Insecticide Resistance Patterns in Mosquitoes of Public Health Importance in North Carolina, 2018–2023

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Abstract **Mosquito insecticide resistance is a global public health issue that must be monitored and addressed at the local level by rotating insecticides with different modes of action. In our study, insecticide resistance was monitored in *Aedes albopictus* and *Culex pipiens/quinquefasciatus* in North Carolina during 2018–2023 via Centers for Disease Control and Prevention bottle bioassays. Trends in insecticide resistance were compared by region and year for mosquito control-formulated insecticide products containing the following active ingredients: bifenthrin, deltamethrin, etofenprox, permethrin, malathion, naled, and sumithrin/prallethrin. There was a significant difference (p = .003) in insecticide resistance between the two species, with *Culex* populations having higher insecticide resistance than *Aedes*. Bottle bioassays that test active ingredients are a starting point for mosquito control programs, and insecticide resistance testing should be conducted at least annually for local mosquito populations. Further assessments of formulated insecticide products should be carried out for mosquito populations showing resistance to active ingredients, which can inform operational decisions.**

Keywords: mosquito insecticide resistance, CDC bottle bioassay, pyrethroid, organophosphate, formulated insecticide products, mosquito control

Introduction

Vectorborne diseases account for approximately 17% of all infectious diseases worldwide and cause an estimated 700,000 deaths annually (World Health Organization, 2024). West Nile virus, Eastern equine encephalitis virus, and La Crosse virus are the three primary endemic arboviruses within North Carolina (North Carolina Department of Health and Human Services [NC DHHS], 2019). Travel-related mosquito-borne diseases (e.g., chikungunya, dengue, malaria, yellow fever) are also reportable in North Carolina (NC DHHS, 2019).

Insecticide resistance in mosquito populations is a dynamic global public health issue because it hinders disease control efforts (Namias et al., 2021; Roberts & Andre, 1994). Mosquitoes continue to develop resistance to insecticide active ingredients in formulated products used in mosquito control (Estep & Sanscrainte, 2024). This resistance can be explained by a variety of factors, including: 1) insecticide pressures from different sources (e.g., agricultural, homeowner, public and private pest control application); 2) insufficient monitoring of insecticide resistance by mosquito control programs; 3) limited data correlating laboratory methods (e.g., bottle bioassay of active ingredients) and field methods (e.g., truck-mounted ultralow volume treatments of formulated insecticide products); and 4) failure to appropriately rotate insecticides with different modes of action, which potentially can lead to sublethal doses (Lehane et al., 2024; Nkya et al., 2013, 2014).

Mosquito control programs should monitor insecticide resistance and collaborate with other entities (e.g., larger mosquito control programs, universities, state environmental and public health laboratories) to remain proactive in best management practices. For the past two decades, pyrethroids (e.g., permethrin) have been the insecticide class most frequently used in adult mosquito control (Agency for Toxic Substances and Disease Registry, 2003; Estep et al., 2020; Stoops et al., 2019). Organophosphates (e.g., malathion, naled) are also used as mosquito control measures, albeit less frequently (U.S. Environmental Protection Agency, 2025).

Financial and political support for mosquito control programs vary and depend on

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TABLE **1**

Diagnostic Doses and Times for Technical Grade Active Ingredients Used in the CDC Bottle Bioassays

Active Ingredient	Classification	Diagnostic Dose (µg/ml)	Diagnostic Time (Min)	
			Culex quinquefasciatus	*Aedes albopictus*
Bifenthrin	Type I pyrethroid	13	30	30
Permethrin	Type I pyrethroid	8	30	30
Sumithrin/ prallethrin	Type I pyrethroid	20/4	30	30
Deltamethrin	Type II pyrethroid	8	15	15
Etofenprox	Type II pyrethroid	15	30	30
Malathion	Organophosphate	400	30	30
Naled	Organophosphate	2	30	30

Note. CDC = Centers for Disease Control and Prevention.

the extent of mosquito-borne disease and other issues in different geographic locations (Del Rosario et al., 2014; Stewart et al., 2009). These variations can disproportionately affect smaller municipalities that might not have the resources to maintain and operate mosquito control programs or conduct routine insecticide resistance testing (Impoinvil et al., 2007). In turn, private companies and homeowners might elect to control mosquitoes themselves, which contributes to inconsistent surveillance and mosquito control (Stoops et al., 2019). Environmental conditions can also influence the effectiveness of insecticides in controlling mosquito populations (Bonds, 2012; Bunn et al., 2019; Richards, White, et al., 2017; Salinas et al., 2021).

