

# Insecticide Resistance Testing in North Carolina

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# Overview

- Insecticide resistance
  - Status of NC studies
  - Partnerships
- Insecticide resistance training workshop at East Carolina University



# Insecticide Resistance

- If mosquitoes are exposed to doses of insecticides that are too weak to kill them, they may develop resistance to those active ingredients.
- Surveillance-based targeted control very important.
- Is the product that is being used working?



# Insecticide Resistance

- Mosquito control programs should check for resistance/susceptibility periodically during the mosquito season to ensure the most effective control measures are used.
- This is especially important if control benchmarks are not being met.



# Current Status of Mosquito Control Programs in the United States

- National survey by National Association of County and City Health Officials (NACCHO) assessed 1,906 vector control programs in the United States.
- **Insecticide resistance testing was the most significant competency that needed to be addressed** in vector control programs due to lack of training and/or capacity for testing.
- Only 14% of programs conduct testing; no details given about the type and/or frequency of testing carried out.
- *National Association of County and City Health Officials. 2017. Mosquito control in the United States.*  
<https://www.naccho.org/uploads/downloadable-resources/Mosquito-control-in-the-U.S.-Report.pdf>

# Resistance Studies at ECU

- RICHARDS SL, Balanay JG, Fields M, and K Vandock **(2017)** Baseline insecticide susceptibility screening against six active ingredients for *Aedes* and *Culex* (Diptera: Culicidae) mosquito populations. *Journal of Medical Entomology* 54 (3): 682-695.
- RICHARDS SL, Balanay JG, White AV, Hope J, Vandock K, Byrd BD, Reiskind MH **(2017)** Insecticide susceptibility screening against *Culex* and *Aedes* (Diptera: Culicidae) mosquitoes from the United States. *Journal of Medical Entomology* 55: 398-407.
- RICHARDS SL, White AV, Byrd BD, Reiskind MH, Doyle M **(2018)** Insecticide resistance profiles of North Carolina *Aedes albopictus* for active ingredients and formulated products, 2017. *Journal of Medical Entomology*. Epub ahead of print December 17, 2018.
- RICHARDS SL, Byrd BD, Reiskind MH, White AV **(2019)** Assessing insecticide resistance in adult mosquitoes: Can we improve our current methods? *In preparation; to be submitted to Environmental Health Insights.*
- RICHARDS SL, White AV, Byrd BD, Reiskind MH **(2020)** Insecticide resistance profiles of North Carolina *Aedes albopictus* for active ingredients and formulated products, 2018-2019. *Manuscript planned.*



# NC Resistance Study (2017)

<u>Active ingredients</u>	<u>Formulated products</u>
• Bifenthrin	Talstar I/T
• Permethrin	Biomist 3 + 15
• Sumethrin+Pralethrin	Duet
• Deltamethrin	Suspend Polyzone
• Tau-fluvalinate	Mavrik
• Chlorpyrifos	MosquitoMist
• Malathion	Fyfanon
• Naled	Dibrom

**CDC Bottle Bioassays**

***Aedes albopictus***

**7 NC Counties**

# CDC Insecticide Resistance Testing Guidelines

- Susceptible:
  - ≥ 97% of mosquitoes dead at the diagnostic time
- Developing Resistance:
  - 90-96 % of mosquitoes dead at the diagnostic time
- Resistant:
  - < 90 % of mosquitoes dead at the diagnostic time

