Journal of the American Mosquito Control Association, 37(1):1–9, 2021

DISTRIBUTION OF *CULEX CORONATOR* IN THE USA

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ABSTRACT. In 1920, *Culex coronator* was reported from San Benito, Texas, and later in Arizona, New Mexico, and Oklahoma. In 2005, this species was reported to be spreading across the southeastern USA. Now reported in 14 states, it has been found as far north as northern Oklahoma; Memphis, TN; and Suffolk, VA. The public health significance of *Cx. coronator* is not firmly established, even though it has been implicated as a potential vector of several arboviral diseases. This study aims to document additional *Cx. coronator* county-level records, to provide information about its continued expansion across the southern USA, and to provide a short research update into its vector potential. Data acquired through multistate collaborations and author collections resulted in 146 new county records from Alabama, Arkansas, Florida, Georgia, Louisiana, Mississippi, North Carolina, Oklahoma, South Carolina, and Texas. No new county records were presented for Arizona, New Mexico, Tennessee, or Virginia, which had previously reported this species. With these new data, this species has been documented in 386 counties in 14 states of the continental USA.

KEY WORDS Culicidae, habitat, mosquito, new records, surveillance

INTRODUCTION

The first collection of *Culex coronator* Dyar and Knab in the USA was made on August 21, 1920, by Harrison G. Dyar (1921) in San Benito, Cameron County, TX. Subsequently, it was reported from Arizona, Louisiana, New Mexico, and Oklahoma (Beyer 1923, King et al. 1942, Murphy 1953, Richards et al. 1956, Hill et al. 1958, Carpenter 1970, Wolff et al. 1975, Hayes et al. 1976, Jones et al. 1977), but it did not receive attention until 2005, when it was reported again in Louisiana (Debboun et al. 2005) and for the first time in Mississippi (Varnado et al. 2005). Over the next 12 years, it was reported in Alabama, Florida, Georgia, North Carolina, again in Oklahoma, South Carolina, Tennessee, and Virginia (Smith et al. 2006, McNelly et al. 2007, Kelly et al. 2008, Moulis et al. 2008, Noden et al. 2015, Harrison et al. 2016, Akaratovic and Kiser 2017, Trimm et al. 2017). In 2019, the Texas distribution records were updated (Sames et al. 2019), and additional records were published for Oklahoma (Bradt et al. 2019). No other new published county records were found for this species.

This study aims to document additional *Cx. coronator* county-level records, to provide information about its continued expansion across the southern USA, and to provide a short research update into its vector potential.

MATERIALS AND METHODS

Many of the collections were from routine surveillance programs conducted from May through October or in response to a nonroutine public health concern such as posthurricane or Zika vector surveillance. Other collections were made by authors in counties where routine surveillance was not conducted.

Adult collections were made with Biogents-Sentinel (BGS), gravid, or Centers for Disease Control and Prevention (CDC) light traps. Larval collections were made using cups, dippers, basters, or siphons. Collections, identifications, and reporting procedures were in accordance with individual state guidance. Independent collectors used Darsie and Ward (2005) and Carpenter and LaCasse (1955) for identifications.

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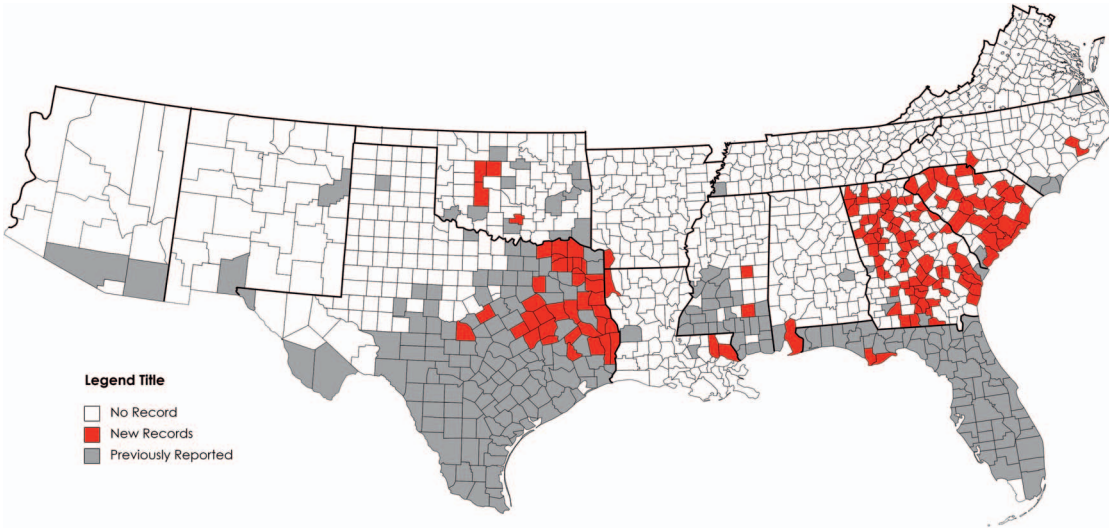

Fig. 1. Distribution of *Culex coronator* in the southern USA.

RESULTS

This study reports 146 new county records for *Cx. coronator* (Table 1) from Alabama (1), Arkansas (1), Florida (2), Georgia (71), Louisiana (3), Mississippi (2), North Carolina (2), Oklahoma (4), South Carolina (25), and Texas (35). No new records were reported from Arizona, New Mexico, Tennessee, or Virginia. Overall, *Cx. coronator* has been reported in 386 US counties across 14 states (Fig. 1).

Culex coronator has been collected January through December in at least the southern counties of Florida, Georgia, Louisiana, Mississippi, and Texas. The remaining states vary in seasonality in part due to a low number of collection events and due to potential unfavorable weather conditions during winter months. Studies following statistical protocols are needed to accurately measure and portray the development and seasonality of this species.