Despite the importance of monitoring and tracking patterns of insecticide resistance, few mosquito control programs include these actions in their public health prevention plans (Richards et al., 2020). This lack of surveillance can lead to failure to recognize when to rotate formulated insecticide products if resistance develops (Lehane et al., 2024). Even if resistance testing is conducted by mosquito control programs using the standard Centers for Disease Control and Prevention (CDC) bottle bioassay, discrepancies could still exist when compared with operational use (e.g., field application of formulated insecticide products that include active ingredients and other ingredients to enhance effectiveness); hence, the standard CDC bottle bioassay is used as a starting point only (CDC, 2013; Richards et al., 2020, 2024).

North Carolina comprises the Coastal Plain, Central Piedmont, and Appalachian Mountain regions. There are more than 60 mosquito species in North Carolina, and many are heterogeneously distributed throughout the state (Harrison et al., 2016). Approximately 83% of mosquito control programs are in the coastal area of the state, while the remaining programs are in the Piedmont and Western regions (Del Rosario et al., 2014). In North Carolina, *Aedes albopictus* and *Culex pipiens/quinquefasciatus* have shown resistance to some active ingredients used in mosquito control and vary in their resistance status to organophosphates and pyrethroid active ingredients (Richards, Balanay, et al., 2017; Richards et al., 2018, 2019).

Another study in North Carolina exposed populations of these mosquito species to formulated insecticide products in a wind tunnel and found *Ae. albopictus* had greater susceptibility than *Cx. pipiens/quinquefasciatus* (Richards et al., 2024). We updated and summarized North Carolina insecticide resistance records for 2018–2023 for *Ae. albopictus* and *Cx. pipiens/quinquefasciatus*. Based on this information, annual or more frequent resistance assessment to active ingredients and/or formulated products can prove beneficial, as identification of insecticide resistance can lead to operational changes (e.g., rotation of differing classes of insecticides) that can improve mosquito control and reduce the use of ineffective insecticides. Thus, insecticide resistance is an ongoing global problem that needs to be addressed at the local level (Richards et al., 2020).

Methods

Mosquitoes

In this study, mosquitoes were reared to adulthood for CDC bottle bioassays from mosquito eggs provided by mosquito control programs in the following North Carolina counties: 1) Western: Buncombe and Transylvania; 2) Central: Davidson, Forsyth, and Wake; and 3) Eastern: Brunswick, Craven, Edgecombe, New Hanover, and Pitt. The species of adult mosquitoes were identified in the laboratory of the investigators. Colonies of *Ae. albopictus* (originating from Louisiana) and *Cx. quinquefasciatus* (Sebring strain) with known susceptibility were used to establish active ingredient diagnostic dose and diagnostic times. Mosquitoes (F_0–F_3) reared from field-collected eggs were processed using standard methods (Richards, Balanay, et al., 2017; Richards et al., 2019). In some instances, mosquitoes were blood fed to propagate additional generations to increase sample size (Richards, Balanay, et al., 2017; Richards et al., 2019). Briefly, larvae were fed a 2:1 mixture of liver powder and yeast, pupae were transferred (in plastic cups with tap water) to 30.5 × 30.5 × 30.5 cm-square cages (BioQuip), and adults were provided 20% sucrose ad libitum (Richards, Balanay, et al., 2017; Richards et al., 2019).

CDC Bottle Bioassays

Stock solutions were prepared by mixing each technical grade active ingredient (Sigma Aldrich) in acetone. Adult female mosquitoes (4–7 days old) were assayed for resistance to seven active ingredients (bifenthrin, deltamethrin, etofenprox, permethrin, malathion, naled, and sumithrin/prallethrin) using the CDC bottle bioassay method (CDC, 2013). Sumithrin and prallethrin were mixed at a

TABLE **2**

Resistance Trends (Percent Mortality at Diagnostic Time) in *Culex pipiens/quinquefasciatus* Over Time by County in North Carolina

