The Distribution Expansion of *Culex nigripalpus*

First record in Virginia, North Carolina records, and updated US distribution

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The Distribution Expansion of Cx. *nigripalpus*

Contents

- Brief bionomics
- Defining (adult) morphological characters
- How the project originated
- Distribution from Darsie and Ward (2005)
- County data from North Carolina (1991-2020)
- New state record in Virginia (2017-2020)
- 2021 Distribution - recent (and some old(er)) northern reports necessitated new US map: Arkansas, Missouri, and as far north as Illinois; also Kentucky, Tennessee, Oklahoma

Photo credit: Culex nigripalpus - UF IFAS Florida Medical Entomology Laboratory - University of Florida, Institute of Food and Agricultural Sciences - UF/IFAS (ufl.edu)

The Distribution Expansion of *Cx. nigripalpus*

Bionomics

- Larval habitat: tolerate diverse environmental conditions
  - Permanent and transient water sources
  - Natural and artificial containers: catch basins, effluent pods, FW swamp, brackish and salt marsh habitat
- Adult collections: most commonly NJ and CDC light traps
  - Also collected via EVS, bait, gravid, resting-ground aspiration, BG-Sentinel 2, and BG-Counter
- Flight range up to 5km
- Seasonality
  - Late summer – fall throughout US range; strong correlation with humidity and rainfall
  - Northern latitudes – majority of collections in fall (September-November)
    - Suspect as population peaks in late summer/early fall, it is able to expand farther northward (e.g. 2017 New Hanover → Beaufort and Nash, NC & Suffolk, VA)

background photo credit: Peggy Greb, USDA

The Distribution Expansion of *Cx. nigripalpus*

Bionomics

- Host preference: opportunistic; primarily avian and mammalian
  - Avian: passerine and gallinaceous (also Charadriiformes, Ciconiiformes, Cuculiformes, Pelecaniformes, and Strigiformes)
  - Over 11 mammalian species including humans
  - Reptiles and amphibians also reported
  - Ornithophilic in winter, spring; transitions to both avian and mammalian hosts in summer/fall
    - Amplification vector in spring; enzootic vector in fall
- Vector competency
  - Primary SLE vector
  - WNV – field transmission to sentinel chickens
  - EEEV and turkey malaria also identified

Photo credit: Jai Nayar, UF

The Distribution Expansion of *Cx. nigripalpus*

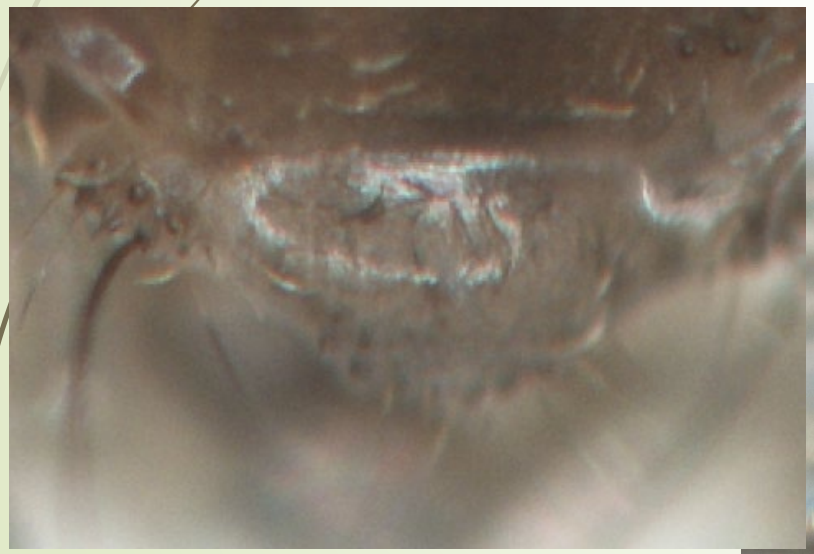
Defining Adult Morphological Characters

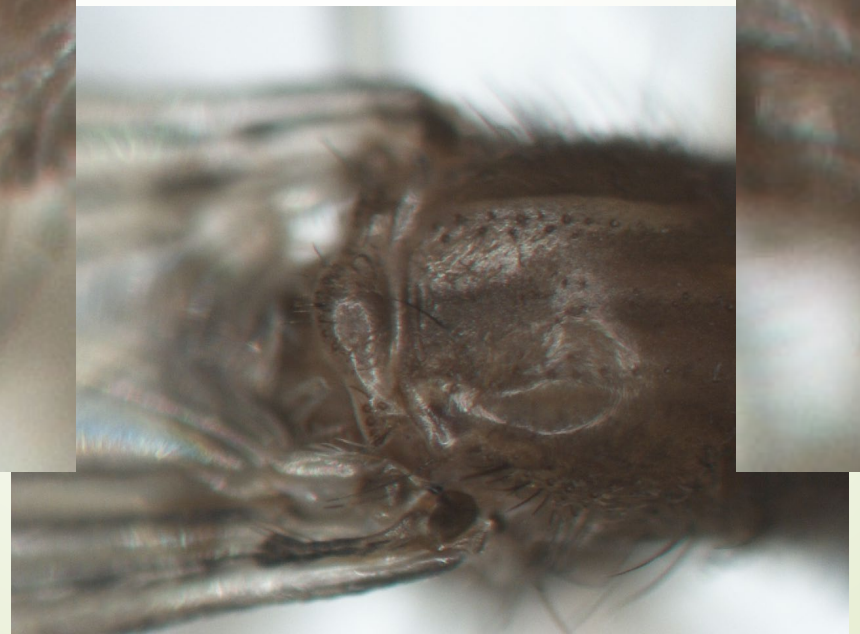
- Separating from *Cx. pipiens*, *Cx. restuans*, and *Cx. salinarius* can be difficult especially when collected in active traps where mosquitoes pass through a fan

The Distribution Expansion of *Cx. nigripalpus*

Defining Adult Morphological Characters

- *Cx. pipiens*/*Cx. restuans* or *Cx. salinarius*/*Cx. nigripalpus?*
  - Abdominal banding is often rubbed/missing so "narrow or indistinct" vs. "distinct and broad" can be impossible to determine
  - Pay close attention to scutellum: basal mid-lobe with dark brown scales (*Cx. pipiens* and *Cx. restuans* will have pale scales)





The Distribution Expansion of *Cx. nigripalpus*

Defining Adult Morphological Characters

- *Cx. salinarius* or *Cx. nigripalpus*?
  - With previously mentioned abdominal rubbing, can be difficult to use character concerning segments VII-VIII with copper-colored scales (*Cx. salinarius*) or dark scales (*Cx. nigripalpus*)
  - Basolateral white patches (VII in Harrison et al. 2016)

The Distribution Expansion of *Cx. nigripalpus*

Defining Adult Morphological Characters

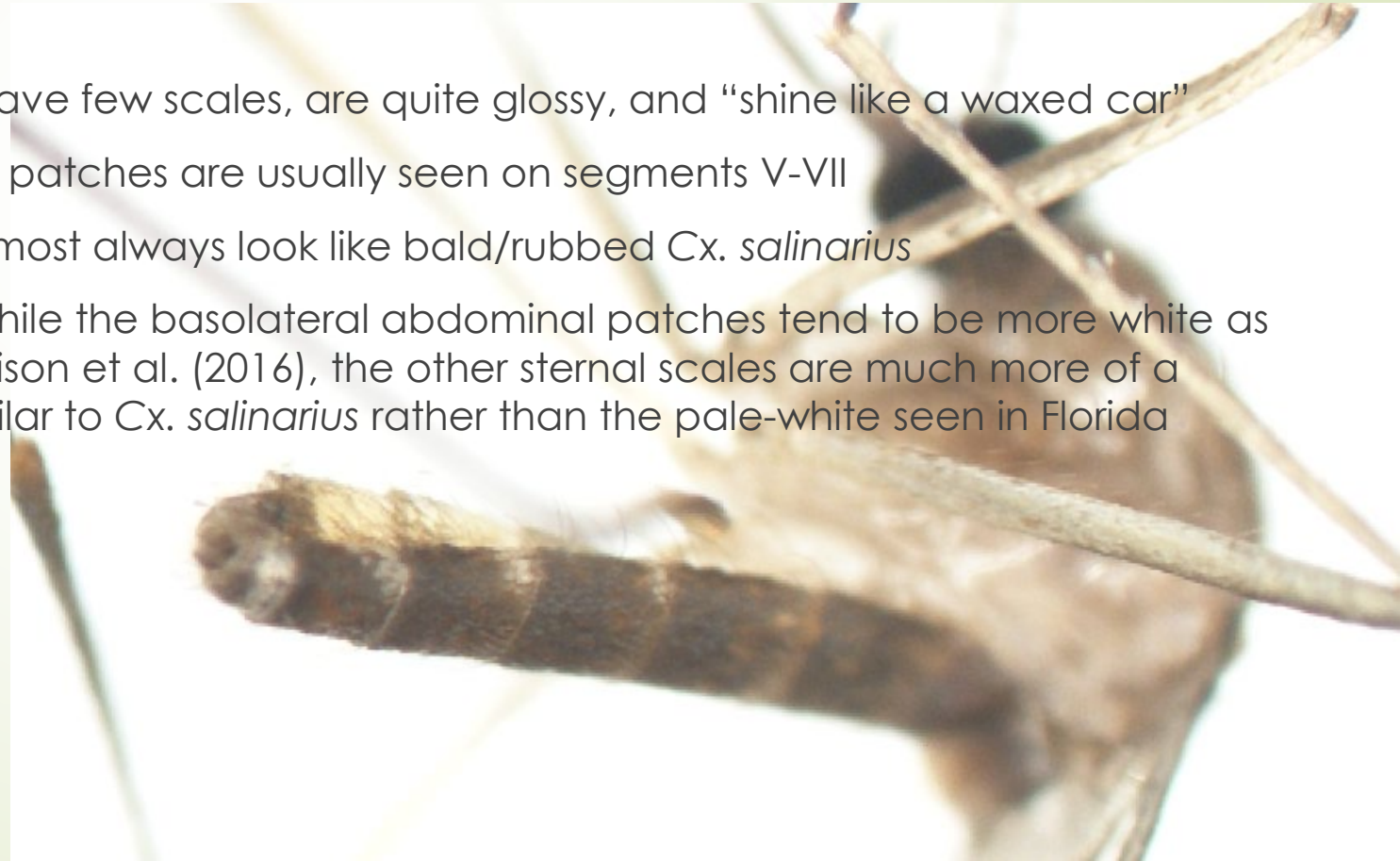
- *Cx. salinarius* or *Cx. nigripalpus*?
  - Mesepimeron is key: missing middle patch of pale scales = *Cx. nigripalpus*

