

SCIENTIFIC NOTE

DISTRIBUTION OF *CULEX CORONATOR* IN TEXAS

WILLIAM J. SAMES,¹ NINA M. DACKO,² BETHANY G. BOLLING,³ ANTHONY B. BOSWORTH,⁴ SONJA L. SWIGER,⁵ R. E. DUHRKOPF⁶ AND ROY G. BURTON⁷

ABSTRACT. The distribution of *Culex coronator* Dyar and Knab by county in Texas was updated by combining data from peer-reviewed literature, military and government reports, and university and private collections, and by collecting specimens from counties where data had not been reported. With 254 counties in Texas, the initial collection effort was focused on counties east of US Highway 277, which runs from Val Verde County on the US and Mexico border to Wichita County on the Texas and Oklahoma border. The study resulted in 127 counties with *Cx. coronator* presence data. The remaining 127 counties need to be surveyed for this species.

KEY WORDS *Culex coronator*, distribution, habitats, mosquito, new records, Texas

In 2005, two publications (Debboun et al. 2005, Varnado et al. 2005) documented the presence of *Culex coronator* Dyar and Knab in Louisiana and Mississippi, respectively. These reports created an awareness of the eastern movement of this species. Over the next 12 years, new collection records, potential of medical importance, and biological observations were reported across the southeastern USA, including species documentation reports in Alabama (McNelly et al. 2007, Gray et al. 2008), Florida (Smith et al. 2006, Alto et al. 2014, Yee and Skiff 2014, Fulcher et al. 2015, Connelly et al. 2016), Georgia (Kelly et al. 2008, Moulis et al. 2008, Buckner et al. 2011, Botello et al. 2013, Rustin et al. 2017), Louisiana (Brauch 2008; Mackay et al. 2008, 2010; Unlu et al. 2009, 2010; Godsey et al. 2013), Mississippi (Goddard et al. 2006; Foppa et al. 2007; Varnado et al. 2012; Yee 2012; Skiff and Yee 2014, 2015; Varnado and Goddard 2015; Yee et al. 2015), North Carolina (Harrison et al. 2016, Brown et al. 2017), Oklahoma (Noden et al. 2015, Bradt 2017, Bradt et al. 2018), South Carolina (Moulis et al. 2008), Tennessee (Trimm et al. 2017), and Virginia (Akaratovic and Kiser 2017).

Prior to 2005, records for *Cx. coronator* in states other than Texas were reported in Cochise and Pima

Counties in Arizona (Richards et al. 1956) and in Dona Ana and Quay Counties in New Mexico (Wolff et al. 1975, Jones et al. 1977). Also, Eldridge et al. (1972) collected 408 *Cx. coronator* females at unspecified locations in Texas, Louisiana, Arkansas, or Oklahoma and tested 30 pools of *Cx. coronator* for eastern, Venezuelan, or western encephalitides. All pools were negative. Hayes et al. (1976) collected *Cx. coronator* from unspecified counties in Arizona, New Mexico, Oklahoma, and Texas. However, the article listed *Cx. coronator* collections by state and stated that *Cx. coronator* was a new species and record for Oklahoma. From their map, the collection appeared to occur in either Choctaw, Tulsa, or Wagoner County. Since Choctaw County is on the Oklahoma-Texas border and not far from the 1958 Bowie County, TX, record (Hill et al. 1958), it might have been the site for this collection.

Two prior reports of *Cx. coronator* in Louisiana were removed as state records. The first was when George L. Beyer reported the collection of several *Cx. coronator* larvae that were reared to the adult stage for identification in New Orleans (Beyer 1923). Unfortunately, the specimens were destroyed by book lice. King et al. (1942) believed the specimens were misidentified and removed *Cx. coronator* from Louisiana's species list. In retrospect, this could have been an unsuccessful introduction rather than a misidentification. Similarly, Hill et al. (1958) reported *Cx. coronator* from Fort Polk, LA. With no subsequent reports on this species from Louisiana, Carpenter (1970) recommended that it be removed from the Louisiana mosquito species list until additional samples could be collected. Darsie and Ward (1981, 2005) made the annotation "not in LA" and referenced Carpenter (1970) on their distribution map for *Cx. coronator*.

Dyar and Knab (1906) described *Cx. coronator* as a new species based upon specimens from Trinidad, Mexico, and Central America. Fourteen years later, Dyar (1921, 1922) reported the collection of *Cx.*

¹ US Army (retired), PO Box 547, Leakey, TX 78873.

² Environmental Health Division, Tarrant County Public Health, 1101 S. Main Street, Suite 2300, Fort Worth, TX 76104.

³ Arbovirus-Entomology Team, Laboratory Services Section, Texas Department of State Health Services, 1100 W. 49th Street, Austin, TX 78756.

⁴ US Army (retired), 13955 Beechwood Circle, Lindale, TX 75771-7703.

⁵ Texas A&M University, 1229 North US Highway 281, Stephenville, TX 76401.

⁶ Department of Biology, Baylor University, One Bear Place #97388, Waco, TX 76798.