Collection Location (i.e., Mosquito Generation)	Bifenthrin	Permethrin	Sumithrin/ Prallethrin	Deltamethrin	Etofenprox	Malathion	Naled
2019							
Pitt County Aqua Lane (F_0)	Resistant 22% *n* = 66	Resistant 69% *n* = 45	–	Resistant 38% *n* = 86	–	–	Resistant 43% *n* = 59
Brunswick County Landfill Road (F_0)	Resistant 18% *n* = 54	Resistant 23% *n* = 58	–	Resistant 27% *n* = 48	–	–	Resistant 0% *n* = 43
2021							
Pitt County Aqua Lane (F_0)	Resistant 13% *n* = 53	Resistant 24% *n* = 46	–	Resistant 69% *n* = 48	Resistant 30% *n* = 47	Resistant 43% *n* = 57	Resistant 86% *n* = 50
Wake County Ligon Street (F_0)	Resistant 0% *n* = 36	Resistant 4% *n* = 49	–	Resistant 15% *n* = 38	Resistant 9% *n* = 54	Resistant 8% *n* = 38	Resistant 54% *n* = 40
Transylvania County Cashier's Valley Road (F_0)	Resistant 67% *n* = 37	Resistant 27% *n* = 38	–	Resistant 28% *n* = 41	Resistant 51% *n* = 34	Resistant 24% *n* = 42	Resistant 64% *n* = 50
Forsyth County Pine Hill Drive (F_0)	Resistant 68% *n* = 38	Resistant 25% *n* = 36	–	Resistant 30% *n* = 42	Resistant 55% *n* = 38	Resistant 20% *n* = 39	Resistant 68% *n* = 37
New Hanover County Government Drive (F_0)	Resistant 16% *n* = 36	Resistant 0% *n* = 36	–	Resistant 18% *n* = 38	Resistant 32% *n* = 33	Resistant 0% *n* = 34	Resistant 21% *n* = 33
2023							
Brunswick County Landfill Road (F_0)	Susceptible 100% *n* = 70	Developing Resistance 90% *n* = 72	Resistant 3% *n* = 43	Susceptible 97% *n* = 106	Susceptible 100% *n* = 64	Resistant 70% *n* = 40	Resistant 67% *n* = 41
New Hanover County Maple Avenue (F_0)	Resistant 4% *n* = 35	Resistant 69% *n* = 49	–	Resistant 64% *n* = 41	Resistant 40% *n* = 61	–	Resistant 3% *n* = 43
Transylvania County Kuykendall Camp Road (F_0)	Resistant 68% *n* = 41	Resistant 16% *n* = 45	Susceptible 100% *n* = 40	Susceptible 100% *n* = 52	–	Resistant 70% *n* = 46	Resistant 23% *n* = 36

Note. This table includes all counties tested in 2019–2023. No *Culex* spp. were tested in 2018. Gray shading = resistance; orange shading = developing resistance; blue shading = susceptible. The *n* represents the number of mosquitoes tested.

5:1 ratio to approximate a formulated product (i.e., Duet) containing these active ingredients. Stock solutions for bioassays were prepared by mixing each active ingredient and formulated product with acetone to reach a final concentration that reflected a typical diagnostic dose after a diagnostic time of 15–30 min (Table 1). Absolute density or actual weight was used for calculations of technical grade active ingredients in respective liquid or solid form. Diagnostic doses for active ingredients were based on our previous studies (Richards, Balanay, et al., 2017; Richards et al., 2019) and the screening step using susceptible *Ae. albopictus* and *Cx. quinquefasciatus* colonies.

Statistical Analyses

A multiple linear regression model was used (SPSS Version 29.0.1.0) to determine the effects ($p < .05$) of active ingredients, county location, species, and year on insecticide resistance in North Carolina from 2018 to 2023. All active ingredients were compared against permethrin, given its common use throughout the U.S. (Barr et al., 2010), with county location classified as either eastern or western for statistical comparisons. This regional classification was used to strengthen the statistical significance of the linear regression model output. Forsyth County's location is in the central portion of North Carolina but closely borders western North Carolina. Therefore, this location was classi-

TABLE 3

Resistance Temporal Trends (Percent Mortality at Diagnostic Time) in *Aedes albopictus* by County in North Carolina