In the following paragraphs, details pertaining to the new county records for *Cx. coronator* are presented by state. All new records are listed in Table 1. The number and percentage of counties with reported collections of *Cx. coronator* and earliest and latest annual collections by state are reported in Table 2.

Alabama

Previously, *Cx. coronator* was reported from Mobile County (McNelly et al. 2007) and Macon County (Gray et al. 2008). On September 12, 2019, C*x. coronator* adults were collected in Baldwin County (Dan Killingsworth, personal communication). No other Alabama records were available for this report.

Arizona

Historically, Murphy (1953) reported 2 collections of *Cx. coronator* (as *Cx. coronata*) in Pima County. Richards et al. (1956) collected 1 larval *Cx. coronator* in Cochise County (St. David, October 22, 1953) and republished the 2 Pima County collections (Arivaca, June 17, 1934, 1 reared female, Coll. LP Wehrle, Det. A. Stone, and Santa Catalina Mountains, March 27, 1930, 1 reared female, Coll. LP Wehrle, Det. A. Stone), which are housed in the University of Arizona Insect Collection (UAIC). An additional 6 reared specimens (2 males, 4 females) from Pima County (Sabino Canyon, Santa Catalina Mountains, November 1, 1963, Coll. and Det. John Burger) are also in the UAIC.

Since its construction in 1996, some 178 *Cx. coronator* females were collected from the 60-acre Sweetwater Wetland, Tucson, AZ (Pima County), which is maintained by Tucson Water. Six CO_2 trap collections were run weekly from March through November, with most *Cx. coronator* being collected from September to November and some collected in March, April, May, and June. The earliest season collection date was March 15, 2017; the latest was November 28, 2012.

Additionally, 2 *Cx. coronator* larvae were collected in a dog's water bowl in Tucson in October 2000 as part of a student project and identified by Frank Ramberg.

Arkansas

On September 5, 2020, early instar *Cx. coronator* larvae were collected in a large ground pool from rains associated with Hurricane Laura in Texarkana, Miller County, AR, for the first report of this species in Arkansas. These larvae were reared to 4th instar (7 identified as larvae) or the adult stage (2 males, 3

females) for identification. In the same pool, *Psorophora columbiae* Dyar and Knab and *Aedes vexans* Meigen were collected in the pupal stage along with all instars of *Cx. nigripalpus* Theobald. The probability that *Cx. coronator* has been in Arkansas for many years is likely given that this species has been collected in states that border Arkansas, including Bowie County, TX (Hill et al. 1958), Shelby County, TN (Trimm et al. 2017), and Sequoyah and McCurtain counties, OK (Noden et al. 2015 and Bradt et al. 2019, respectively).

Florida

Connelly et al. (2016) presented collection data for 64 of the 67 counties in Florida. New records of *Cx. coronator* larvae collected in tires in Gulf and Franklin counties are reported. In Gulf County, the larvae were associated with *Ae. albopictus* (Skuse) and in Franklin County, they were associated with *Cx. quinquefasciatus* Say (Table 1). Monroe County is the only county without a confirmed presence of *Cx. coronator*. Staff members at the Florida Keys Mosquito Control District in Monroe County have not collected *Cx. coronator* in the Florida Keys and they do not survey the mainland area of Monroe County, which is primarily the Everglades National Park (Larry Hribar, personal communication).

Georgia

Prior to this study, *Cx. coronator* was reported from Baker, Chatham, Dougherty, Lowndes, and Muscogee counties (Kelly et al. 2008, Moulis et al. 2008, Buckner et al. 2011). Data from the Georgia Department of Public Health, health districts, county mosquito control districts, and other collaborators resulted in the detection of *Cx. coronator* in an additional 71 counties (Table 1). Gravid or CDC light traps were used to acquire these data, which resulted in the collection of 5,313 females during 892 adult collection events. No larval collections were reported.

Louisiana

Culex coronator were reported in Orleans Parish (Beyer 1923) and Vernon Parish (Hill et al. 1958), but these reports were negated by King et al. (1942) and Carpenter (1970), respectively. Later, Debboun et al. (2005) reported *Cx. coronator* in Vernon Parish, and Mackay et al. (2008) reported it in East Baton Rouge Parish. In addition to Vernon and East Baton Rouge parishes, this study reports 3 new parish records.

Culex coronator adults were collected in St. Tammany Parish in 181 trapping events using gravid and CDC light traps from 2013 to 2019 according to digital records. During these 7 years, 325 specimens (mean = 1.8 per trap; range = 1–8) were collected. Hard copy records prior to 2013 were not accessed (St. Tammany Parish Mosquito Abatement District, personal communication).

In Tangipahoa Parish, *Cx. coronator* and *Ae. albopictus* larvae were collected from a jon boat in a private yard on September 12, 2020.

During October 6–11, 2020, *Cx. coronator* larvae were collected at 4 of 6 locations in Shreveport, Caddo Parish, and identified by WJ Sames. The larvae were collected in a ground pool and in 3 separate tire piles. They were associated with *Ae. albopictus*, *Ae. vexans*, *Anopheles quadrimaculatus* Say, *Cx. nigripalpus*, *Cx. restuans* Theobald, *Cx. quinquefasciatus*, *Orthopodomyia signifera* (Coquillett), and *Ps. columbiae*. This was the first time *Or. signifera* was collected in association with *Cx. coronator*.

Mississippi

Previously, *Cx. coronator* had been reported in 28 counties (Varnado et al. 2005, Goddard et al. 2006, Varnado et al. 2012, Skiff and Yee 2014, Varnado and Goddard 2015, Yee et al. 2015, Goddard et al. 2017). Data from the Mississippi Department of Health's mosquito-borne disease surveillance program resulted in the detection of *Cx. coronator* in Jones and Neshoba counties.

New Mexico

Culex coronator were reported in Dona Ana County (Wolff et al. 1975) and Quay County (Jones et al. 1977). No new records or collections of *Cx. coronator* in New Mexico are reported here.