⁷ Texas Department State Health Services (retired), 1464 Jordan Crossing, New Braunfels, TX 78130.

coronator larvae on August 21, 1920, in Cameron County, TX, for the first record of this species in the USA. Now, almost 99 years later, *Cx. coronator* appears to be a common species, especially in the eastern half of Texas.

In Texas, *Cx. coronator* has not been proven to be a major vector species, and it appears to rarely bite humans. Publications about Texas mosquitoes tend to focus on the major vector and nuisance species (e.g., *Cx. quinquefasciatus* Say, *Aedes aegypti* (L.), *Ae. albopictus* (Skuse), and *Psorophora* spp.), whereas surveillance and control for *Cx. coronator* have been a low priority. Another factor contributing to the lack of information regarding this species is the lack of mosquito surveillance activities in most Texas counties. Only a few counties have a mosquito control district, or some type of surveillance program, and these counties are mainly characterized by high human population densities. Hence, the presence of *Cx. coronator* in Texas is underreported, and it is severely underrepresented in distribution maps (Darsie and Ward 1981, 2005; Fournier et al. 1989).

This study established the presence of *Cx. coronator* in 127 of the 254 counties in Texas (Table 1 and Fig. 1). Fournier et al. (1989) was the last consolidated report on *Cx. coronator*, and they showed it to be in 20 counties. Since an adequate baseline was never established for this species in Texas, the results of this study should not be interpreted as recent movement of this species, but a reporting of what has probably been the presence of this species in these counties for an undetermined amount of time, perhaps decades.

In addition to the reports by Eldridge et al. (1972) and Hayes et al. (1976), a review of Texas-related mosquito studies, documents, and reports resulted in 40 mentions of *Cx. coronator*. *Culex coronator* was never the subject of these studies, but it normally was listed as an "other species collected." The paragraphs below chronologically identify the source and the county from which *Cx. coronator* occurrences were reported.

Dyar (1921, 1922) collected *Cx. coronator* larvae in Cameron County for the first record of this species in the USA. Fisk and Le Van (1940) used New Jersey light traps (LTs) to collect adult *Cx. coronator* individuals in Cameron County; Hammon and Reeves (1943) conducted laboratory transmission experiments on *Cx. coronator* females from Cameron County; Randolph and O'Neill (1944) provided general information on *Cx. coronator*; Thurman et al. (1945) reported larval (L) collections in Cameron and Hidalgo Counties; Rueger and Druce (1950) reported larval collections in Webb County; Eads et al. (1951) reported adult collections from New Jersey LTs in Dimmit and Starr Counties; McCleskey (1951) collected *Cx. coronator* larvae in Dallas County; and Beadle et al. (1957) collected *Cx. coronator* larvae. They also collected adults using New Jersey LTs, aspirators in resting locations

(animal shelters, garages, and outbuildings), and in human-baited landing-biting counts in Hidalgo County. In a military document, Hill et al. (1958) published the first by-county distribution maps of mosquito species in Texas. They showed *Cx. coronator* in 10 counties (Bexar, Bowie, Cameron, Dimmit, Hidalgo, Live Oak, Milam, Starr, Webb, and Willacy).

Eads and Strom (1957) listed *Cx. coronator* in a species list for Cameron County. Wiseman et al. (1959) collected *Cx. coronator* larvae in drainage ditches and adults using LTs, sweep nets, and by hand in Cameron County. Eads et al. (1961) collected larvae from fire barrels in Cameron County; Johnston et al. (1964) collected larvae in Cameron County; and Easton et al. (1968) collected adults using malaise and small mammal-baited traps in Presidio County.

Sudia et al. (1971) collected adults using Centers for Disease Control and Prevention (CDC) LTs in Nueces County; in this study, 2,753 *Cx. coronator* specimens tested negative for California Group arboviruses. The US Air Force Aerospace Medical Division (1971) collected adults using LTs in Webb County (Laredo Air Force Base); Olson (unpublished) reported the collection of adults with LTs in Cameron, Hidalgo, Webb, Brewster, and Presidio Counties; Suyemoto et al. (1973) conducted precipitin tests and found *Cx. coronator* individuals feeding on rabbits; Olson and Grimes (1974) collected adults using CDC LTs with dry ice in Brooks, Dimmit, Kenedy, Maverick, Starr, and Zapata Counties; *Cx. coronator* specimens in this study tested negative for St. Louis encephalitis, Western equine encephalitis, and Venezuelan equine encephalitis (VEE) viruses. Sudia et al. (1975) collected adults using CDC LTs with dry ice in Cameron and Hidalgo Counties; they pooled *Cx. coronator* specimens with other species, and all pools tested negative for VEE.