**Diagnostic times and doses determined (bottles calibrated) using a susceptible *Aedes albopictus* colony.**



# NC Resistance Study (2017)

County (generation)	Bifenthrin	Permethrin	Sumethrin + Prallethrin	Deltamethrin	Tau-fluvalinate	Chlorpyrifos	Malathion	Naled
<b>Buncombe (F<sub>2</sub>)</b>	Susceptible 100% N*=33	Susceptible 100% N=33	Susceptible 100% N=25	Susceptible 100% N=33	Susceptible 97% N=29	Developing Resistance 92% (83-100%) N=25	Developing Resistance 96% (89-100%) N=51	Susceptible 100% N=25
<b>Transylvania (F<sub>1</sub>)</b>	Susceptible 98% N=50	Susceptible 100% N=55	Susceptible 100% N=51	Susceptible 100% N=51	Susceptible 100% N=54	<b>Resistant†</b> 49% (32-66%) N=49	Developing Resistance 90% (80-100%) N=50	Susceptible 100% N=47
<b>Forsyth (F<sub>3</sub>)</b>	Susceptible 100% N=17	Susceptible 100% N=18	Susceptible 100% N=25	Susceptible 100% N=26	Susceptible 100% N=44	<b>Resistant†</b> 22% (7-35%) N=19	Developing Resistance 94% (86-100%) N=34	Susceptible 100% N=24
<b>Mecklenburg (F<sub>4</sub>)</b>	Susceptible 100% N=15	Susceptible 100% N=16	Susceptible 100% N=34	Susceptible 100% N=16	Susceptible 100% N=16	<b>Resistant†</b> 40% (23-57%) N=15	<b>Resistant†</b> 10% (0-22%) N=18	Susceptible 100% N=15
<b>Wake (F<sub>2</sub>)</b>	Susceptible 100% N=38	Susceptible 100% N=35	Susceptible 100% N=34	Susceptible 100% N=34	Susceptible 100% N=37	<b>Resistant†</b> 63% (44-78%) N=41	Developing Resistance 94% (87-100%) N=37	Susceptible 100% N=30
<b>Brunswick (F<sub>2</sub>)</b>	Susceptible 100% N=32	Susceptible 100% N=35	Susceptible 100% N=32	Susceptible 98% N=35	<b>Resistant†</b> 66% (59-89%) N=34	<b>Resistant†</b> 39% (29-63%) N=36	<b>Resistant†</b> 32% (16-47%) N=35	Susceptible 100% N=30
<b>Pitt (F<sub>1</sub>)</b>	Susceptible 100% N=41	Developing Resistance 91% N=47	Susceptible 100% N=48	Susceptible 100% N=43	Susceptible 100% N=55	<b>Resistant†</b> 28% (13-43%) N=50	<b>Resistant†</b> 62% (44-78%) N=54	Susceptible 100% N=48

# NC Resistance Study (2017)

County (generation)	TalStar** (AI=Bifenthrin)	Biomist 3+15 (AI=Permethrin)	Duet (AI=Sumethrin + Prallethrin)	Suspend Polyzone <sup>1</sup> (AI=Deltamethrin)	Mavrik <sup>1</sup> (AI=Tau-fluvalinate)	MosquitoMist (AI=Chlorpyrifos)	Fyfanon (AI=Malathion)	Dibrom (AI=Naled)
<b>Buncombe (F<sub>2</sub>)</b>	Susceptible 100% (DT) 100% (24 h) N=32*	Susceptible 100% N=22	Susceptible 100% N=34	Susceptible 100% (DT) 100% (24 h) N=23	<b>Resistant†</b> 0% (DT) 0% (24 h) N=23	Developing Resistance 94% (85-100%) N=32	Susceptible 100% N=26	Susceptible 100% N=27
<b>Transylvania (F<sub>1</sub>)</b>	Susceptible 100% 100% (24 h) N=40	Susceptible 100% N=41	Susceptible 100% N=37	Susceptible 100% (DT) Developing Resistance 90% (24 h) N=41	<b>Resistant†</b> 49% (DT) (31-66%) 52% (24 h) N=33	Susceptible 100% N=38	Susceptible 97% N=37	Susceptible 100% N=42
<b>Forsyth (F<sub>3</sub>)</b>	Susceptible 100% 100% (24 h) N=18	Susceptible 100% N=17	Susceptible 100% N=20	Susceptible 100% (DT) 100% (24 h) N=15	<b>Resistant†</b> 0% (DT) 0% (24 h) N=15	<b>Resistant†</b> 42% (27-61%) N=16	<b>Resistant†</b> 50% (33-64%) N=16	Susceptible 100% N=19
<b>Mecklenburg (F<sub>4</sub>)</b>	Susceptible 100% 100% (24 h) N=20	Susceptible 100% N=19	Susceptible 100% N=15	Susceptible 100% (DT) 100% (24 h) N=16	<b>Resistant†</b> 17% (DT) (4-29%) 0% (24 h) N=24	<b>Resistant†</b> 42% (39-73%) N=18	Susceptible 100% N=17	Susceptible 100% N=16
<b>Wake (F<sub>2</sub>)</b>	Susceptible 100% 100% (24 h) N=36	Susceptible 100% N=36	Susceptible 100% N=43	Susceptible 97% (DT) 100% (24 h) N=38	<b>Resistant†</b> 17% (DT) (5-30%) Susceptible 100% (24 h) N=40	<b>Resistant†</b> 49% (32-66%) N=43	Susceptible 98% N=42	Susceptible 100% N=38
<b>Brunswick (F<sub>2</sub>)</b>	Susceptible 100% 100% (24 h) N=47	Susceptible 100% N=35	Susceptible 100% N=30	Susceptible 98% (DT) 100% (24 h) N=37	<b>Resistant†</b> 0% (DT) 8% (24 h) N=30	<b>Resistant†</b> 30% (18-51%) N=32	Developing Resistance 95% (90-100%) N=29	Susceptible 100% N=29
<b>Pitt (F<sub>1</sub>)</b>	Susceptible 100% 100% (24 h) N=43	Susceptible 100% N=49	Susceptible 100% N=49	Developing Resistance 93% (88-100%) Susceptible 98% (24 h) N=41	<b>Resistant†</b> 58% (DT) (40-73%) Susceptible 100% (24 h) N=46	<b>Resistant</b> 84% (71-96%) N=43	Susceptible 98% N=45	Susceptible 100% N=46