North Carolina

In North Carolina, Harrison et al. (2016) reported *Cx. coronator* in Brunswick and New Hanover counties and Brown et al. (2017) reported it in Columbus County. This study reports 2 new county records: Craven and Mecklenburg counties. The separation of the southeastern cluster of Brunswick, New Hanover, and Columbus counties from the eastern Craven County and more central Mecklenburg County suggest this species may be more widespread throughout the eastern half of the state.

Oklahoma

Prior to this study, *Cx. coronator* were reported from 12 counties (Hayes et al. 1976, Paras et al. 2014, Noden et al. 2015, Bradt et al. 2018, 2019). In July–August 2020, *Cx. coronator* were collected at 14 CDC light trap sites, which resulted in 4 new county records: Blaine, Caddo, Kingfisher, and Murray counties.

South Carolina

Moulis et al. (2008) collected *Cx. coronator* in Jasper County for the first record of this species in

Table 1. New county-level records for *Culex coronator* in the USA.

State	County	City or location	Date	Collector
AL	Baldwin	Fairhope	Sep 12, 2019	Killingsworth D
AR	Miller	Texarkana	Sep 05, 2020	Sames WJ
FL	Franklin	Eastpoint	Sep 12, 2020	Riles MT
FL	Gulf	Honeyville	Jul 08, 2020	Riles MT
GA	Atkinson	Axson	Aug 14, 2018	Georgia Dept of Public Health
GA	Bacon	Alma	Aug 09, 2018	Georgia Dept of Public Health
GA	Baldwin	Milledgeville	Aug 19, 2016	Georgia Dept of Public Health
GA	Banks	Commerce	May 15, 2020	Georgia District 2 Public Health, Environ. Health
GA	Ben Hill	Fitzgerald	Sep 20, 2018	Georgia District 8-1 Public Health, Environ. Health
GA	Berrien	Nashville	Sep 07, 2018	Georgia District 8-1 Public Health, Environ. Health
GA	Bibb	Macon	Aug 19, 2016	Georgia Dept of Public Health
GA	Brooks	Quitman	Sep 26, 2018	Georgia District 8-1 Public Health, Environ. Health; VSU
GA	Bryan	Richmond Hill	Jun 28, 2017	Georgia Dept of Public Health
GA	Bulloch	Statesboro	Sep 14, 2007	Georgia Dept of Public Health
GA	Carroll	Whitesburg	Sep 09, 2020	Georgia Dept of Public Health
GA	Chattooga	Summerville	Jun 18, 2019	Georgia District 1-1 Public Health, Environ. Health
GA	Clarke	Athens	Aug 07, 2019	Georgia District 10 Public Health, Environ. Health
GA	Clayton	Jonesboro	Sep 17, 2019	Georgia Dept of Public Health
GA	Cobb	Powder Springs	Sep 08, 2017	Georgia Dept of Public Health
GA	Cook	Adel	Sep 26, 2018	Georgia District 8-1 Public Health, Environ. Health
GA	Coweta	Newnan	Sep 09, 2020	Georgia Dept of Public Health
GA	Crisp	Cordele	Aug 07, 2019	Georgia Dept of Public Health
GA	Dawson	Dawsonville	Aug 03, 2017	Georgia District 2 Public Health, Environ. Health
GA	Dodge	Rhine	Sep 14, 2018	Georgia Dept of Public Health
GA	Echols	Statenville	Sep 27, 2018	Georgia District 8-1 Public Health, Environ. Health
GA	Elbert	Elberton	Oct 13, 2020	Georgia District 1-2 Public Health, Environ. Health
GA	Evans	Claxton	Aug 16, 2018	Georgia Dept of Public Health
GA	Fayette	Fayetteville	Aug 12, 2020	Georgia Dept of Public Health
GA	Floyd	Rome	Jun 13, 2019	Georgia District 1-1 Public Health, Environ. Health
GA	Forsyth	Cumming	May 24, 2019	Georgia District 2 Public Health, Environ. Health
GA	Franklin	Lavonia	May 31, 2018	Georgia District 2 Public Health, Environ. Health
GA	Fulton	Atlanta	Aug 18, 2017	Clarke/Fulton Co. Board of Health, Environ. Health. Serv.
GA	Glascock	Gibson	May 07, 2019	Richmond Co. Public Health, Mosquito Control Div.
GA	Glynn	Jekyll Island	Oct 31, 2017	Mosquito Control Serv, Glynn Co. Public Works
GA	Gordon	Fairmont	Jun 13, 2019	Georgia District 1-1 Public Health, Environ Health
GA	Gwinnett	Suwanee	Sep 12, 2016	Georgia Dept of Public Health
GA	Hall	Gainesville	Aug 06, 2019	Georgia District 2 Public Health, Environ. Health
GA	Houston	Warner Robins	Aug 19, 2016	Georgia Dept of Public Health
GA	Irwin	Ocilla	Sep 26, 2018	Georgia District 8-1 Public Health, Environ. Health
GA	Jasper	Mansfield	Aug 15, 2012	Georgia Dept of Public Health
GA	Jenkins	Millen	Dec 06, 2017	Richmond Co. Public Health, Mosquito Control Div.
GA	Jones	Gray	Sep 26, 2016	Georgia Dept of Public Health
GA	Lanier	Lakeland	Oct 17, 2018	Georgia District 8-1 Public Health, Environ. Health
GA	Laurens	Dublin	Aug 14, 2017	Georgia Dept of Public Health
GA	Lee	Leesburg	Jul 12, 2017	Georgia Dept of Public Health
GA	Liberty	Hinesville	Sep 10, 2011	Georgia Dept of Public Health
GA	Lincoln	Lincolnton	Jun 18, 2019	Richmond Co. Public Health, Mosquito Control Div.
GA	Long	Hinesville	Sep 19, 2008	Georgia Dept of Public Health
GA	Lumpkin	Cleveland	Jul 10, 2019	Georgia District 2 Public Health, Environ. Health
GA	Marion	Buena Vista	Aug 12, 2020	Georgia Dept of Public Health
GA	McIntosh	Townsend	Jul 16, 2020	Georgia Dept of Public Health
GA	Meriwether	Greenville	Oct 13, 2020	Georgia Dept of Public Health
GA	Mitchell	Camilla	Oct 12, 2018	Georgia Dept of Public Health
GA	Montgomery	Uvalda	Aug 28, 2018	Georgia Dept of Public Health
GA	Murray	Chatsworth	Aug 24, 2017	Georgia District 1-2, Public Health, Environ. Health
GA	Newton	Covington	Aug 24, 2017	Georgia Dept of Public Health
GA	Oglethorpe	Winterville	Sep 13, 2019	Georgia District 10. Public Health, Environ. Health
GA	Paulding	Dallas	Jun 25, 2019	Georgia District 1-1, Public Health, Environ. Health
GA	Peach	Fort Valley	Sep 27, 2016	Georgia Dept of Public Health
GA	Pickens	Talking Rock	Sep 24, 2020	Georgia District 1-2, Public Health, Environ. Health
GA	Pike	Concord	Oct 13, 2020	Georgia Dept of Public Health
GA	Putnam	Eatonton	Sep 26, 2016	Georgia Dept of Public Health
GA	Richmond	Augusta	Mar 30, 2016	Richmond Co. Public Health, Mosquito Control Div.