Photo credit: Chris Evans, SCDEHC

The Distribution Expansion of *Cx. nigripalpus*

Defining Adult Morphological Characters

- Other characters not stated in Harrison et al. (2016)
  - Generally, pretty dark brown in comparison to *Cx. pipiens, Cx. restuans, or Cx. salinarius*
  - Pleural sclerites have few scales, are quite glossy, and "shine like a waxed car"
  - Basolateral white patches are usually seen on segments V-VII
  - VA specimens almost always look like bald/rubbed *Cx. salinarius*
  - VA specimens: while the basolateral abdominal patches tend to be more white as described in Harrison et al. (2016), the other sternal scales are much more of a copper-pale, similar to *Cx. salinarius* rather than the pale-white seen in Florida specimens



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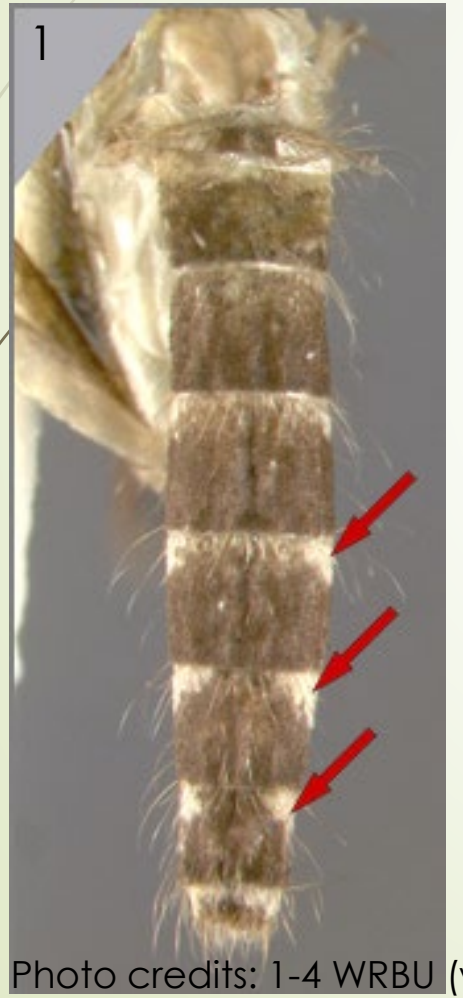
Defining Adult Morphological Characters

- Ideal specimen photos



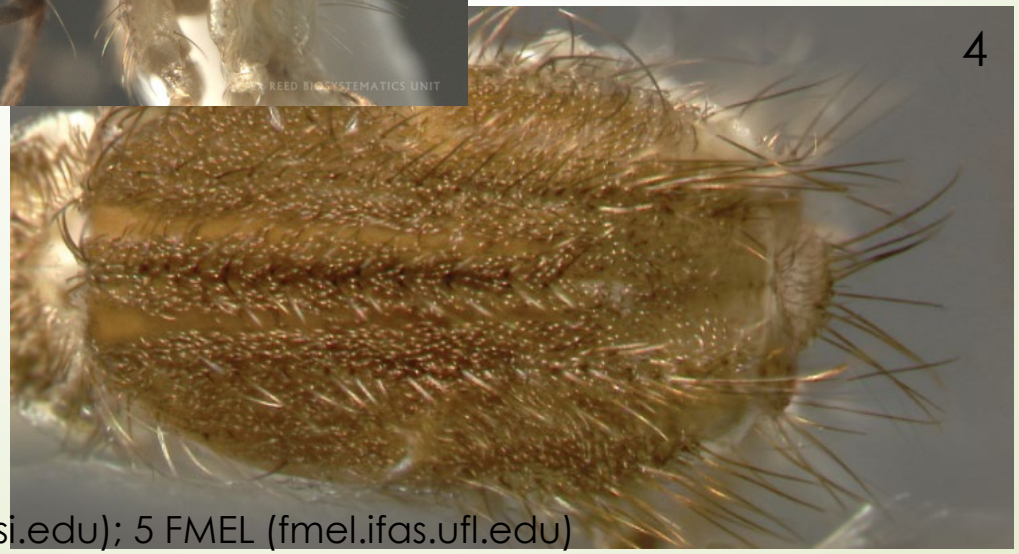


Photo credits: 1-4 WRBU (wrbu.si.edu); 5 FMEL (fmel.ifas.ufl.edu)

The Distribution Expansion of *Cx. nigripalpus*

Project origination

- October 6, 2017 - Dr. Harrison reminded VA authors to be on the lookout for *Cx. nigripalpus* moving northward into VA soon
  - 1 week later on October 13, Suffolk VA found first specimens

Bruce's Corner

There be Skeeters in Those Mountains

By Bruce A. Harrison

Many years ago in the late 1940s, my dad drove me from south Georgia to Spruce Pine, NC, to visit an aunt, and I remember the huge mountains, forests, and I marveled at the trout in the stream behind her house. Actually, I caught 4-5 small trout using worms and crickets for bait and they were my first taste of rainbow trout. That short trip rang the bell for my love of the mountains of North Carolina. This was enhanced further during the summer of 1958 when I was a student in Wildlife and Fisheries at N.C. State College and worked as a fishery biologist helper for 13 weeks camped out on seven of the beautiful reservoirs in the mountains. I was in love (and still am) with nature during that period (and girls), but I vividly remember that there were mosquitoes coming out of those forests late in the afternoon and at night that did not mind the stench of fish on me and would bite anything that wasn't covered by clothing or a blanket. Coming from the flatlands, swamps, rivers and creeks of southern Georgia where mosquitoes can be "top dog" outdoors I had never contemplated finding mosquitoes in a mountainous region. However, I suspect that there are a significant number of people from the coastal plain and piedmont of North Carolina today that have not considered mosquitoes being in or being of importance in the mountains. In fact, I'm sure of this because a friend told me that a legislative representative from a mountainous county that was being interviewed in 2010 commented "*You mean there are still mosquitoes in the mountains?*" This occurred just seven years ago when efforts were being made to save the state elimination of the Public Health Pest Management Section of the NCDENR.

When I returned to NC in March, 1993 to work in Public Health Pest Management it was fortuitous that I was assigned as the medical entomologist for 47 of the most-western counties in the state. This opened the door for me to repeatedly travel to the mountains. When Parker Whitt was hired in 1995 to work with me that doubled our efforts. We obtained permits to work in the state parks and when we had time, other than responding to complaints about ticks, flies, fleas, head lice, bed bugs, midges, rats, mice, bees, wasps, ants, delusions of parasitosis, post-hurricane surveillance and mosquito pooling work, etc., we made mosquito collections in our counties as often as possible. These trips increased dramatically after West Nile virus arrived in NC in 2000 and TVA contracted us with annual funding assistance to collect mosquitoes for WNv testing in mountainous counties with drainage into the French Broad River system that flows into Tennessee. Thus, we quickly built up collections and records for mosquito species that we found in the mountains. We also discovered that the few roads, predominately forested mountains, and our inability to get into certain areas made mosquito surveillance difficult. But like other North Carolinians the people of the mountains are friendly, provided you are courteous and respectful of their property. (continued next page)

Bruce's Corner

What's the Real Distribution of *Culex nigripalpus* in North Carolina?

By Bruce A. Harrison (Ret.) and Parker B. Whitt, NCDA&CS

Most of you reading this article probably think the distribution of *Culex nigripalpus* Theobald is primarily in the southeastern counties of North Carolina, based on map 29A in Darsie and Ward (2005). However, during our years of collecting and confirming specimens in this state we have discovered that is not correct. It may be more abundant in those counties, but it has been encountered across the state.

In 1993, after arriving in Winston-Salem to work in the Public Health Pest Management (PHPM) Section, one of the first things I did was obtain a copy of Slaff and Apperson (1989) or the "Red Book" and also started reviewing knowledge about mosquitoes in the state and refreshing my ID skills for the NC species. I quickly discovered there were no specimens of *Cx. nigripalpus* in the PHPM collections, and noticed that in the Red Book this species was considered "rare" in North Carolina. I was familiar with this species because of previous mosquito ID work in Atlanta, and the vector role of this species in the St. Louis encephalitis (SLE) virus outbreaks in Florida during the 1950-60s, so I decided to target it during collections.

Carpenter et al. (1945) published the first record for *Cx. nigripalpus* in North Carolina during WWII, in 1944 collections made on Camp Sutton in Union County, but I could not find subsequent published NC collection records for this species. In 1994, Rick Hickman, Brunswick County, said he had *Cx. nigripalpus* and kindly provided a number of specimens for the PHPM collection. Later that year I collected specimens of this species in Cabarrus, Henderson, Rowan, Rutherford (from Nolan Newton), and Transylvania counties. The following year, after Parker joined PHPM, we collected specimens in Forsyth, Mecklenburg, and additional specimens from Cabarrus, Forsyth, and Rowan counties. Post-hurricane collections during 1996-99 along with the arrival of West Nile virus in 2000 dramatically increased program-level identifications and pooling, as well as confirmed specimens of this species. During the last two months (2017) specimens of this species have been collected and confirmed from Beaufort County. This represents a new county record for Beaufort County (Eugene McRoy, personal communication), and increases the northern distribution of *Cx. nigripalpus* in eastern NC to nearly 2/3 of the way up the east coast and not far from Virginia. Currently, our records show *Cx. nigripalpus* occurring in 25 counties of North Carolina, *i.e.*, **Coastal Plain**, 10 counties – Beaufort, Bladen, Brunswick, Columbus, Duplin, Jones, New Hanover, Onslow, Pender, and Sampson; **Piedmont**, 9 counties – Anson, Cabarrus, Davidson, Forsyth, Mecklenburg, Richmond, Rowan, Scotland, and Union; and **Mountains**, 6 counties – Henderson, Jackson, Macon, McDowell, Rutherford, and Transylvania.

What's this doing in Virginia?

Bruce A. Harrison, Karen I. Akaratovic, Jay P. Kiser, and Charles F. Abadam

Figure 1. Arrow showing lack of scales on mesepimeron

Figure 2. Arrow showing basolateral patches on abdominal terga.

We suspect you won't immediately recognize this species, but you better start learning about it and look for it in your trap collections. Basically this is a fall mosquito that can: remain around until late November, become very common, and should be considered for pooling because in some states it is a known vector of arboviruses that cause human disease.

