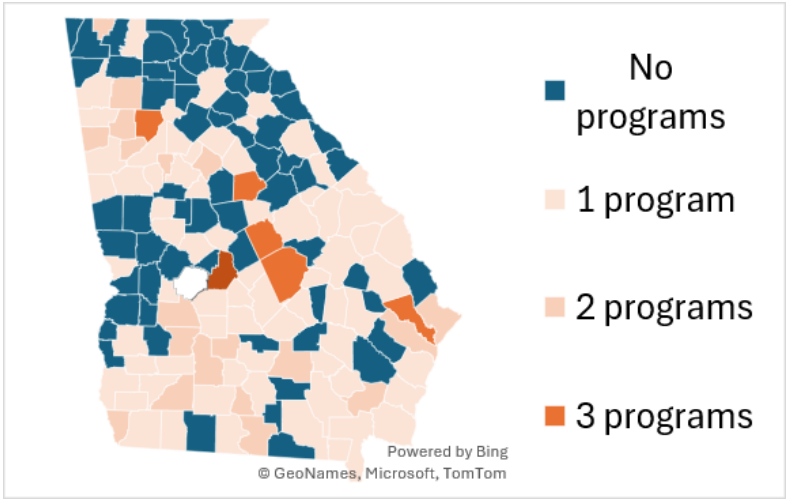
An. atropos

Georgia Mosquito Control Programs

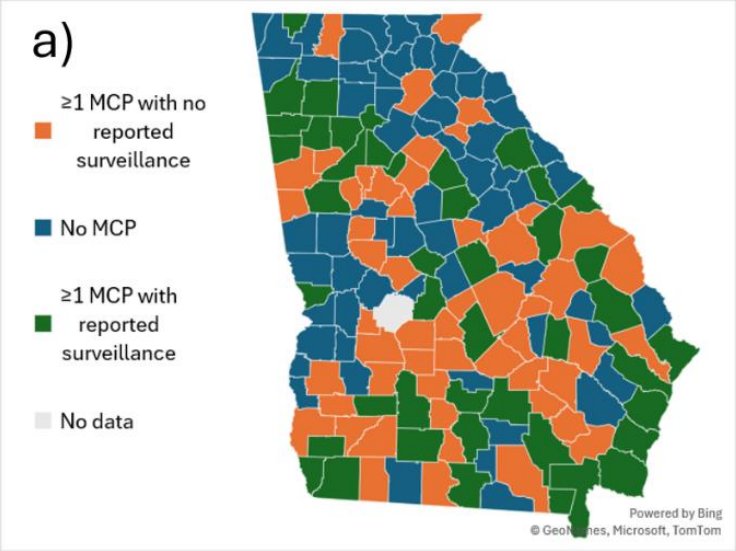
Georgia Mosquito Surveillance, 2017

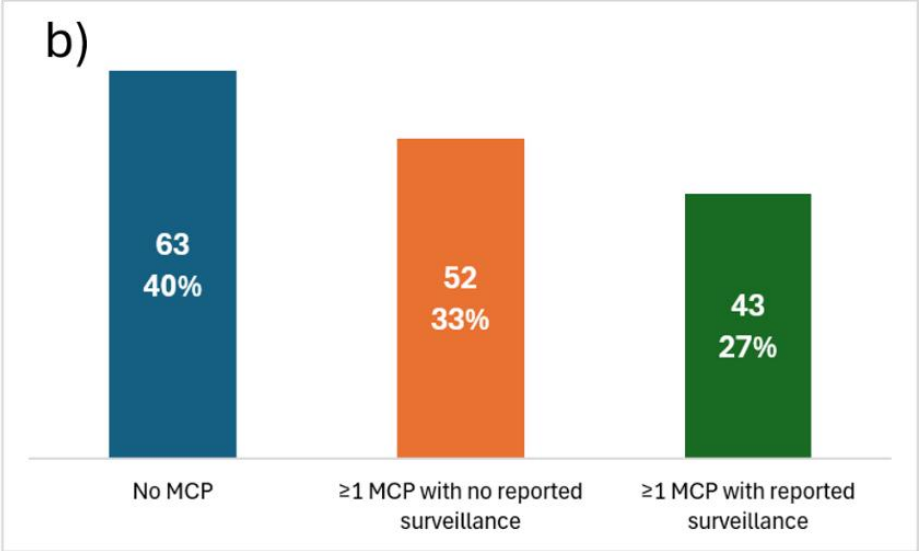
- 2017 survey conducted by Georgia Southern University
- 342 local mosquito control staff interviewed
- 126 mosquito control programs identified
- Between 0 and 3 programs per county