Table 1. Continued.

State	County	City or location	Date	Collector
GA	Rockdale	Conyers	Jul 29, 2020	Georgia Dept of Public Health
GA	Schley	Ellaville	Aug 18, 2020	Georgia Dept of Public Health
GA	Spalding	Griffin	Aug 26, 2020	Georgia Dept of Public Health
GA	Talbot	Talbotton	Aug 28, 2020	Georgia Dept of Public Health
GA	Telfair	McRae	May 24, 2017	Georgia Dept of Public Health
GA	Thomas	Thomasville	Jun 19, 2020	Georgia Dept of Public Health
GA	Tift	East Tifton	Sep 20, 2018	Georgia District 8-1, Public Health, Environ. Health
GA	Toombs	Lyons	Ju 14, 2017	Georgia Dept of Public Health
GA	Turner	Ashburn	Sep 26, 2018	Georgia District 8-1, Public Health, Environ. Health
GA	Walker	LaFayette	Jun 18, 2019	Georgia District 1-1, Public Health, Environ. Health
GA	Walton	Loganville	Oct 27, 2016	Georgia District 10, Public Health, Environ. Health
GA	Wilcox	Abbeville	Sep 14, 2018	Georgia Dept of Public Health
LA	Caddo	Shreveport	Oct 11, 2020	Desha DL, Desha MB
LA	St. Tammany	multiple locations	Jul 29, 2013	St. Tammany Mosquito Abatement
LA	Tangipahoa	Kentwood	Sep 12, 2020	Day W, Killingsworth D
MS	Jones	Choctaw Indian Reservation	Jul 26, 2019	Mississippi Dept of Health
MS	Neshoba	Philadelphia	Oct 30, 2016	Mississippi Dept of Health
NC	Craven	New Bern	Apr 17, 2018	Craven Co. Mosquito Control
NC	Mecklenburg	Charlotte	Sep 08, 2017	Mecklenburg Co. Mosquito Control
OK	Blaine	Watonga	Jul 24, 2020	Maichak C
OK	Caddo	Binger	Jul 30, 2020	Maichak C
OK	Kingfisher	Okeene	Aug 07, 2020	Maichak C
OK	Murray	Joy	Aug12, 2020	Maichak C
SC	Aiken	Aiken	Sep 22, 2015	SCDHEC Aiken Co.
SC	Anderson	Anderson	Oct 18, 2017	SCDHEC Anderson Co.
SC	Beaufort	Bluffton	Sep 10, 2008	Beaufort Co. Mosquito Control
SC	Berkeley	Moncks Corner	Jul 13, 2016	Santee Cooper Vector Management
SC	Charleston	Charleston	Sep 12, 2012	Charleston Co. Mosquito Control
SC	Clarendon	Summerton	Nov 18, 2015	Santee Cooper Vector Management
SC	Colleton	Cottageville	Sep 20, 2017	SCDHEC Central Office
SC	Darlington	Hartsville	Sep 16, 2020	City of Hartsville
SC	Dorchester	Summerville	Aug 31, 2016	SCDHEC Central Office
SC	Florence	Florence	Aug 17, 2017	Florence Co. Environ. Serv
SC	Georgetown	Georgetown	Jul 20, 2016	Georgetown Co. Mosquito Control
SC	Greenville	Greenville	Aug 09, 2017	SCDHEC Greenville Co.
SC	Greenwood	Greenwood	Sep 16, 2015	SCDHEC Greenwood Co.
SC	Horry	North Myrtle Beach	Jul 19, 2017	City of North Myrtle Beach
SC	Lancaster	Lancaster	Oct 19, 2016	SCDHEC Lancaster Co.
SC	Lexington	Lexington	Sep 27, 2016	SCDHEC Richland Co.
SC	Marion	Marion	Jul 19, 2016	SCDHEC Florence Co.
SC	Newberry	Newberry	Aug 16, 2017	City of Newberry
SC	Oconee	Walhalla	Aug 16, 2017	SCDHEC Oconee Co.
SC	Orangeburg	Orangeburg	Aug 23, 2017	SCDHEC Orangeburg Co.
SC	Richland	Gadsden	Aug 28, 2008	SCDHEC Central Office
SC	Spartanburg	Spartanburg	Aug 16, 2017	SCDHEC Spartanburg Co.
SC	Sumter	Sumter	Sep 20, 2017	SCDHEC Sumter Co.
SC	Union	Jonesville	Sep 27, 2017	SCDHEC Spartanburg Co.
SC	York	Rock Hill	1Sep 15, 2017	SCDHEC Central Office
TX	Anderson	Palestine	Sep 04, 2020	Sames WJ
TX	Angelina	Diboll	Sep 03, 2020	Sames WJ
TX	Camp	Pittsburg (6.2 mi S)	Oct 02, 2020	Bosworth AB
TX	Cherokee	Jacksonville	Sep 04, 2020	Sames WJ
TX	Delta	Cooper	Sep 06, 2020	Sames WJ
TX	Falls	Marlin	Sep 09, 2020	Mann JG
TX	Fannin	Bonham	Sep 06, 2020	Sames WJ
TX	Franklin	Mount Vernon	Sep 06, 2020	Sames WJ
TX	Freestone	Teague	Oct 08, 2019	Sames WJ
TX	Hamilton	Hamilton	Oct 07, 2019	Sames WJ
TX	Harrison	Harleton (1.2 mi W)	Oct 02, 2020	Bosworth AB
TX	Hopkins	Sulphur Springs	Sep 06, 2020	Sames WJ
TX	Jasper	Jasper	Sep 17, 2017	TX DSHS
TX	Kaufman	Kaufman	Sep 18, 2020	Mann JG