In the past this species has not been considered a migratory species. Now, with strong evidence supporting climate change, it should be considered an opportunistic species in the US that expands its distribution during warm winters similar to other "emerging emigrant species" like *Culex coronator* (Dyar and Knab), (Akaratovic and Kiser 2017) and *Mansonia titillans* (Walker), (Moulis et al. 2015). After several sequential warm winters it can alter its previous distribution by hundreds of miles. That is exactly what has happened in Virginia, as it apparently surged northward in North Carolina during the last 3-4 years and into Virginia in 2017. In eastern North Carolina this species was previously considered found only in the southeastern coastal counties, but this year specimens have been found much further north and over halfway to Virginia in Beaufort County (Eugene McRoy, personal communication) while in the southeastern counties hundreds of specimens have been collected (Jeff Brown and Marie Hemmen, personal communication). Now it has spread into Virginia and has been detected in Suffolk in widely separated collections.

By now you probably know its name is **Culex nigripalpus** Theobald, and it represents another new species record for Virginia. Below are some important facts about this species.

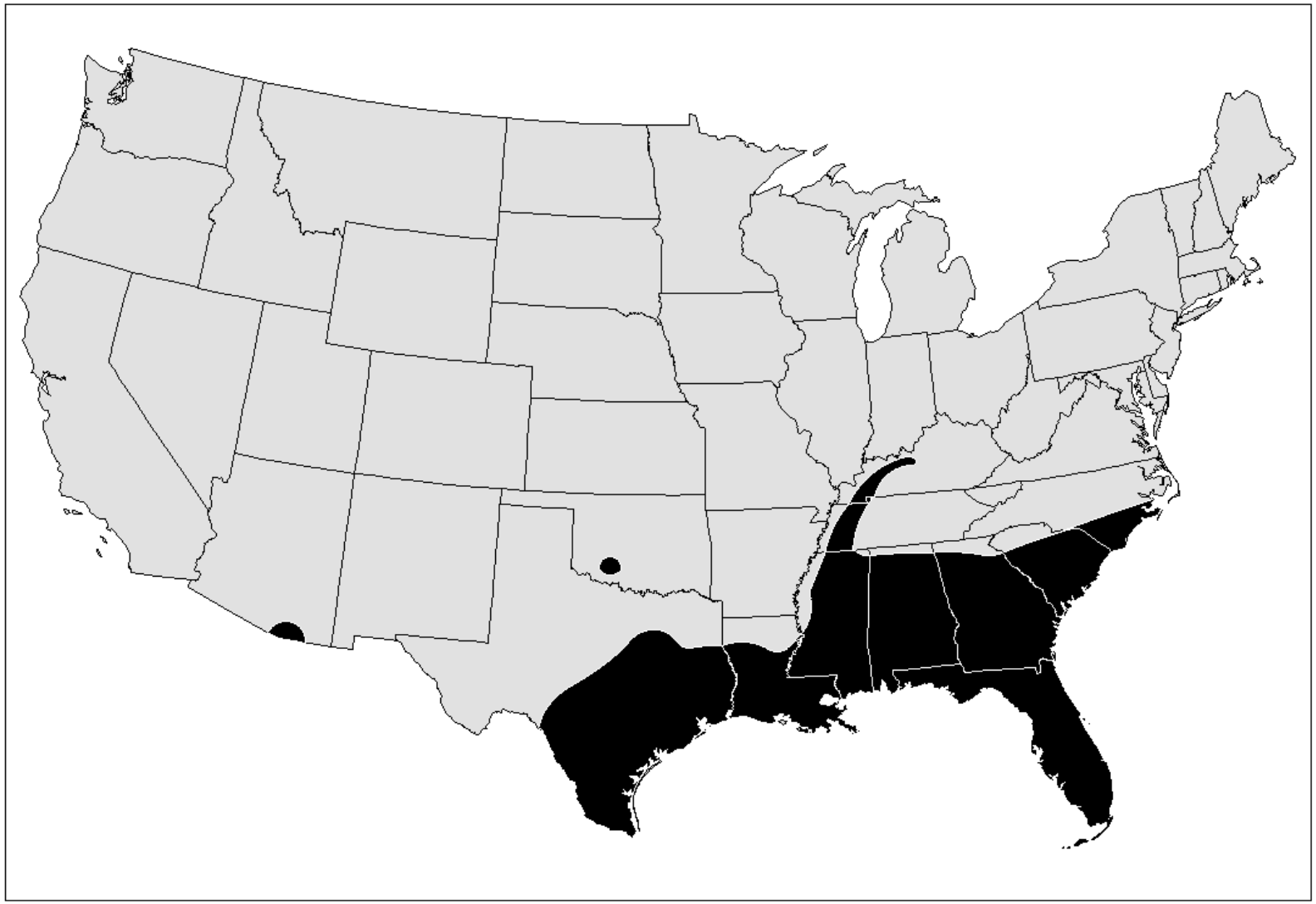
Suffolk Collection. Four females were collected in Suffolk, Virginia on October 13, 2017 from 3 trapsites (Figure 4). One specimen was collected in a CDC light trap in the southwestern portion of the city that is a small suburban outpost with adjacent residential and industrial properties, surrounded by agricultural land. This is the same site at which *Cx. coronator* was found one year prior. The other 3 specimens were collected over 30 km away, in northwest Suffolk. Two were collected in a CDC light trap from a rural site bordered by fresh water to the north (Chuckatuck Creek) and south (Nansemond River) with adjacent abandoned dilapidated housing and ditches/tire ruts that occasionally flood. The last specimen was collected in a BG-Sentinel 2® trap from the most northwest tip of the city, within 500 m of where the Nansemond River meets the James River. It is a suburban site with pockets of mostly loblolly pine (*Pinus taeda* L.) forest.

Continued on next page

The Distribution Expansion of *Cx. nigripalpus*

Darsie & Ward 2005 Distribution

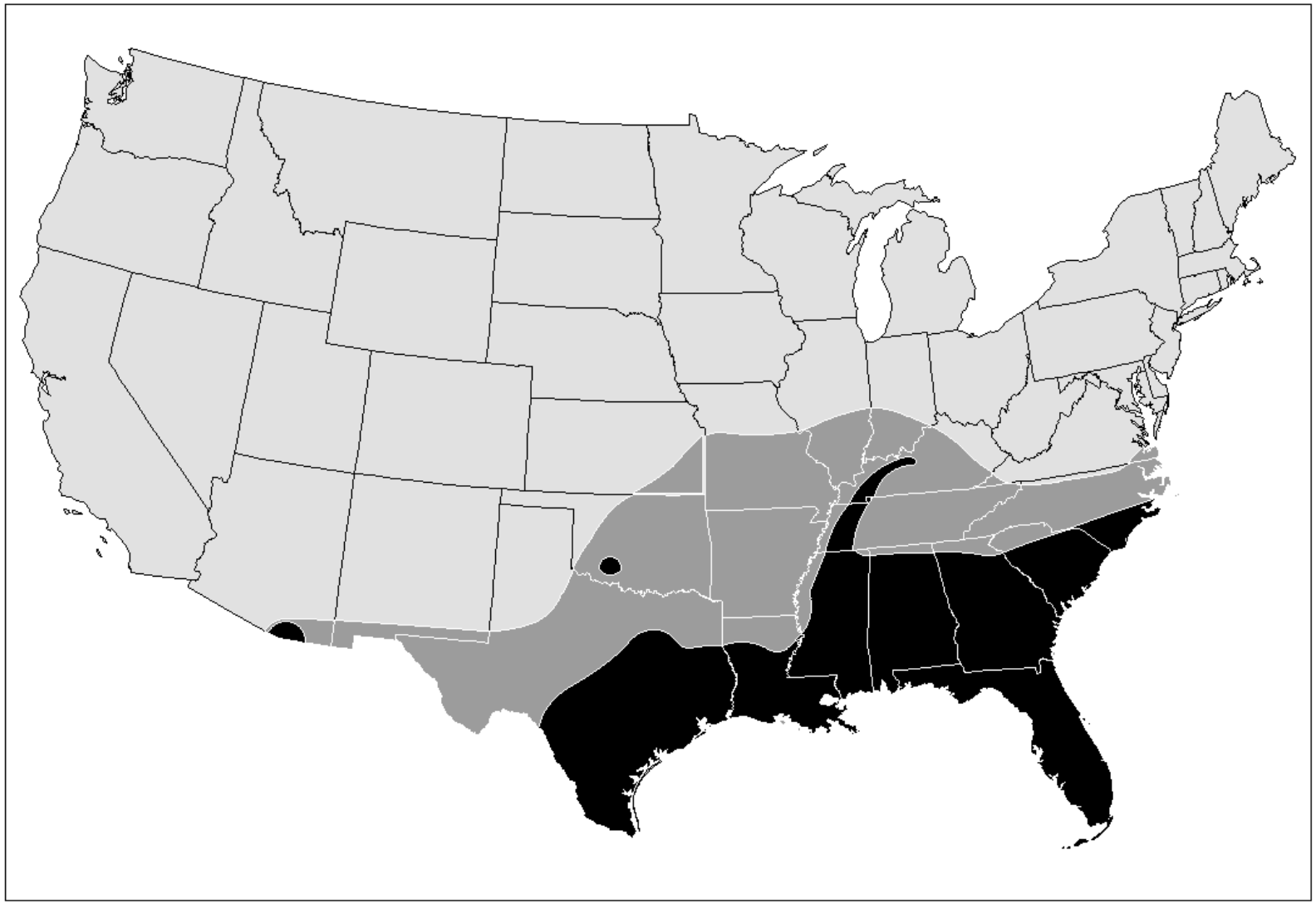
- AR and OK shown in Darsie and Ward (1981); referenced but not displayed on Darsie and Ward (2005)



The Distribution Expansion of *Cx. nigripalpus*

2021 Distribution

- Black area- Darsie and Ward (2005)
- Gray area indicates updated 2021 distribution