Collection Location (i.e., Mosquito Generation)	Bifenthrin	Permethrin	Deltamethrin	Etofenprox	Malathion	Naled
2018						
Buncombe County (F_1)	Susceptible 100% *n* = 82	Susceptible 100% *n* = 82	Susceptible 100% *n* = 99	–	–	–
Pitt County Magnolia Ridge Road (F_1)	Susceptible 100% *n* = 49	Susceptible 100% *n* = 44	Susceptible 100% *n* = 48	–	–	–
2019						
Transylvania County Knob Road (F_0)	Susceptible 98% *n* = 54	Susceptible 100% *n* = 53	Developing Resistance 94% *n* = 65	–	–	Resistant 17% *n* = 47
Forsyth County Frontis Plaza Boulevard (F_2)	Susceptible 100% *n* = 50	Susceptible 100% *n* = 53	Susceptible 100% *n* = 39	–	–	Susceptible 100% *n* = 51
Pitt County Jarvis Street (F_1)	Susceptible 100% *n* = 47	Susceptible 100% *n* = 39	Susceptible 100% *n* = 42	–	–	Susceptible 100% *n* = 51
Edgecombe County Thorpe Road (F_3)	Susceptible 100% *n* = 57	Susceptible 100% *n* = 46	Susceptible 100% *n* = 62	–	–	Susceptible 100% *n* = 66
2021						
Pitt County Garland Street (F_1)	Resistant 44% *n* = 48	Susceptible 100% *n* = 47	Susceptible 100% *n* = 44	Susceptible 100% *n* = 57	Susceptible 100% *n* = 48	Resistant 26% *n* = 45
Craven County Graveyard Road (F_1)	Developing Resistance 92% *n* = 41	Susceptible 100% *n* = 43	Susceptible 100% *n* = 43	Susceptible 100% *n* = 43	Resistant 23% *n* = 47	Resistant 7% *n* = 40
Edgecombe County Thorpe Road (F_1)	Susceptible 100% *n* = 52	Susceptible 100% *n* = 68	Susceptible 100% *n* = 65	Susceptible 100% *n* = 49	Resistant 74% *n* = 54	Susceptible 100% *n* = 44

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fied as western North Carolina and became the cutoff location between eastern and western regions. Mosquito mortality rates at the diagnostic time of 90–96% (developing resistance) or <90% (resistant) were used, according to the CDC (2013) guideline.

Results

The active ingredients tested, diagnostic dose, and diagnostic times are listed in Table 1. Mosquito mortality and insecticide resistance data are shown in Tables 2 and 3 (all data for each species) and Tables 4 and 5 (data for locations where repeated collections were conducted over multiple study years). Differences were observed between active ingredients in levels of resistance (0–86% mortality for *Culex*; 7–86% for *Aedes*), development of resistance (90% mortality for *Culex*; 92–94% for *Aedes*) and susceptibility (100% mortality for *Culex*; 98–100% for *Aedes*). The degree of variation differed by location, active ingredient, and year.

A significant difference (p = .003) was observed in insecticide resistance between the two species (*Cx. pipiens/quinquefasciatus* and *Ae. albopictus*), with *Culex* populations having higher insecticide resistance than *Aedes*. Moreover, *Cx. pipiens/quinquefasciatus* showed widespread resistance, whereas *Ae. albopictus* showed widespread susceptibility, with some exceptions (Tables 2–5). For example, a Brunswick County *Culex* population sampled from the same location showed resistance (18–27% mortality) in 2019 to tested pyrethroid active ingredients (i.e., bifenthrin, permethrin, and deltamethrin), but the population was classified as susceptible (97–100% mortality) or developing resistance (90% mortality) to the same active ingredients in 2023 (Table 4). No significant differences (p = .081) were observed in mor-

TABLE **3** continued from page 11

Resistance Temporal Trends (Percent Mortality at Diagnostic Time) in *Aedes albopictus* by County in North Carolina

Collection Location (i.e., Mosquito Generation)	Bifenthrin	Permethrin	Deltamethrin	Etofenprox	Malathion	Naled
2022						
Wilson County Atlantic Street (F_1)	Susceptible 100% *n* = 41	Susceptible 100% *n* = 41	Susceptible 100% *n* = 39	Susceptible 100% *n* = 38	Susceptible 100% *n* = 41	–
Edgecombe County (F_1)	Susceptible 100% *n* = 81	Susceptible 100% *n* = 73	Susceptible 100% *n* = 74	Susceptible 100% *n* = 51	Susceptible 100% *n* = 75	Susceptible 100% *n* = 73
New Hanover County Division Drive (F_1)	Susceptible 100% *n* = 57	Susceptible 100% *n* = 56	Susceptible 100% *n* = 67	Susceptible 100% *n* = 72	Susceptible 100% *n* = 59	Resistant 27% *n* = 67
Pitt County Garland Street (F_1)	Susceptible 100% *n* = 85	Susceptible 100% *n* = 72	Susceptible 100% *n* = 64	Susceptible 100% *n* = 67	Resistant 43% *n* = 68	Resistant 49% *n* = 83
Brunswick County Landfill Road (F_1)	Susceptible 100% *n* = 38	Susceptible 100% *n* = 33	Susceptible 100% *n* = 31	Susceptible 100% *n* = 34	Resistant 86% *n* = 41	Susceptible 100% *n* = 40
Perquimans County Doll Harrell Road (F_1)	Susceptible 100% *n* = 38	Susceptible 100% *n* = 31	Susceptible 100% *n* = 31	Susceptible 100% *n* = 34	Susceptible 100% *n* = 41	Susceptible 100% *n* = 40
2023						
Mecklenburg County Beattie's Ford Road (F_0)	Susceptible 100% *n* = 48	Susceptible 100% *n* = 40	Susceptible 100% *n* = 41	Susceptible 100% *n* = 48	Susceptible 100% *n* = 47	Resistant 80% *n* = 39
New Hanover County Division Drive (F_0)	–	Susceptible 100% *n* = 66	Susceptible 100% *n* = 51	Susceptible 100% *n* = 54	Resistant 82% *n* = 59	–