Table 1. Continued.

State	County	City or location	Date	Collector
TX	Lamar	Paris	Sep 06, 2020	Sames WJ
TX	Leon	Centerville	Oct 23, 2019	Brazos Co. Health Dept
TX	Limestone	Groesbeck	Oct 19, 2019	Mann JG
TX	Madison	North Zulch	Oct 23, 2019	Brazos Co. Health Dept
TX	Marion	Jefferson	Sep 05 2020	Sames WJ
TX	Morris	Daingerfield	Oct 17, 2020	Bosworth AB
TX	Navarro	Corsicana	Oct 08, 2019	Sames WJ
TX	Newton	Burkeville	Sep 13, 2017	TX DSHS
TX	Panola	Carthage	Sep 04, 2020	Sames WJ
TX	Red River	Avery	Oct 16, 2020	Bosworth AB
TX	Robertson	Calvert	Oct 19, 2019	Mann JG
TX	Rusk	Henderson	Sep 04, 2020	Sames WJ
TX	Sabine	Bronson	Sep 04, 2020	Sames WJ
TX	San Augustine	Norwood	Sep 04, 2020	Sames WJ
TX	San Jacinto	Willis (10 mi E)	Sep 17, 2017	TX DSHS
TX	San Saba	San Saba	Oct 17, 2019	Sames WJ
TX	Shelby	Center	Sep 04, 2020	Sames WJ
TX	Titus	Pittsburg (9.2 mi E)	Oct 02, 2020	Bosworth BA
TX	Trinity	Trinity	Sep 03, 2020	Sames WJ
TX	Tyler	Rockland	Sep 04, 2020	Sames WJ
TX	Upshur	Gladewater (1.9 mi W)	Sep 05, 2020	Sames WJ

South Carolina. County surveillance samples submitted to the South Carolina Department of Health and Environmental Control (SCDHEC) resulted in 25 additional county records: Aiken, Anderson, Beaufort, Berkeley, Charleston, Clarendon, Colleton, Darlington, Dorchester, Florence, Georgetown, Greenville, Greenwood, Horry, Lancaster, Lexington, Marion, Newberry, Oconee, Orangeburg, Richland, Spartanburg, Sumter, Union, and York. The adult samples were collected using BGS, gravid, and CDC light traps.

Tennessee

Trimm et al. (2017) reported *Cx. coronator* in Shelby County, TN. While no new county records of *Cx. coronator* in Tennessee were reported, Andrew Insch (personal communication) reported that *Cx. coronator* were not found in 2018–2019, but collected again in October 2020 when *Cx. coronator* larvae were found at 2 locations. Of 49 collection events (2017, 2020), 48 were larval collections associated with ground pools (natural and concrete

Table 2. Number and percent of counties with reported collections of *Cx. coronator* and earliest and latest annual collections by state.

State (No. counties)	No. counties with *Cx. coronator* (%)	Earliest annual collection date[3]	Latest annual collection date[3]
Alabama (67)	3 (4.48)	Sep 13	Nov 01
Arizona (15)	2 (13.33)	Mar 15	Nov 28
Arkansas (75)	1 (1.33)	Sep 05	Sep 05
Florida (67)	66 (98.51)	Jan 08	Dec 14
Georgia (159)	77 (48.42)	Jan 03	Dec 17
Louisiana (64)[1]	5 (7.81)	Jan 03	Dec 14
Mississippi (82)	30 (36.60)	Jan 06	Dec 22
New Mexico (33)	2 (6.06)	Jul 28	Sep 12
North Carolina (100)	5 (5.00)	Feb 20	Oct 30
Oklahoma (77)	16 (20.78)	May 21	Sep 20
South Carolina (46)	26 (56.52)	Mar 09	Nov 18
Tennessee (95)	1 (1.05)	Aug 14	Oct 26
Texas (254)	162 (63.78)	Jan 05	Dec 31
Virginia (133)[2]	1 (0.75)	Nov 01	Nov 16

[1] Louisiana follows a parish system of political subdivisions, which function like counties.
[2] Virginia is comprised of 95 counties and 38 independent cities.
[3] Range of dates based upon the following number of total collection events in each state. AL = 6, AR = 1, AZ = 5, FL = 66, GA = 892, LA = 197, MS = 634, NM = 4, NC = 65, OK = 50, SC = 177, TN = 49, TX = 9831, VA = 2. States with few data (AR, AZ, NM, TN, VA) depict the narrowest seasonal range; monthly surveillance results from those states would increase the reliability of when this species might be collected in their state. Seasonal date ranges may not apply across an entire state.

ditches, and around culverts). The larval collections were identified as larvae, and the *Cx. coronator* larvae were associated with larvae of *Ae. albopictus*, *Cx. erraticus* (Dyar and Knab), *Cx. pipiens/quinquefasciatus*, *Cx. restuans*, *Cx. salinarius* Coquillett, *Cx. territans* Walker, *Ps. columbiae*, and *Ps. ferox* (von Humboldt).