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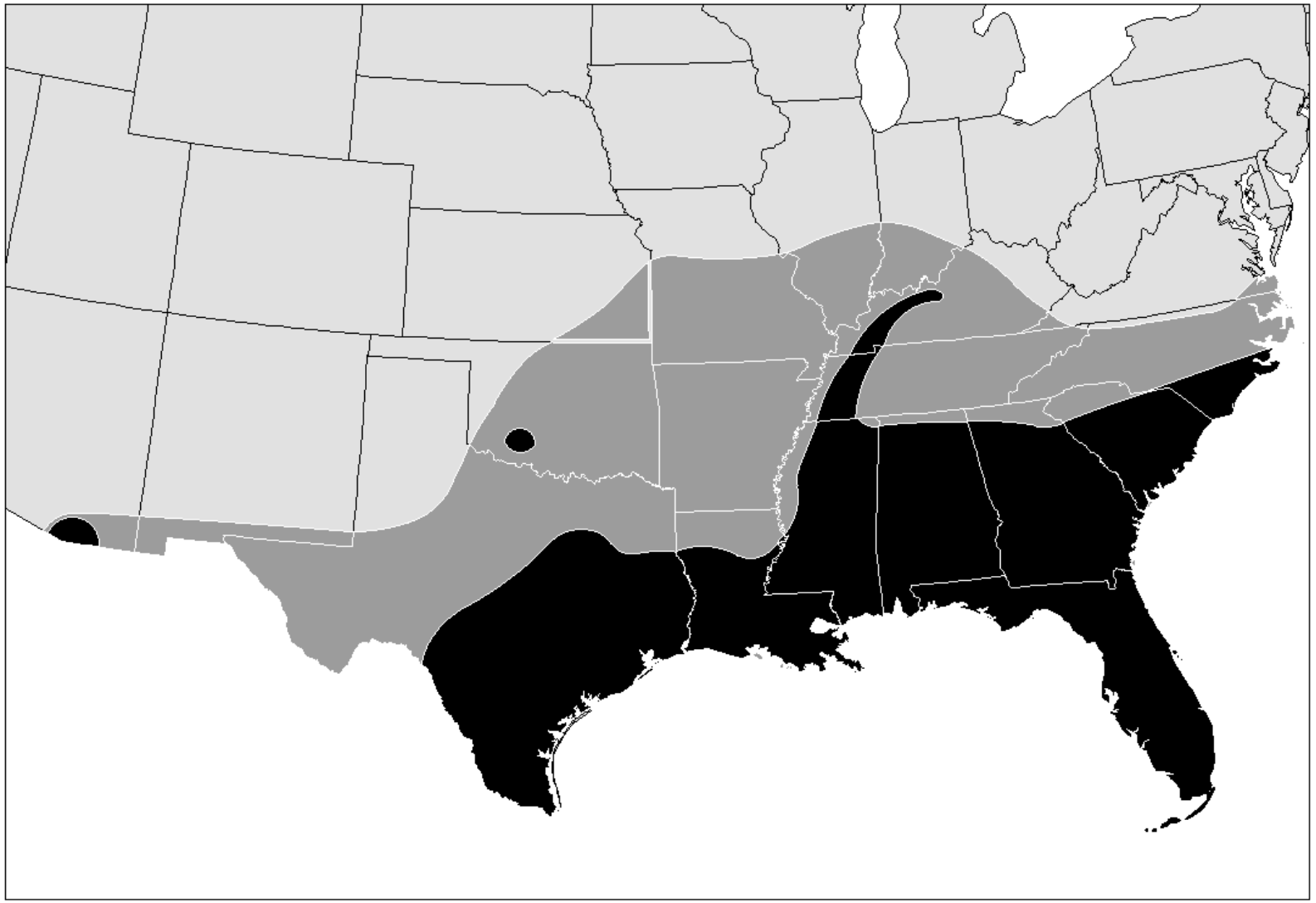
2021 Distribution

- Close-up view; note limit line runs through NM, KS, and IN. However, collections have not been reported from these states



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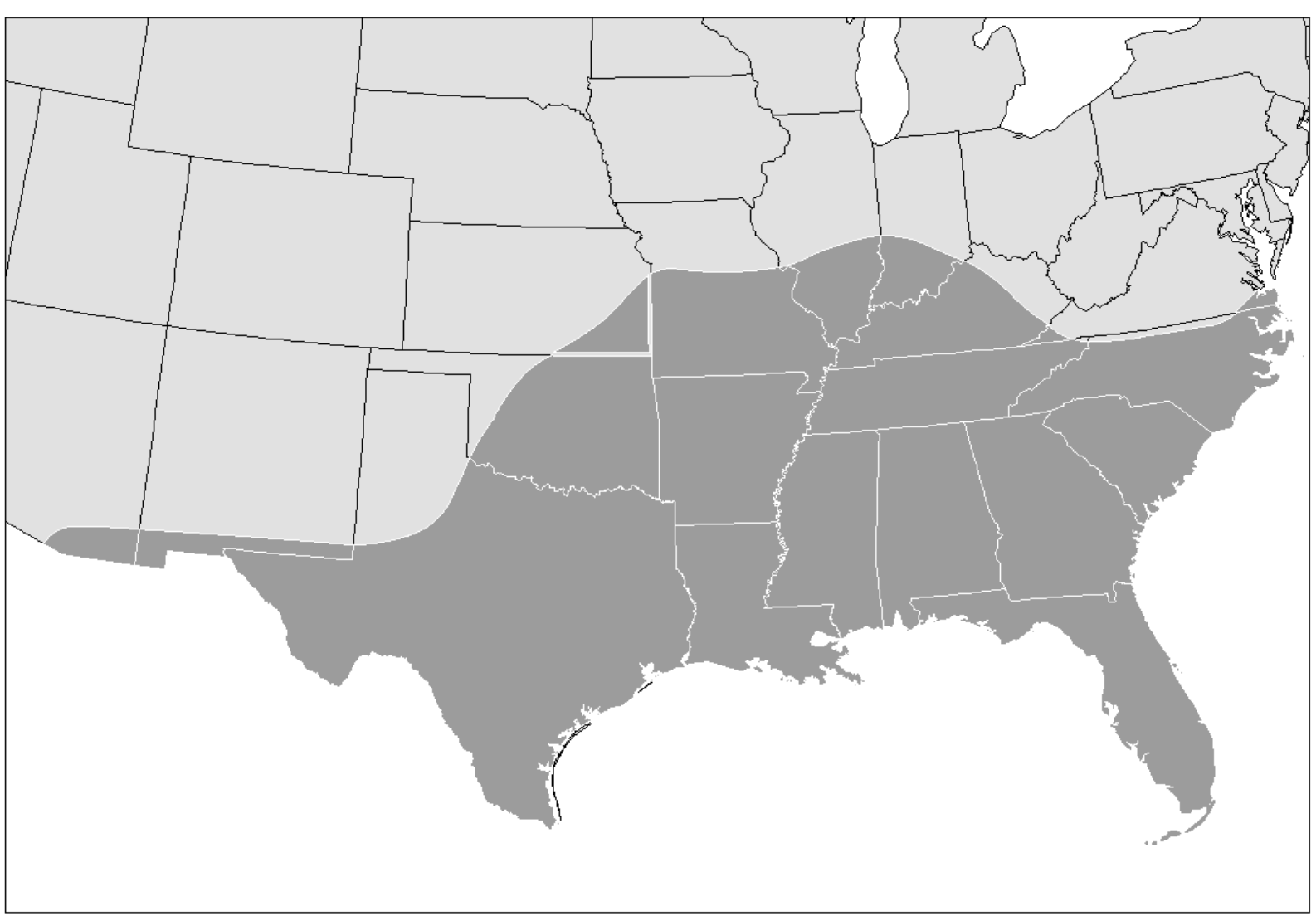
2021 Distribution



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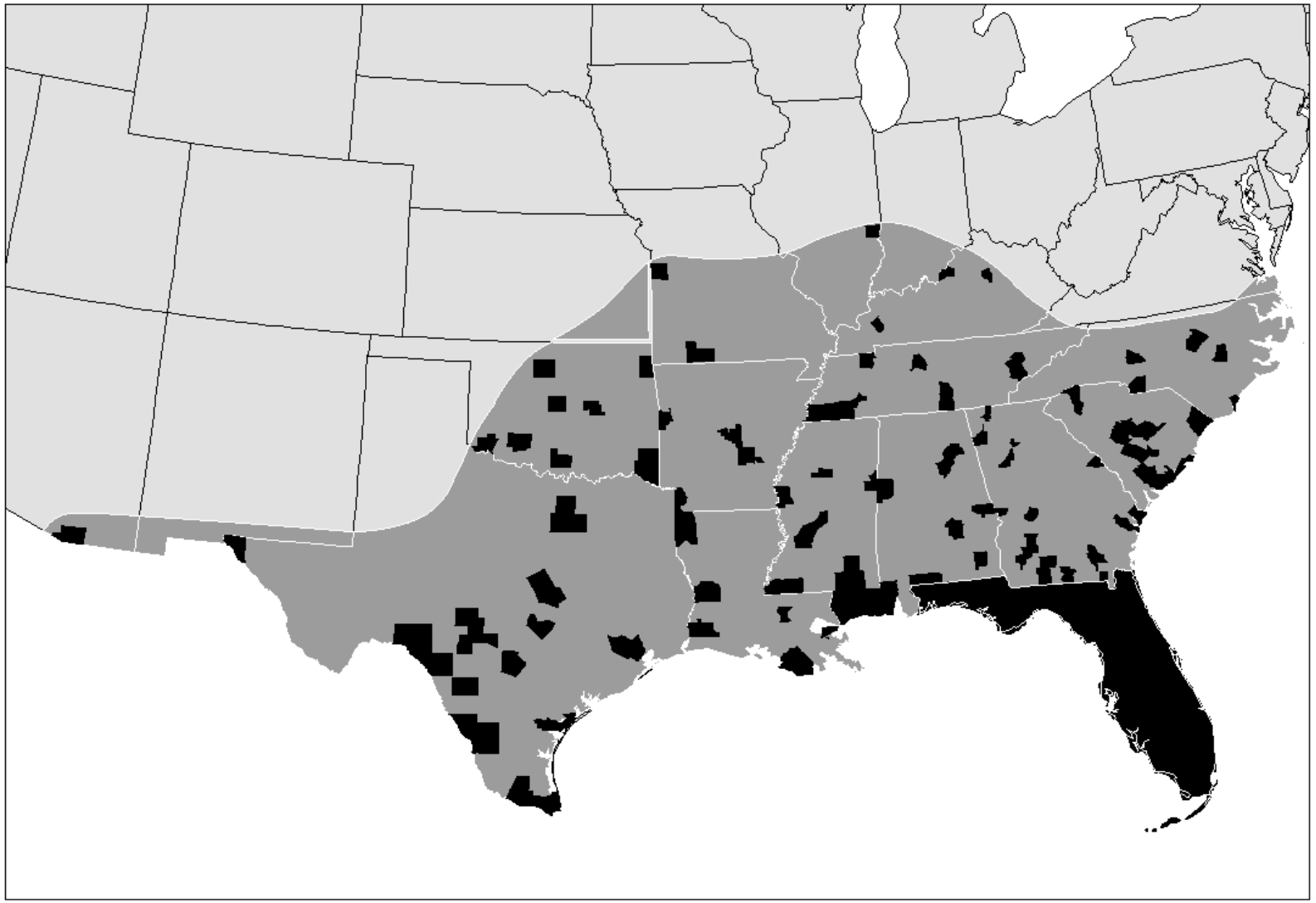
2021 Distribution