Note. This table includes all counties tested in 2018–2023. Sumithrin/prallethrin was not tested for this mosquito species. Gray shading = resistance; orange shading = developing resistance; blue shading = susceptible. The *n* represents the number of mosquitoes tested.

tality rates between location, active ingredients, and year.

Discussion and Conclusion

Mosquitoes are exposed to varying levels of insecticide pressures from a variety of sources, such as agricultural, homeowner application, and public and private pest control (Coleman et al., 2017; Li et al., 2018; Richards et al., 2020). We found that *Ae. albopictus* in North Carolina were generally susceptible and *Cx. pipiens/quinquefasciatus* were widely resistant to tested active ingredients, with some exceptions. Trend analysis shows that *Cx. pipiens/quinquefasciatus* were more frequently classified as resistant or developing resistance to active ingredients than were *Ae. albopictus*, regardless of location, active ingredients, or year.

A resistance study in Malaysia on *Ae. albopictus* found that pyrethroid active ingredients were effective against the species (Wan-Norafikah et al., 2023). Other studies in North Carolina of *Ae. albopictus* have shown variability in effectiveness of active ingredients between regional populations (Richards, Balanay, et al., 2017; Richards et al., 2018, 2019). Mosquitoes in Southern Miami-Dade County, Florida, demonstrated greater resistance to pyrethroids and organophosphates in *Cx. quinquefasciatus* where agricultural operations are more routine versus more urbanized northern and eastern regions (Unlu et al., 2024). This difference should be investigated further in North Carolina.

We found that insecticide resistance varied from year-to-year among mosquito populations in some locations, demonstrating the importance of repeated and routine testing. Local mosquito control programs should conduct active ingredient and formulated product testing of target mosquito populations and collaborate with others for testing mosquitoes at least annually to inform operational decisions. Bottle bioassays are a starting point to inform operational decisions of mosquito control programs to avoid field trials evaluating formulated products, as field trials are labor intensive and costly (Praulins et al., 2024; Richards et al., 2020, 2024).

TABLE **4**

Resistance Temporal Trends (Percent Mortality at Diagnostic Time) in *Culex pipiens/quinquefasciatus* by County in North Carolina

Year	Collection Location (i.e., Mosquito Generation)	Bifenthrin	Permethrin	Sumithrin/ Prallethrin	Deltamethrin	Etofenprox	Malathion	Naled
Pitt County								
2019	Aqua Lane F_0	Resistant 22% *n* = 66	Resistant 69% *n* = 45	–	Resistant 38% *n* = 86	–	–	Resistant 43% *n* = 59
2021	Aqua Lane F_0	Resistant 13% *n* = 53	Resistant 24% *n* = 46	–	Resistant 69% *n* = 48	–	Resistant 43% *n* = 57	Resistant 86% *n* = 50
Brunswick County								
2019	Landfill Road F_0	Resistant 18% *n* = 54	Resistant 23% *n* = 58	–	Resistant 27% *n* = 48	–	–	Resistant 0% *n* = 43
2023	Landfill Road F_0	Susceptible 100% *n* = 70	Developing Resistance 90% *n* = 72	–	Susceptible 97% *n* = 106	–	–	Resistant 67% *n* = 41
New Hanover County								
2021	Government Drive F_0	Resistant 16% *n* = 36	Resistant 0% *n* = 36	–	Resistant 18% *n* = 38	Resistant 32% *n* = 33	Resistant 0% *n* = 34	Resistant 21% *n* = 33
2023	Maple Avenue F_0	Resistant 4% *n* = 35	Resistant 69% *n* = 49	–	Resistant 64% *n* = 41	Resistant 40% *n* = 61	–	Resistant 3% *n* = 43
Transylvania County								
2021	Cashier's Valley Road F_0	Resistant 67% *n* = 37	Resistant 27% *n* = 38	–	Resistant 28% *n* = 41	Resistant 51% *n* = 34	Resistant 24% *n* = 42	Resistant 64% *n* = 50
2023	Kuykendall Camp Road F_0	Resistant 68% *n* = 41	Resistant 16% *n* = 45	Susceptible 100% *n* = 40	Susceptible 100% *n* = 52	–	Resistant 70% *n* = 46	Resistant 23% *n* = 36