Texas

Sames et al. (2019) reported 127 historical and new *Cx. coronator* records in Texas. Since then, data for 35 new county records were acquired, of which 30 were larval collections, 2 were light trap collections by the Brazos County Health Department, and 3 were light trap collections by Clarke Mosquito Control, St. Charles, IL, under contract to the Texas Department of State Health Services after Hurricane Harvey in 2017 (Whitney Qualls, personal communication). In 2019–2020, *Cx. coronator* larval collections (n = 157; 30 were records plus 127 other collections) were from ground pools (97, which included roadside ditches, flooded depressions in fields, areas around leaking pipes or overflowing water troughs), water troughs (concrete [11], metal [8], plastic [5]), tires (17), plastic tubs (12), steel barrels (4), abandoned swimming pools (2), and a steel wheelbarrow (1). These author collections were in the eastern half of Texas and not limited to the counties with new records of this species.

Except for *Ae. trivittatus* (Coquillett), the 22 species reported by Sames et al. (2019) were collected in association with *Cx. coronator* larvae. Additionally, 8 new larval associates were collected. These were *Ae. bimaculatus* (Coquillett), *Ae. taeniorhynchus* (Wiedemann), *Cx. erraticus*, *Cx. pilosus* (Dyar and Knab), *Ps. cyanescens* (Coquillett), *Ps. longipalpus* Randolph and O'Neill, *Ps. signipennis* (Coquillett), and *Uranotaenia anhydor syntheta* Dyar and Shannon.

Virginia

Akaratovic and Kiser (2017) reported *Cx. coronator* in the independent City of Suffolk for the first record of this species in Virginia. In addition to this collection, Karen Akaratovic (personal communication) reported a second BG-Sentinel trap collection of 1 female *Cx. coronator* in Suffolk on November 16, 2020. These data suggest *Cx. coronator*, if not established, is still making seasonal incursions into the state.

DISCUSSION

The collection of *Cx. coronator* in 146 additional counties (total = 386) in the continental USA is documented in this paper. These collections suggest that this species is well established across the southern states (Alabama, Florida, Georgia, Louisiana, Mississippi, South Carolina, Texas). States to the north of these (Arkansas, North Carolina, Oklahoma, Tennessee, Virginia) may be in a unique situation to study the northern limits of this species, and states along the western edge (Arizona, New Mexico, Oklahoma, Texas) of the *Cx. coronator* geographic range can study its northern and western expansion into arid ecosystems.

As the range of *Cx. coronator* has expanded at a surprisingly rapid rate in the USA, including in major metropolitan areas, more studies are needed to clarify the vector competency of *Cx. coronator* and its potential to act as a bridge vector for arboviruses. Although historically *Cx. coronator* has not been linked to outbreaks of human disease, arboviruses of medical relevance have been identified in field collected *Cx. coronator* adults. Examples include isolation of St. Louis virus (SLV) from a field specimen in Trinidad (Aitken et al. 1964), West Nile virus (WNV) from specimens in Louisiana (Mackay et al. 2008, Unlu et al. 2010), and Zika virus detected in salivary glands of *Cx. coronator* collected near Guadalajara, Mexico (Elizondo-Quiroga et al. 2018). In the latter study, Zika was found in female and male specimens, leading the authors to suggest that vertical transmission is possible. Laboratory experiments have demonstrated susceptibility of *Cx. coronator* to viral infection of both SLV and WNV. In the former case, transmission of SLV to chickens occurred 8–10 days after a suspension of the virus was fed to females (Hammon and Reeves 1943a, 1943b). In the latter, WNV dissemination rates were noted to be comparable to those of other *Culex* vectors, while transmission rates were lower under the conditions examined (Alto et al. 2014). A recent study (Miranda et al. 2019) reported the presence of *Culex* Flavivirus (CxFV) in *Cx. coronator* pools from Colombia. Although insect-specific flaviviruses do not cause disease in humans, their presence can potentially block infection by other flaviviruses of public health importance (Burivong et al. 2004, Kent et al. 2010).

Culex coronator females have been characterized as preferring mammalian hosts (Mackay et al. 2010). Notably, a recent report (Mann et al. 2020) identified chickens and white-winged doves in *Cx. coronator* bloodmeals from Harris County, TX, indicating that this species may feed opportunistically, perhaps varying with seasonal host availability. Added to this, *Cx. coronator* may also be a vector of avian malaria (Noden et al. 2021). Like *Ae. aegypti* (L). and *Ae. albopictus*, *Cx. coronator* appears to be adaptable to artificial container breeding (Yee 2012, Yee and Skiff 2014, Skiff and Yee 2015), implying that the prospects for its control in urban areas could be quite challenging.

Looking for this and other mosquito species in previously unreported areas and habitats is encouraged in order to improve mosquito distributional information and help provide a baseline from which species movement can be observed and monitored. Studies designed to determine factors related to its development and other bionomical factors are needed

to understand and predict the geographic range of *Cx. coronator*. States should continue to report the distribution of *Cx. coronator* to help determine the spread and limits of this species.