# NC Resistance Study (2018)

<u>Active ingredients</u>	<u>Formulated products</u>
• Bifenthrin	Talstar I/T
• Permethrin	Biomist 3 + 15
• Deltamethrin	Suspend Polyzone Fyfanon

Data analysis in progress

**CDC Bottle Bioassays**  
***Ae. albopictus, Ae. triseriatus***  
**5 NC Counties**

# Current and Planned Resistance Studies in NC

- Funded via CDC Southeastern Center of Excellence in Vector Borne Diseases and NC Dept. of Health and Human Services
- Expanded insecticide resistance testing of NC mosquitoes (from western, central, and eastern NC) to be conducted in spring/summer 2019.
  - *Ae. albopictus*, *Ae. triseriatus*, and *Cx. pipiens/quinqüefasciatus* from NC (and possibly from additional states).
  - Salt marsh mosquitoes?

# Insecticide Resistance Workshop

- Partnership between CDC Southeastern Center of Excellence in Vector-borne Diseases and East Carolina University
  - February 12, 2019 at East Carolina University in Greenville, NC
  - Possibility of repeating training event for additional states in 2020?
  - Topics covered:
    - Importance of insecticide resistance testing
    - Hands-on training using CDC bottle bioassays
    - How to analyze the data to help make mosquito control decisions



CDC Southeastern  
Center of Excellence in  
Vector Borne Diseases  
The Gateway Program



## 2019 Insecticide Resistance

### Training Workshop

February 12, 2019

East Carolina University

3504 Carol Belk Building

Greenville, NC



**CDC Southeastern  
Center of Excellence in  
Vector Borne Diseases**  
The Gateway Program



8:00 - 9:00 am - Onsite registration

#### First Session

9:00 a.m. Welcome and introduction  
-Dr. Stephanie Richards

9:15 a.m. Why is monitoring  
insecticide resistance  
important?

-Dr. Brian Byrd

9:45 a.m. Summary of CDC bottle  
bioassay procedure

-Dr. Stephanie Richards

10:10—10:40 a.m. Break

10:40 a.m. Description/demonstration  
of preparing insecticide  
stocks and coating bottles

-Avian White

11:15 a.m.-12:15 p.m. Lunch (on site)

#### Second Session

12:15 p.m. Participants conduct CDC  
bottle bioassay with live  
mosquitoes

-All instructors assist

1:30 p.m. Data review and analysis

-Dr. Brian Byrd

2:00 - 2:30 p.m. Break

2:30 p.m. Possible pitfalls and how  
to address them

-All instructors assist

3:00 p.m. Q & A

4:00 p.m. Adjourn

## CONTINUING EDUCATION

In NC, the program is approved for REHS (Course #19003 for 4.5 h) and Pesticide hours in Categories B/N/D (Course #703001 for 4.5 hrs). In SC, the program has been approved for continuing education in Pesticide (Course #19346 for 2 hrs). Please complete the CEU rosters to receive credit.

## INSTRUCTORS

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*Thank you for your participation!*

# ECU Insecticide Resistance Workshop

- 14 trainees from NC and SC in laboratory classroom
- NC (N=9)
  - Brunswick County (southeastern)
  - Pitt County (eastern)
  - New Hanover (eastern)
  - Forsyth County (central)
  - Transylvania County (western)
- SC (N=5)
  - City of Columbia (central)
  - Richland County (central)
  - Beaufort County (southeastern)
  - Charleston County (eastern)
  - SC Dept. of Health and Environmental Control (central)



# Building Partnerships

- In 2018, 15 local health departments received financial assistance through NC DHHS for mosquito-related activities.
  - Albemarle Regional Health District, Carteret, Craven, Forsyth, Gaston, Haywood, Henderson, Mecklenburg, Nash, New Hanover, Onslow, Pender, Pitt, Transylvania, Wake.
  - Funding from State Appropriations and Federal Epidemiology and Laboratory Capacity Grant.
  - Programs consult with NC DHHS, ECU, NCSU, WCU for assistance with mosquito surveillance, resistance testing, etc.



# Insecticide Resistance Training and Testing

- Promote insecticide resistance training/testing in mosquito control programs across NC and other states in our region.
- ECU can potentially provide training and advice to programs interested in resistance testing.
- ECU can potentially conduct resistance testing for programs, if needed.

# Final Notes

- Lack of funding can be a significant barrier to public health initiatives. Usually forced to take a reactive, rather than proactive approach.
- Advocate to sustain support for mosquito control programs to protect public health.
- Only the most effective insecticides should be used for targeted control.
- Insecticide resistance assessments help mosquito control programs protect public health.



# Questions

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