Note. This table includes counties with repeated mosquito collections over the years. Gray shading = resistance; orange shading = developing resistance; blue shading = susceptible. The *n* represents the number of mosquitoes tested.

A mosquito population exhibiting resistance to an active ingredient does not necessarily mean it will be resistant to a formulated product that contains that active ingredient, because these products have additional ingredients (e.g., synergists) that enhance effectiveness (Cataldo et al., 2020; Richards et al., 2024). This factor should be considered when interpreting the results of CDC bottle bioassays. A compact laboratory wind tunnel has been developed to provide a convenient method for routine formulated product testing as a screening step and as an alternative to field trials (Richards et al., 2024). Current CDC bottle bioassay methods are designed for active ingredients and not formulated products. An understanding of resistance trends will help mosquito control programs develop operational plans for routine management and emergency response (e.g., disease outbreak, flooding) (Brown et al., 2022; Chanda et al., 2016; Estep & Sanscrainte, 2024; Namias et al., 2021).

Resistant *Culex* species are a concern because they are the primary bridge vectors for West Nile virus (17,379 U.S. cases from 2015 to 2023; CDC, 2025). While *Ae. albopictus* in North Carolina appears to have fewer issues with resistance to the active ingredients we tested in our study, insecticide resistance should continue to be monitored due to this species' varied resistance status in other regions, which depends on external insecticides and other pressures (Estep & Sanscrainte, 2024). *Ae. albopictus* is also a vector of West Nile virus and is involved in transmission cycles of other arboviruses such as La Crosse, Zika, and dengue (Bohers et al., 2024; Garcia-Rejon et al., 2021; Goldman & Hamer, 2024). In addition to evaluating insecticide resistance in species of public health importance, nuisance species should

TABLE **5**

Resistance Trends (Percent Mortality at Diagnostic Time) in *Aedes albopictus* Over Time by County in North Carolina

Year	Collection Location (i.e., Mosquito Generation)	Bifenthrin	Permethrin	Deltamethrin	Etofenprox	Malathion	Naled
Pitt County							
2018	Magnolia Ridge Road F_1	Susceptible 100% *n* = 49	Susceptible 100% *n* = 44	Susceptible 100% *n* = 48	–	–	–
2019	Jarvis Street F_1	Susceptible 100% *n* = 47	Susceptible 100% *n* = 39	Susceptible 100% *n* = 42	–	–	Susceptible 100% *n* = 51
2021	Garland Street F_1	Resistant 44% *n* = 48	Susceptible 100% *n* = 47	Susceptible 100% *n* = 44	–	Susceptible 100% *n* = 48	Resistant 26% *n* = 45
2022	Garland Street F_1	Susceptible 100% *n* = 85	Susceptible 100% *n* = 72	Susceptible 100% *n* = 64	–	Resistant 43% *n* = 68	Resistant 49% *n* = 83
New Hanover County							
2022	Division Drive F_1	Susceptible 100% *n* = 57	Susceptible 100% *n* = 56	Susceptible 100% *n* = 67	Susceptible 100% *n* = 72	Resistant 64% *n* = 59	Resistant 27% *n* = 67
2023	Division Drive F_1	–	Susceptible 100% *n* = 66	Susceptible 100% *n* = 51	Susceptible 100% *n* = 54	Resistant 82% *n* = 59	–

Note. This table includes counties with repeated mosquito collections. Sumithrin/prallethrin was not tested for this mosquito species. Gray shading = resistance; blue shading = susceptible. The *n* represents the number of mosquitoes tested.

also be monitored. This additional monitoring is especially important in coastal regions that could experience large-scale emergences of salt marsh and floodwater mosquito species throughout the year.

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