ACKNOWLEDGMENTS

The authors thank the many participants in county, university, and other surveillance programs that indirectly impacted this study as they worked diligently to protect the people in their communities. The authors also thank the following for their support of this study: Karen Akaratovic, Suffolk Mosquito Control, Whitney Qualls (former TX DSHS Entomologist), Nicolas DeLisi and staff (St. Tammany Parish, LA), David and Margaret Desha, David Gaines (Virginia Department of Health), Wesley E. Hall, University of Arizona Insect Collection, Andrew Insch, James Washington, and Adrianna Sharkey (Shelby County Vector Control, Shelby, TN), Herff Jones (AMCA South Central Regional Director), Margaret Snyder, Tucson Water, and the Vector Control staff of the Brazos County Health Department. The authors also thank the property owners or managers who granted permission to collect mosquito larvae on their property. The authors thank mapchart.net for allowing access and use of their online mapping capabilities in the creation of Fig. 1.

REFERENCES CITED

Aitken THG, Downs WG, Spence L, Jonkers AH. 1964. St. Louis encephalitis virus isolations in Trinidad, West Indies, 1953-1962. *Am J Trop Med Hyg* 13:450–451.

Akaratovic KI, Kiser JP. 2017. First record of *Culex coronator* in Virginia, with notes on its rapid dispersal, trapping methods, and biology. *J Am Mosq Control Assoc* 33:225–228.

Alto BW, Connelly CR, O'Meara GF, Hickman D, Karr N. 2014. Reproductive biology and susceptibility of Florida *Culex coronator* to infection with West Nile virus. *Vector-borne Zoonotic Dis* 14:606–614.

Beyer GE. 1923. Mosquitoes of Louisiana. *LA State Bd Health Quarterly Bull* 14:54–84, illus.

Bradt D, Coburn L, Bradley KK, Noden BH. 2018. First record of *Aedes japonicus* in Oklahoma, 2017. *J Am Mosq Control Assoc* 34:38–41.

Bradt D, Wormington JD, Long JM, Hoback WW, Noden BH. 2019. Differences in mosquito communities in six cities in Oklahoma. *J Med Entomol* 56:1395–1403.

Brown J, White A, Hickman R, Hemmen M, Bunn J. 2017. The seasonal distribution of *Culex coronator* in southeast North Carolina in 2016, an operational perspective. *The Biting Times* March 2017:7–10.

Buckner EA, Blackmore MS, Golladay SW, Covich AP. 2011. Weather and landscape factors associated with adult mosquito abundance in southwestern Georgia, USA. *J Vector Ecol* 36:269–278.

Burivong P, Pattanakitsakul SN, Thongrungkiat S, Malasit P, Flegel TW. 2004. Markedly reduced severity of dengue virus infection in mosquito cell cultures persistently infected with *Aedes albopictus* densovirus (AalDNV). *Virology* 329:261–269.

Carpenter SJ. 1970. Review of recent literature on mosquitoes of North America. *California Vector Views* 17:39–65.

Carpenter SJ, LaCasse WJ. 1955. *Mosquitoes of North America (North of Mexico)*. Berkeley and Los Angeles, CA: University of California Press, 360 pp.

Connelly CR, Alto BW, O'Meara GF. 2016. The spread of *Culex coronator* (Diptera: Culicidae) throughout Florida. *J Vector Ecol* 41:195–199.

Darsie RF, Ward RA. 2005. *Identification and geographic distribution of the mosquitoes of North America, north of Mexico*. Gainesville, FL: University Press of Florida, 384 pp.

Debboun M, Kuhr DD, Rueda EM, Pecor JE. 2005. First record of *Culex (Culex) coronator* in Louisiana, USA. *J Am Mosq Control Assoc* 21:455–457.

Dyar HG. 1921. Ring-legged *Culex* in Texas (Diptera, Culicidae). *Ins Ins Mens* 9:32–34.

Elizondo-Quiroga D, Medina-Sánchez A, Sánchez-González JM, Eckert KA, Villalobos-Sánchez E, Navarro-Zúñiga AR, Sánchez-Tejeda G, Correa-Moraleș F, González-Acosta C, Arias CF, López S, Del Ángel RM, Pando-Robles V, Elizondo-Quiroga AE. 2018. Zika virus in salivary glands of five different species of wild-caught mosquitoes from Mexico. *Sci Rep* 16:809.

Goddard J, Moraru GM, Mcinnis SJ, Portugal III JS, Yee DA, Deerman JH, Varnado W. 2017. A statewide survey for container-breeding mosquitoes in Mississippi. *J Am Mosq Control Assoc* 33:229–232.

Goddard J, Varnado WC, Harrison BA. 2006. Notes on the ecology of *Culex coronator* Dyar and Knab, in Mississippi. *J Am Mosq Control Assoc* 22:622–625.

Gray KM, Burkett-Cadena ND, Eubanks MD. 2008. Distribution expansion of *Culex coronator* in Alabama. *J Am Mosq Control Assoc* 24:585–587.

Hammon WM, Reeves WC. 1943a. Laboratory transmission of St. Louis encephalitis virus by three genera of mosquitoes. *J Exper Med* 78:241–253.

Hammon WM, Reeves WC, Gray M. 1943b. Mosquito vectors and inapparent animal reservoirs of St. Louis and western equine encephalitis viruses. *Am J Pub Health* 33:201–207.

Harrison BA, Byrd BD, Sither CB, Whitt PB. 2016. *The mosquitoes of the mid-Atlantic region: an identification guide*. Cullowhee, NC: Western Carolina University, 201 pp.

Hayes RO, Francy DB, Lazuick JS, Smith GC, Jones RH. 1976. Arbovirus surveillance in six states during 1972. *Am J Trop Med Hyg* 25:463–476.

Hill SO, Smittle BJ, Philips FM. 1958. Distribution of mosquitoes in the Fourth U.S. Army area. Fort Sam Houston, TX: Entomology Division, Fourth U.S. Army Med Lab, 155 pp.

Jones RH, Hayes RO, Potter HW Jr, Francy DB. 1977. A survey of biting flies attacking equines in three states in the southwestern United States. *J Med Entomol* 14:441–447.