- Counties reporting collections that necessitate new limit line; most published in the last 15 years



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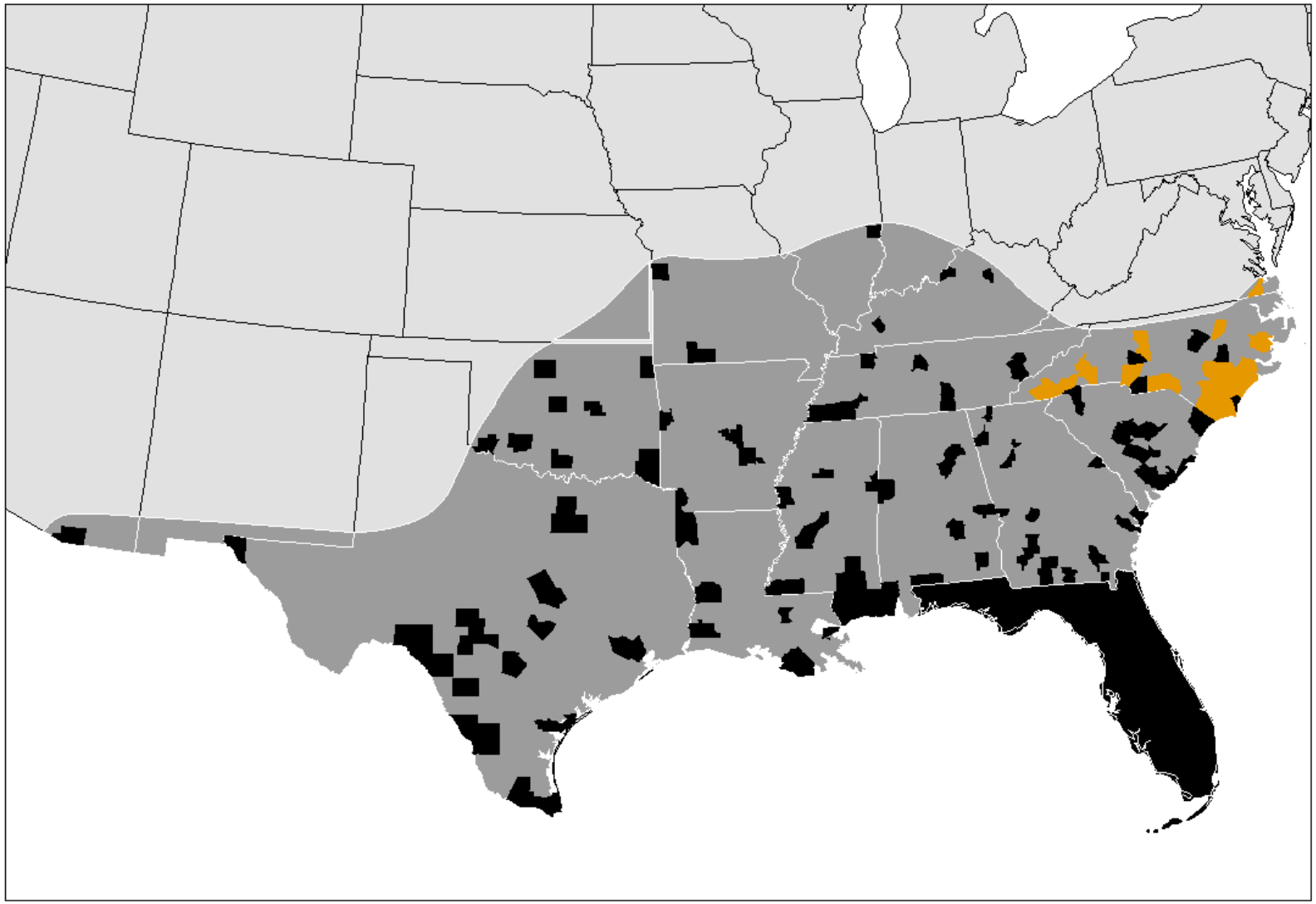
2021 Distribution

- Gold shows NC counties and one VA city (Suffolk) reported in upcoming article (Akaratovic et al. December 2021)



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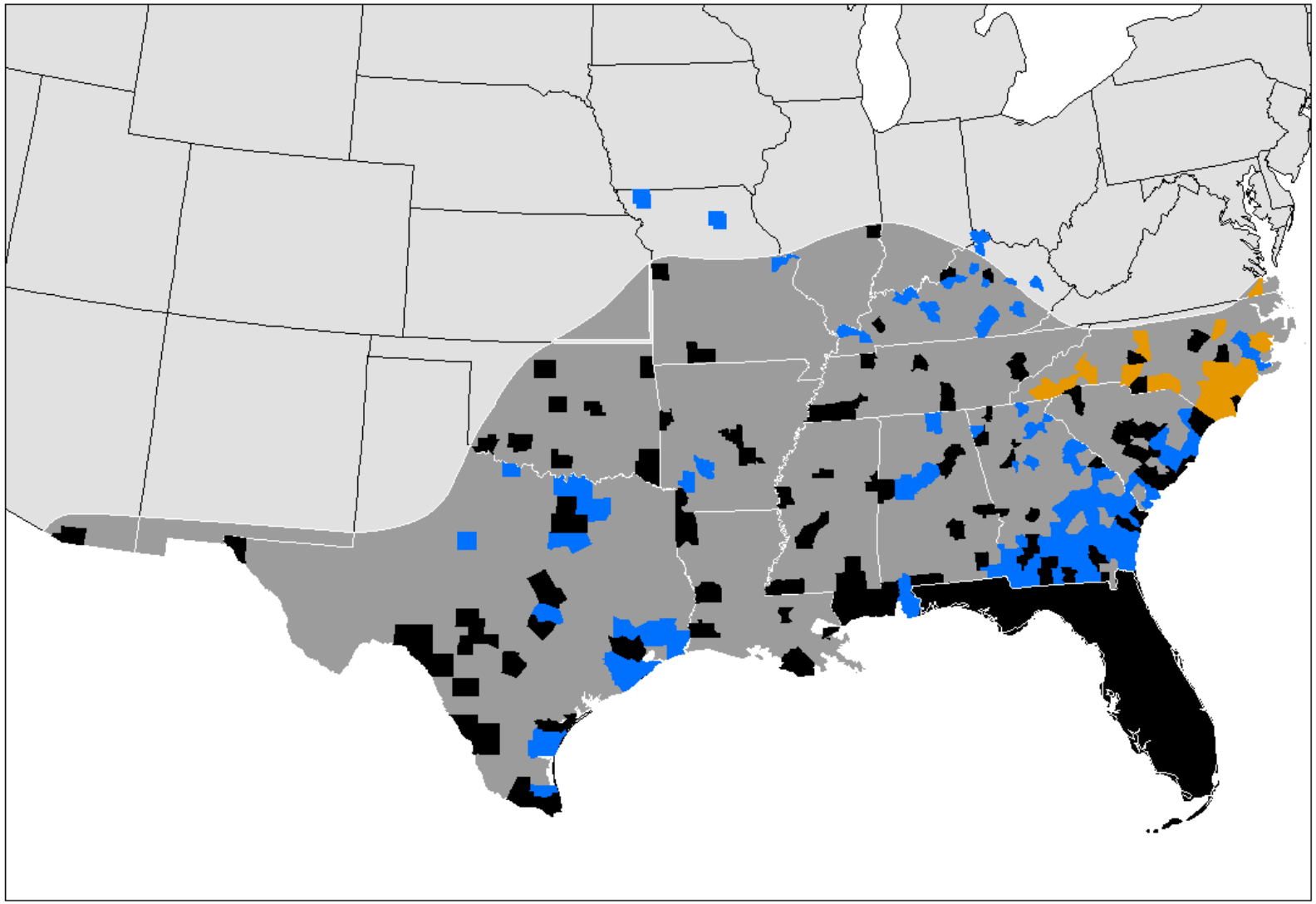
2021 Distribution