- Additional datasets
- Mosquito surveillance
- Malaria and West Nile virus cases
- 2017 county financial expenditures report

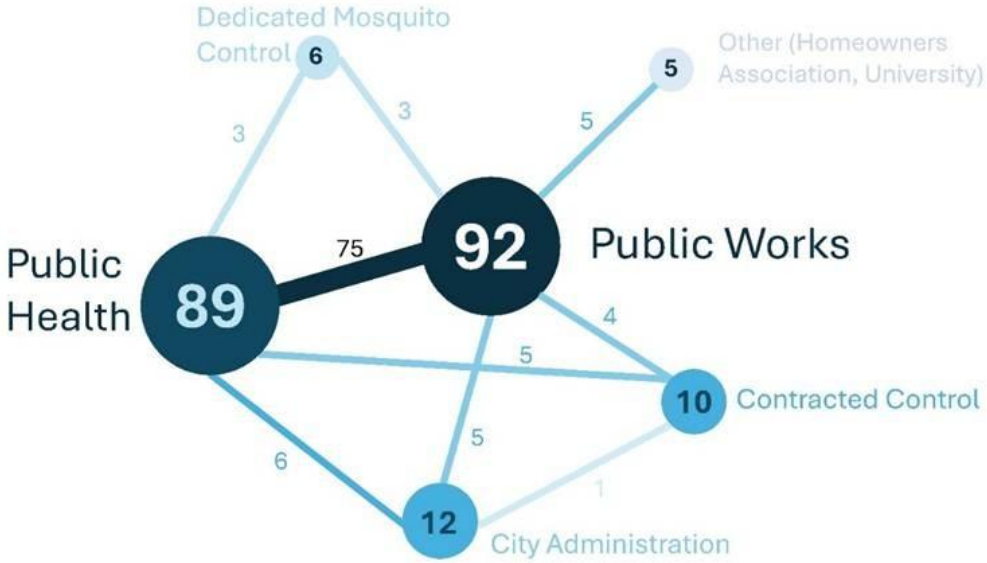


27% of Counties Reported Surveillance

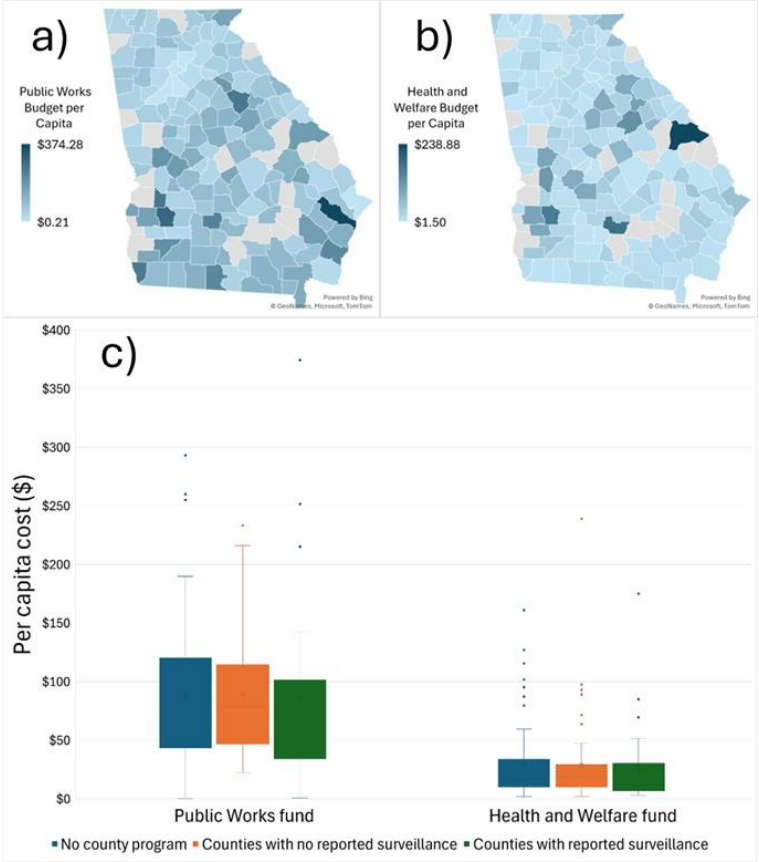




Strong Interagency Collaborations Between Public Works and Public Health



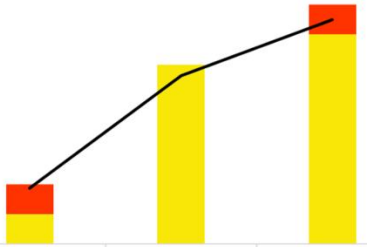
Higher Public Works and Public Health Budgets Not Associated With Conducting Surveillance



50% of Counties with Travel-Associated Malaria do Not Have Surveillance

a)

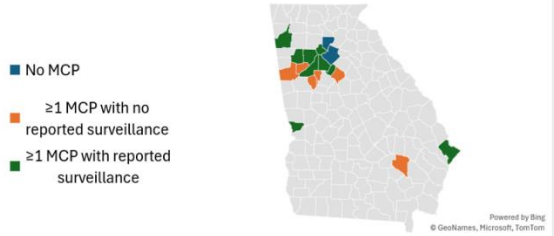
Travel-Associated Malaria Cases in Sixteen (16) Georgia Counties by Mosquito Control Program Status (2017)



	No MCP	≥1 MCP with no reported surveillance	≥1 MCP with reported surveillance
10+ cases	1		1
<10 cases	1	6	7
% of Malaria-Affected Counties	12.5%	37.5%	50.0%

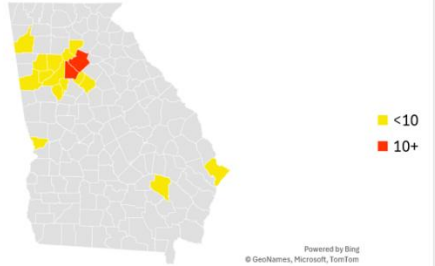
b)

Program Capacity of Sites With Travel-Associated Malaria Cases



c)

Reported Travel-Associated Malaria Cases in Georgia (2017)



Additional Projects

PLASMODIUM DETECTION IN MOSQUITOES

Supporting Domestic Malaria Outbreaks

- State public health labs (SPHLs) ship *Anopheles* mosquitoes collected in areas surrounding autochthonous malaria cases.
- CDC Entomology lab tests mosquitoes for *Plasmodium* parasite using immunoassay and molecular lab methods.
- Targeted assay turn-around time of 24 hours to provide timely results to SPHLs.
- Results allow assessment for further treatment, spraying and trapping.
- This methodology was used in 2023 to support outbreaks in MD, AR, TX, FL and 2025 in NJ and WA.
- CDC labs can work with SPHLs to provide resources and services for entomological assessment and testing during periods of local malaria transmission.

D1 Mosquitoes shipped to CDC



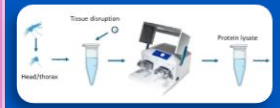
D2 CDC receives and accessions specimens



Mosquitoes dissected for lab analysis



D3 CDC performs lab tests on mosquitoes



Results reported to SPHLs



Approximate 24-hour turn-around time to results once mosquitoes are received in the EB lab