Kelly R, Mead D, Harrison BA. 2008. Discovery of *Culex coronator* Dyar and Knab (Diptera: Culicidae) in Georgia. *Proc Entomol Soc Wash* 110:258–260.

Kent RJ, Crabtree MB, Miller BR. 2010. Transmission of West Nile virus by *Culex quinquefasciatus* Say infected with *Culex* Flavivirus Izabal. *PLoS Negl Trop Dis* 4:e671.

King WV, Bradley GH, McNeel TE. 1942. The mosquitoes of the Southeastern States. US Dept Agr Misc Pub 336.

Mackay AJ, Kramer WL, Meece JK, Brumfield RT, Foil LD. 2010. Host feeding patterns of *Culex* mosquitoes (Diptera: Culicidae) in East Baton Rouge Parish, Louisiana. *J Med Entomol* 47:238–248.

Mackay AJ, Roy A, Yates MM, Foil LD. 2008. West Nile Virus detection in mosquitoes in East Baton Rouge Parish, Louisiana, from November 2002 to October 2004. *J Am Mosq Control Assoc* 24:28–35.

Mann JG, Washington M, Guynup T, Tarrand C, Dewey EM, Fredregill C, Duguma D, Pitts RJ. 2020. Feeding habits of vector mosquitoes in Harris County, TX, 2018. *J Med Entomol* 57:1920–1929.

McNelly JR, Smith M, Micher-Stevens KM, Harrison B. 2007. First record of *Culex coronator* from Alabama. *J Am Mosq Control Assoc* 23:473–475.

Miranda J, Mattar S, Gonzalez M, Hoyos-López R, Aleman A, Aponte J. 2019. First report of *Culex* flavivirus infection from *Culex coronator* (Diptera: Culicidae), Colombia. *Virol J* 16:1.

Moulis RA, Russell JD, Lewandowski HB Jr, Thompson PS, Heusel JL. 2008. *Culex coronator* in coastal Georgia and South Carolina. *J Am Mosq Control Assoc* 24:588–590.

Murphy DR. 1953. Collection records of some Arizona mosquitoes (Diptera: Culicidae). *Entomol News* 64:233–238.

Noden BH, Bradt DL, Sanders JD. 2021. Mosquito-borne parasites in the Great Plains: searching for vectors of nematodes and avian malaria parasites. *Acta Trop* 213:105735.

Noden BH, Coburn L, Wright R, Bradley K. 2015. An updated checklist of the mosquitoes of Oklahoma including new state records and West Nile virus vectors, 2003-2006. *J Am Mosq Control Assoc* 31:336–345.

Paras KL, O'Brien VA, Reiskind MH. 2014. Comparison of the vector potential of different mosquito species for the transmission of heartworm, *Dirofiliaria immitis*, in rural and urban areas in and surrounding Stillwater, Oklahoma, U.S.A. *Med Vet Entomol* 28:60–70.

Richards C S, Nielsen LT, Rees DM. 1956. Mosquito records from the great basin and drainage of the lower Colorado River. *Mosquito News* 16:10–17.

Sames WJ, Dacko NM, Bolling BG, Bosworth AB, Swiger SL, Duhrkopf RE, Burton RG. 2019. Distribution of *Culex coronator* in Texas. *J Am Mosq Control Assoc* 35:55–64.

Skiff JJ, Yee DA. 2014. Behavioral differences among four co-occurring species of container mosquito larvae: effects of depth and resource environments. *J Med Entomol* 51:375–381.

Skiff JJ, Yee DA. 2015. The effects of protozoans on larval container mosquito performance. *Annals Entomol Soc Am* 108:282–288.

Smith JP, Walsh JD, Cope EH, Tennant RA Jr, Kozak JA III, Darsie RF Jr. 2006. *Culex coronator* Dyar and Knab: a new Florida species record. *J Am Mosq Assoc* 22:330–332.

Trimm A, Insch A, Carlson T. 2017. First record of *Culex coronator* in Shelby County, Tennessee. *J Am Mosq Control Assoc* 33:345–347.

Unlu I, Kramer WL, Roy AF, Foil LD. 2010. Detection of West Nile virus RNA in mosquitoes and identification of mosquito blood meals collected at alligator farms in Louisiana. *J Med Entomol* 47:625–633.

Varnado W, Goddard J. 2015. Abundance and diversity of mosquito species collected from a rural area of central Mississippi: implications for West Nile virus transmission in Mississippi. *J Am Mosq Control Assoc* 31:182–186.

Varnado WC, Goddard J, Harrison BA. 2005. New state record of *Culex coronator* Dyar and Knab (Diptera: Culicidae) from Mississippi. *Proc Entomol Soc Wash* 107:476–477.

Varnado WC, Goddard J, Harrison B. 2012. Identification guide to adult mosquitoes in Mississippi. Starkville, MS: Mississippi State University Extension Service.

Wolff TA, Nielsen LT, Hayes RO. 1975. A current list and bibliography of the mosquitoes of New Mexico. *Mosquito Systematics* 7:13–18.

Yee DA. 2012. Constitutive differences between natural and artificial container mosquito habitats: vector communities, resources, microorganisms, and habitat parameters. *J Med Entomol* 49:482–491.

Yee DA, Abuzeineh AA, Ezeakacha NF, Schelble SS, Glasgow WC, Flanagan SD, Skiff JJ, Reeves A, Kuehn K. 2015. Mosquito larvae in tires from Mississippi, United States: the efficacy of abiotic and biotic parameters in predicting spatial and temporal patterns of mosquito populations and communities. *J Med Entomol* 52:394–407.

Yee DA, Skiff JF. 2014. Interspecific competition of a new invasive mosquito, *Culex coronator*, and two container mosquitoes, *Aedes albopictus* and *Cx. quinquefasciatus* (Diptera: Culicidae), across different detritus environments. *J Med Entomol* 51:89–96.