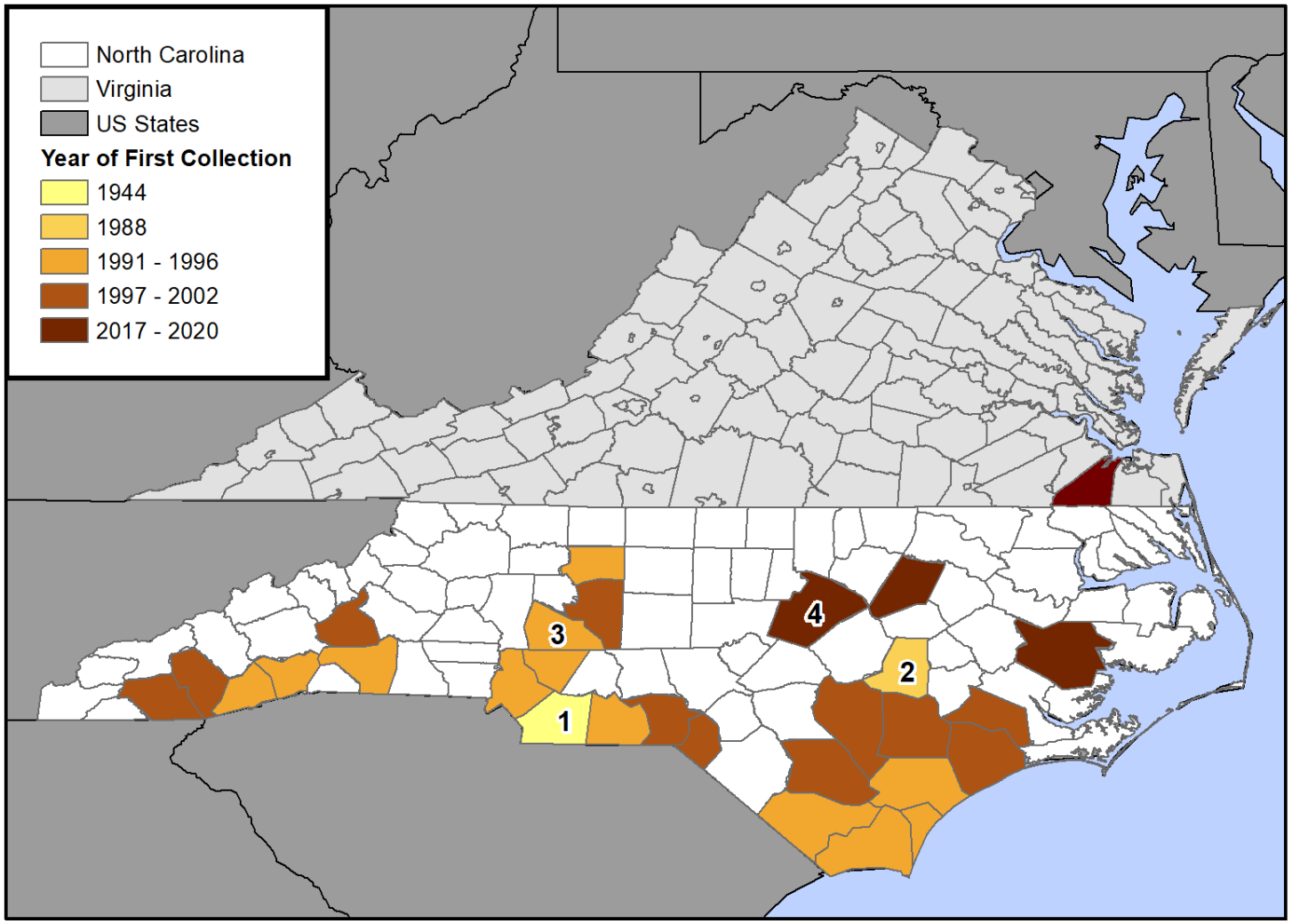
- Blue counties reported in CDC MosquitoNET show more coverage and would extend the limit line even farther north
- Unfortunately could not publish this data as it is not a publicly accessible database



The Distribution Expansion of *Cx. nigripalpus*

NC & VA Distribution

- Suffolk, VA first collected in 2017; subsequent collections in 2019-2020 (more in 2021)
- NC data reported here: mostly collected by Dr. Bruce Harrison and Parker Whitt (notes for counties labeled 1-4)



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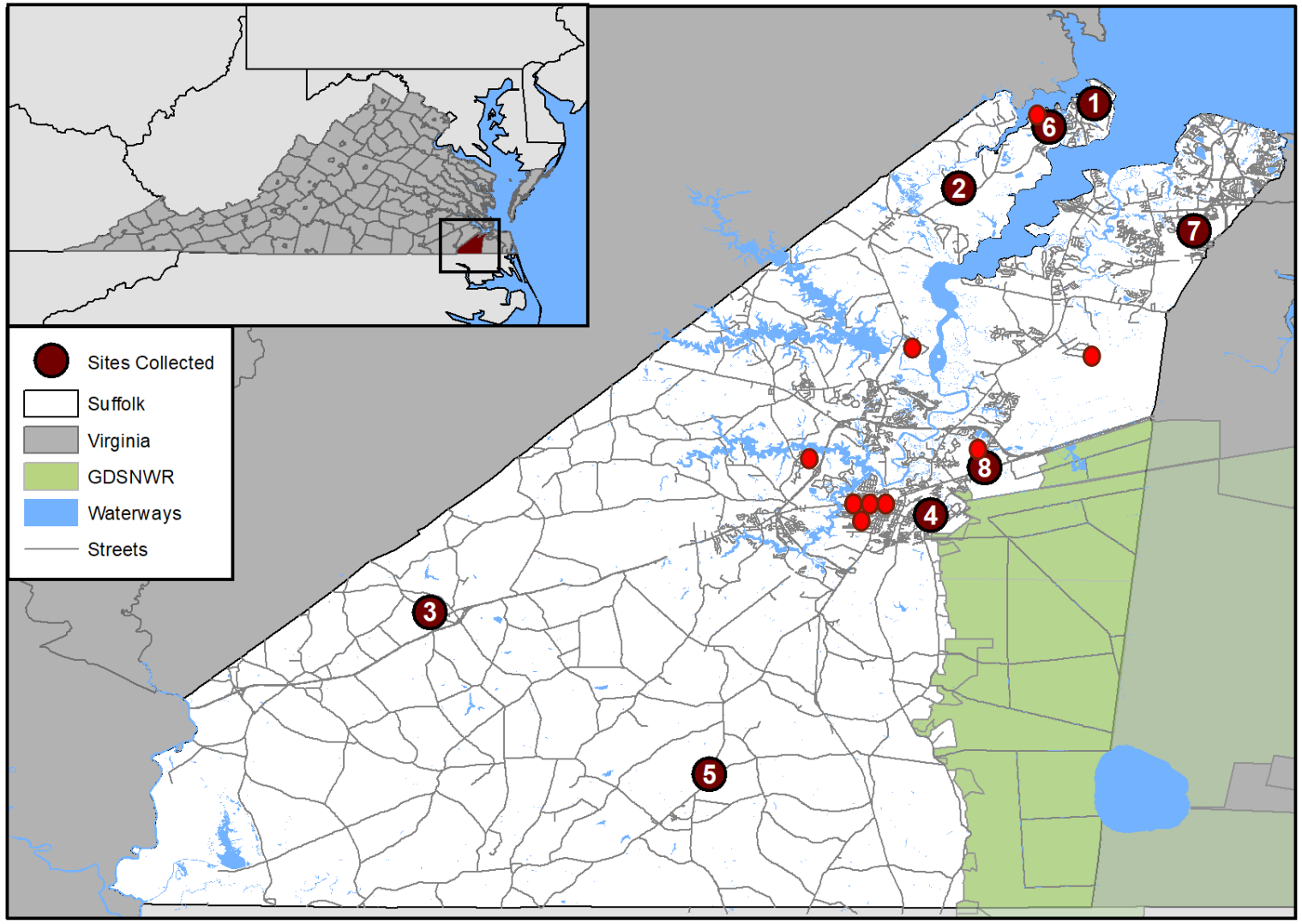
Suffolk, VA Distribution

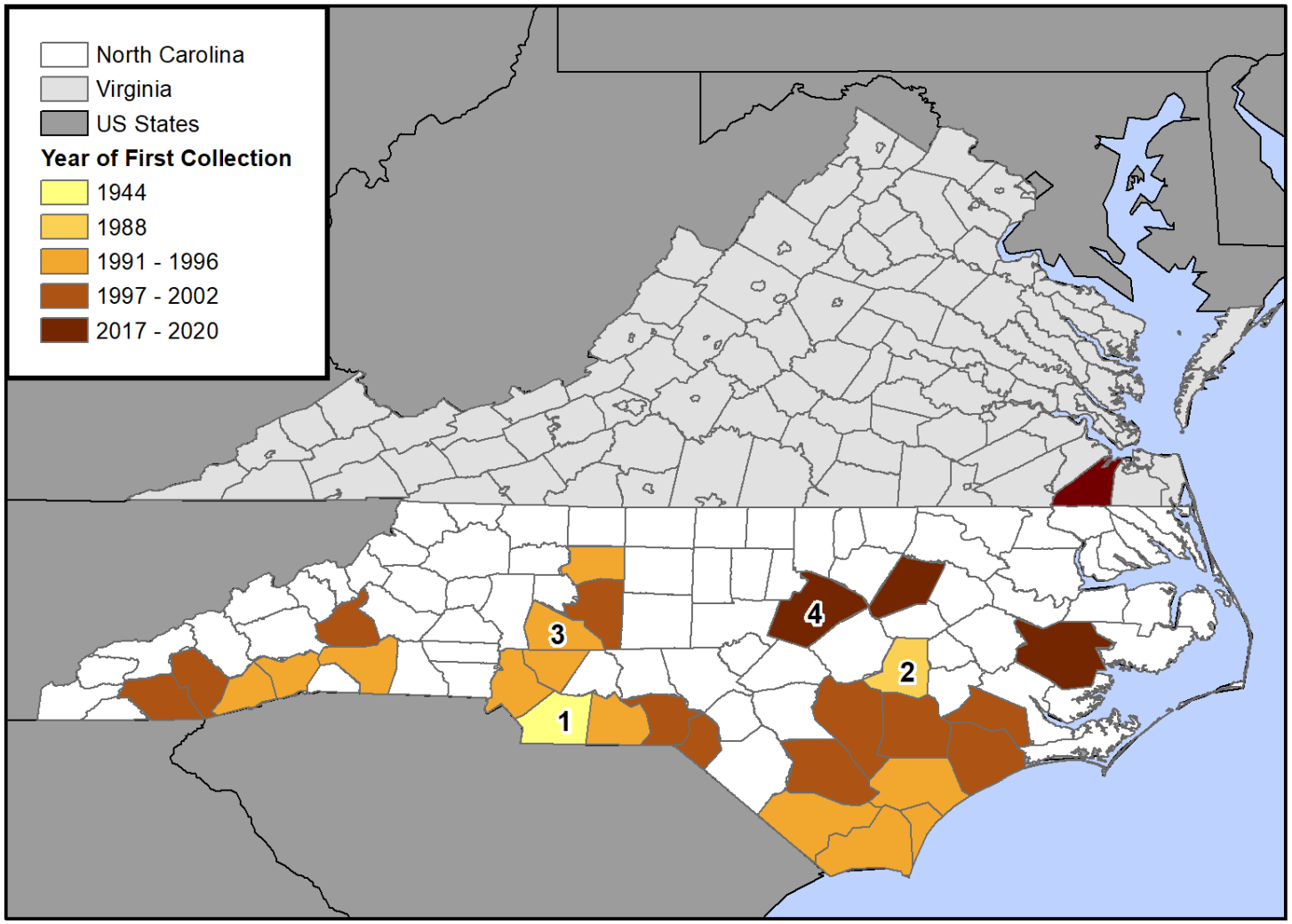
- 2017 (5): sites 1-3
- 2018: none
- 2019 (2): sites 4,5
- 2020 (4): sites 6-8
- 2021 (10): sites •