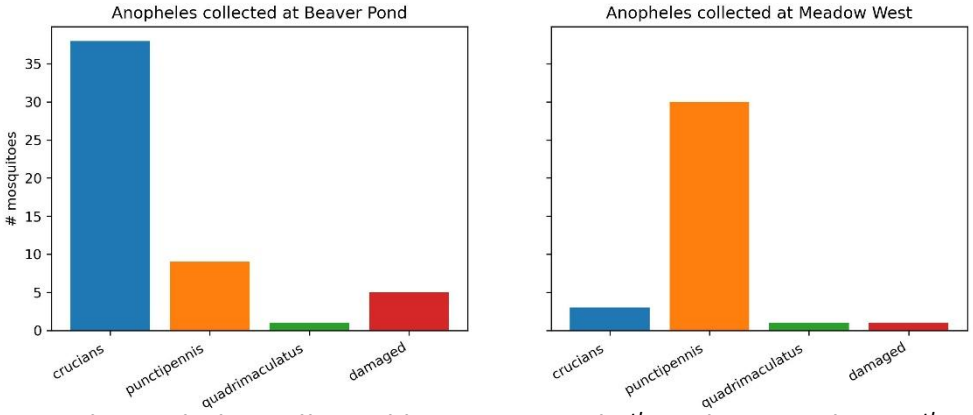
Biology, ecology, and habitat preferences of *Anopheles crucians* s.l. and *An. punctipennis* in selected collection sites, GA

Two nearby sites show very different *Anopheles* profiles in Decatur, GA



Beaver Pond, Clyde Shepherd Nature Preserve, Decatur, GA







Peachtree Creek South Fork, Little Creek Horse Farm, Decatur, GA

Total Anopheles collected between April 9th and September 15th, 2026, using light traps, no-light traps, and resting traps.

Acknowledgements

- Thank you to all the Environmental Health Specialists, students, and interns at the local and independent mosquito control programs for their contributions collecting these data.
- Chatham County Mosquito Control.
- Environmental Health Section, GADPH
- Subhika Rao is funded through Public Health Entomology for All (PHEFA), a partnership with the Entomological Society of America (ESA) and CDC.

Thank you



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For more information, contact CDC
1-800-CDC-INFO (232-4636)
TTY: 1-888-232-6348 www.cdc.gov

The findings and conclusions in this report are those of the authors and do not necessarily represent the official position of the Centers for Disease Control and Prevention.

References

1. Padda H, Jacobs D, Gould CV, et al. West Nile Virus and Other Nationally Notifiable Arboviral Diseases — United States, 2023. MMWR Morb Mortal Wkly Rep 2025;74:358–364. DOI: http://dx.doi.org/10.15585/mmwr.mm7421a1
2. Centers for Disease Control and Prevention. The History of Malaria in the United States. October 2024.
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4. DeVita, T. N., Morrison, A. M., Stanek, D., Drennon, M., Sarney, E., Brennan, W., ... & McElroy, P. D. (2025). Public health response to the first locally acquired malaria outbreaks in the US in 20 years. JAMA Network Open, 8(10), e2535719.
5. Sutcliffe, A., Rafferty, C., Leite, L., Rao, S., Rogers, E., Dotson, E., Lenhart, A. (2026, March 11-13). *Entomological laboratory testing of mosquitoes during domestic malaria outbreaks* [Conference poster presentation]. CDC Vector Week Conference, Fort Collins, CO, United States.



Limitations

- **Selection of collection sites are not targeted towards *Anopheles* spp.**
  - Driven by *Culex* spp. / West Nile presence
  - Selected based on medical relevance
  - Selected based on ease of access
- **Surveillance over 25 years conducted by multiple different people/organizations/jurisdictions**
- **Molecular results from bycatch affected by specimen integrity**
- **Molecular assays for domestic *Anopheles* species are limited**

Future Directions

- **Continue to work with local, state, and independent mosquito control programs**
  - Opportunities for collaboration, information sharing, and mutual support.
- **Prioritize engagement based on program needs, potential impact, and available resources,**
  - Level and scope of support may vary depending on funding, staff capacity, and timing.
- **Retain and analyze *Anopheles* bycatch to:**
  - Inform management of future malaria outbreaks
  - Support an integrated vector surveillance strategy
  - Guide *Anopheles*-specific surveillance or research
  - Help develop new tools