The Distribution Expansion of *Cx. nigripalpus*

NC Distribution

- 28 NC counties reporting
- 1- Union
  (Carpenter et al. 1945)
- 2- Wayne
  (McHugh et al. 1988)
- 3- Rowan
  collected by BAH/PBW but reported in Hartwig et al. 2018
- 4- Wake
  (Day et al. 2020)

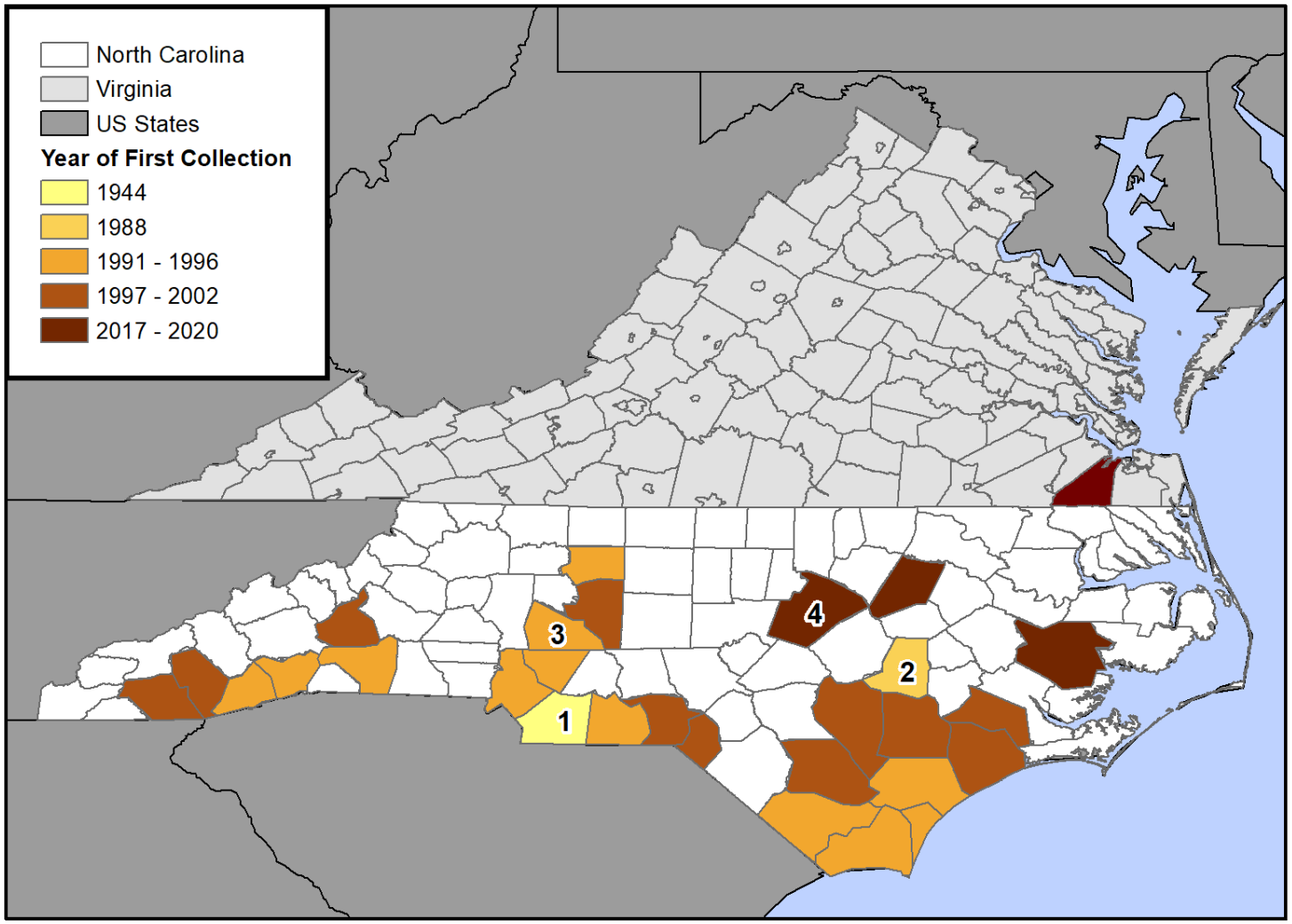


The Distribution Expansion of *Cx. nigripalpus*

NC Distribution

- 1944 & 1988:
  *Union and *Wayne
- 1991-1996:
  Anson, Brunswick, Cabarrus, Columbus, Forsyth, Mecklenburg, New Hanover, Pender, *Rowan, Rutherford, Transylvania
- 1997-2002:
  Bladen, Davidson, Duplin, Henderson, Jackson, Jones, Macon, McDowell Onslow, Richmond, Sampson, Scotland
- 2017-2020:
  Beaufort, Nash, *Wake

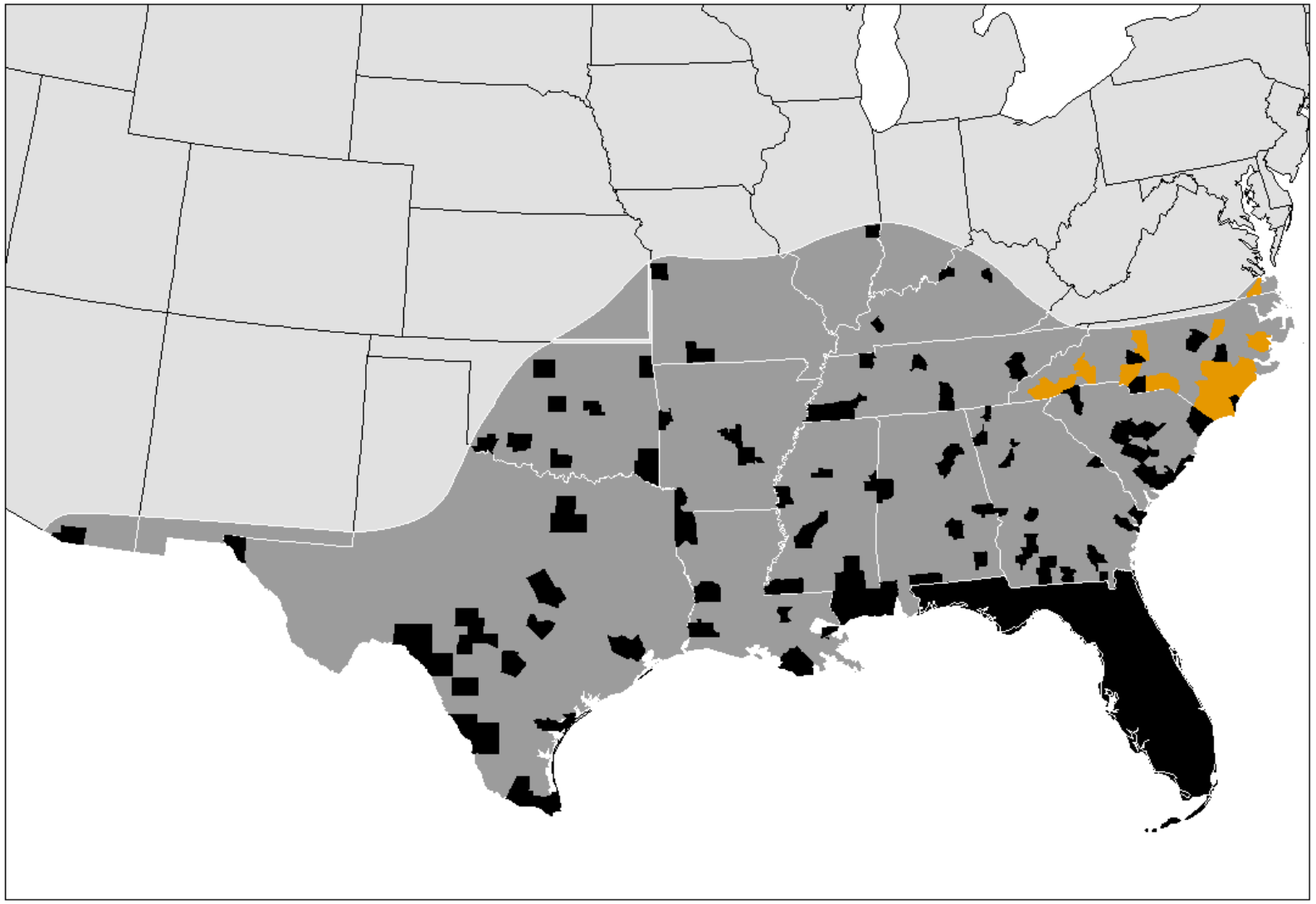
*previously published data



The Distribution Expansion of *Cx. nigripalpus*

2021 Distribution

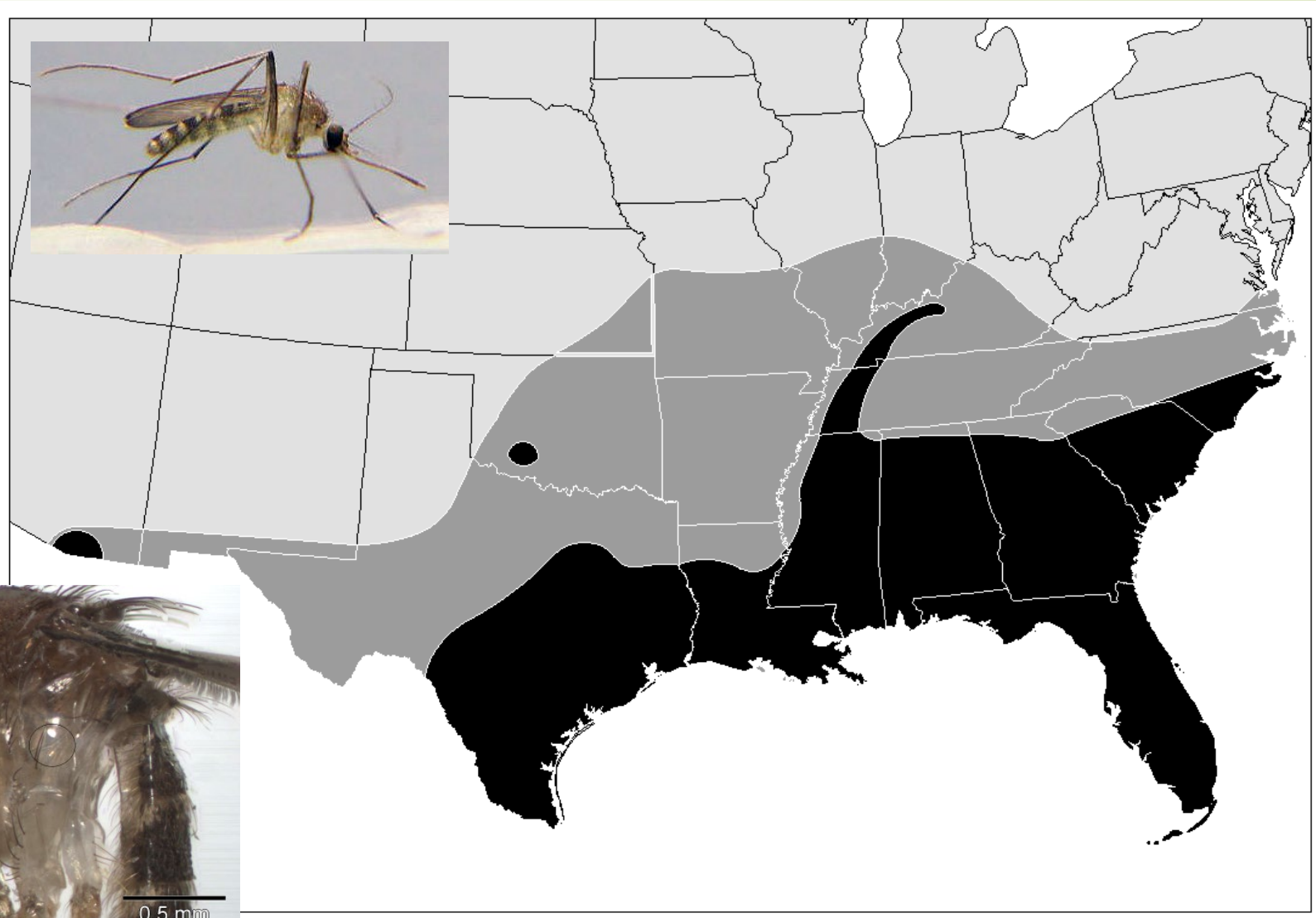
- Published expansion encompasses 201 jurisdictions in 16 states
- Increasing global temperatures – warmer winters and heavy precipitation in fall months
- Opportunistic feeder and diverse oviposition habitat
- Anthropogenic introductions



The Distribution Expansion of *Cx. nigripalpus*

Future Outlook

- Look out for *Cx. nigripalpus*, coming to a town near you!



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Publication December 2021

- Available open-access
  https://meridian.allenpress.com/jamca/issue/37/4

Journal of the American Mosquito Control Association, 37(4):188–197, 2021

CULEX NIGRIPALPUS DISTRIBUTION EXPANSION: FIRST RECORD IN VIRGINIA, NEW COUNTY RECORDS IN NORTH CAROLINA, AND REVISED UNITED STATES MAP

KAREN I. AKARATOVIC,[1] JAY P. KISER,[1] PARKER B. WHITT,[2] RYAN L. HARRISON[3] AND BRUCE A. HARRISON[4,5]

ABSTRACT. Theobald first described *Culex nigripalpus* in 1901 from St. Lucia Island of the Lesser Antilles. It is a Neotropical mosquito species that is documented throughout Central and South America, the Caribbean, and the southeastern USA. Reports within the last 3 decades show the species has expanded its range farther into North America and is not only being discovered sporadically but appears to be establishing itself in several states, of which data are underreported and difficult to find. Five female specimens were collected—4 on October 13 and 1 on December 6, 2017—at 3 separate sites in the city of Suffolk, VA—2 in a BG-Sentinel 2® trap, 3 in Centers for Disease Control and Prevention light traps—during routine mosquito surveillance; subsequent collections were made in 2019 and 2020. These findings represent the 1st record of *Cx. nigripalpus* in the state of Virginia and the most northeastern records in the USA. An updated mosquito species checklist for the state of Virginia is provided. Additionally, this report serves to update the records of North Carolina to 28 total counties reporting *Cx. nigripalpus*. These new records, along with other reports and published studies, show this species now documented in 201 jurisdictions in 16 states of the USA. As recent literature on this species is scarce, we provide a review of the bionomics, defining morphological characters, and an updated US distribution map.

KEY WORDS Bionomics, *Culex nigripalpus*, distribution, North Carolina, US map, Virginia

Table 1. The 58 mosquito species of Virginia (named or provisional species, subspecies, and 1 hybrid).[1]

Species name	% collected in Suffolk, VA, 2017
Aedes aegypti	
Ae. albopictus[a]	4.0
Ae. atlanticus[a]	3.6
Ae. atropalpus	
Ae. aurifer[a]	<0.1
Ae. canadensis canadensis[a]	2.2
Ae. cantator[a]	<0.1
Ae. cinereus	
Ae. dupreei[a]	<0.1
Ae. fulvus pallens[a]	<0.1
Ae. grossbecki	
Ae. hendersoni	
Ae. infirmatus[a]	0.5
Ae. japonicus japonicus[a]	<0.1
Ae. mitchellae[a]	<0.1
Ae. sollicitans[a]	0.1
Ae. sticticus[a]	<0.1
Ae. stimulans	
Ae. taeniorhynchus[a]	<0.1
Ae. thibaulti[a]	<0.1
Ae. tormentor[a]	0.1
Ae. triseriatus[a]	0.2
Ae. trivittatus	
Ae. vexans[a]	1.0
Anopheles atropos	
An. barberi	
An. bradleyi	
An. crucians s.l.[a]	1.9
An. punctipennis[a]	0.2
An. quadrimaculatus[a]	0.5
An. smaragdinus	
An. walkeri	
Coquillettidia perturbans[a]	1.7
Culex coronator[b]	
Cx. erraticus[a]	7.1
Cx. nigripalpus[a,b]	<0.1
Cx. peccator	
Cx. pipiens[c]	
Cx. pipiens × *quinquefasciatus*[a,c]	1.6
Cx. restuans[a]	0.6
Cx. salinarius[a]	3.7
Cx. tarsalis	
Cx. territans[a]	0.2
Culiseta inornata[a]	<0.1
Cx. melanura[a]	67.2
Orthopodomyia alba	
Or. signifera[a]	<0.1
Psorophora ciliata[a]	<0.1
Ps. columbiae[a]	0.7
Ps. cyanescens	
Ps. discolor	
Ps. ferox[a]	2.8
Ps. horrida	
Ps. howardii[a]	<0.1
Ps. mathesoni[a]	<0.1
Toxorhynchites rutilus septentrionalis[a]	<0.1
Uranotaenia sapphirina[a]	0.3
Wyeomyia smithii	

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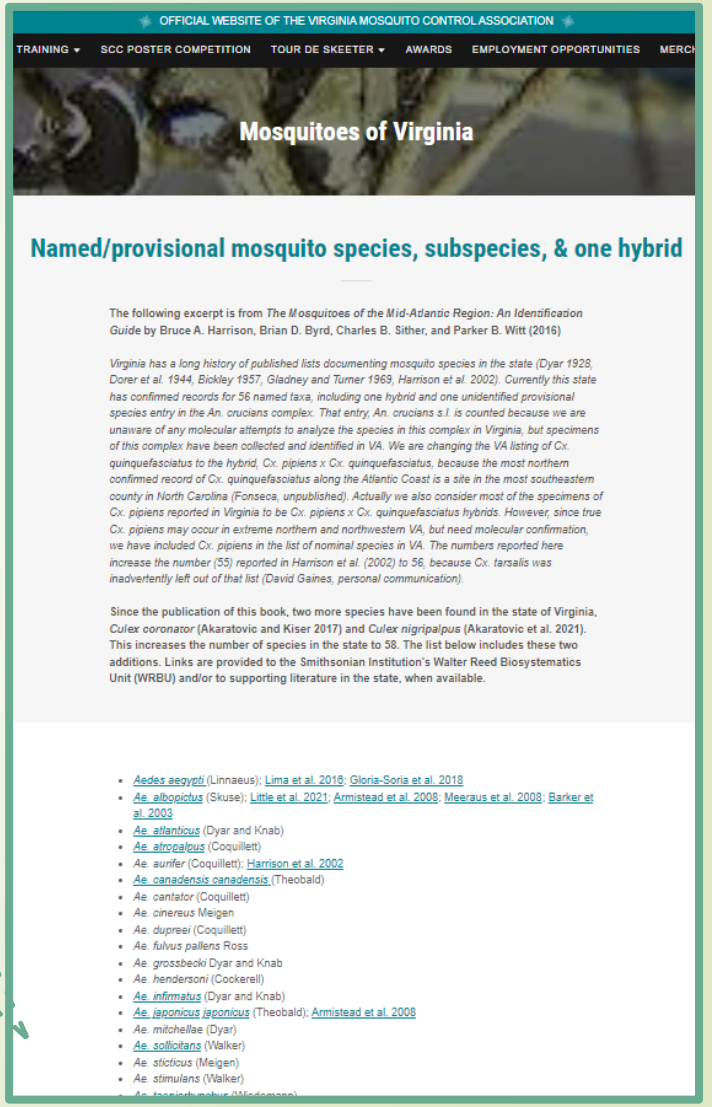
Publication December 2021

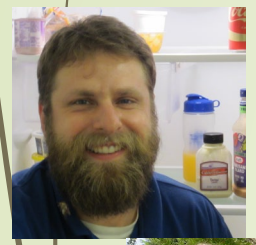
- Can also find the link on VMCA website
  - Mosquitoes of Virginia page
  - mosquito-va.org/mosquitoes-of-virginia

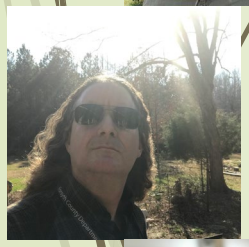
- *Coquillettidia perturbans* (Walker)
- *Culex coronator* Dyar and Knab; Akaratovic & Kiser 2017
- *Cx. erraticus* (Dyar and Knab)
- *Cx. nigripalpus* Theobald; Akaratovic et al. 2021
- *Cx. peccator* Dyar and Knab
- *Cx. pipiens* Linnaeus; Khalil et al. 2021
- *Cx. pipiens* x *Cx. quinquefasciatus* hybrids



The Distribution Expansion of *Cx. nigripalpus*

Acknowledgements





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- City of Suffolk, VA field collections & funding
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- Personal Communication of Data
  - Charles Apperson, NC State University
  - Jeff Brown and Rick Hickman, Brunswick County, NC
  - Robert Collins and Neal Watson, Nash County, NC
  - Marie Hemmen and Jeff Suggs, New Hanover County, NC
  - Eugene McRoy, Beaufort County, NC
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Questions?

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