In a Texas Department of Health manual, Fournier and Snyder (1977) published the second by-county distribution maps of mosquito species in Texas. They showed *Cx. coronator* in 16 counties (Bexar, Bowie, Cameron, Dallas, Dimmit, El Paso, Hidalgo, Kleberg, Live Oak, Milam, Nolan, Presidio, San Patricio, Starr, Webb, Willacy). In this document, all San Patricio County records were attributed to Foley (unpublished data). Mosquito data for Foley (unpublished) and Johnson (1982) were provided by the Medical Zoology Branch, Medical Field Service School, Fort Sam Houston, TX, from 1965–70 collections at the Welder Wildlife Refuge in Sinton, TX (Anthony Bosworth, Ray Parsons, personal communication).

Jones et al. (1977) aspirated mosquitoes feeding on equines in Maverick County, and Ochoa and Biery (1978) listed US Air Force (USAF) adult collections in Bexar and Webb Counties, and Pinkovsky and McKenna (1980) listed *Cx. coronator* as being in Texas (Bexar and Webb Counties), Arizona, and New Mexico. Johnson (1982) presented a US Army list of mosquitoes collected in San Patricio County in

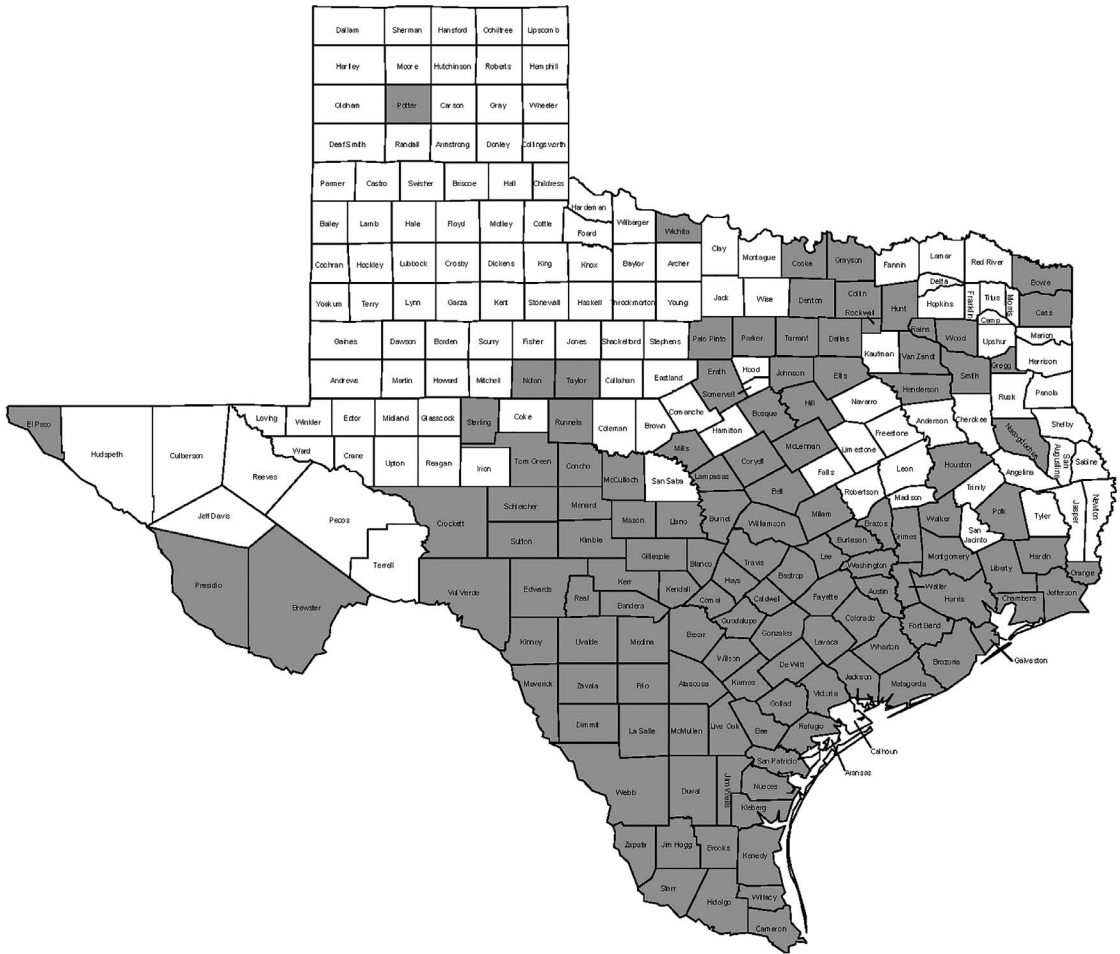


Fig. 1. By-county distribution of *Culex coronator* Dyar and Knab in Texas ($n = 127$ counties). Data were compiled from a review of literature and unpublished records, and from collections made during this study.

which *Cx. coronator* was listed; McHugh et al. (1987) presented USAF larval collections in Bexar and Travis Counties, and McHugh et al. (1988) presented additional USAF larval collections in Bexar County. Fournier et al. (1989) was an update to Fournier and Snyder (1977). They showed *Cx. coronator* in 20 counties, including the 16 counties from Fournier and Snyder (1977) plus Brewster, Orange, Tarrant, and Val Verde Counties.

Parsons (2003) reported collections of *Cx. coronator* adults in underground storm sewers with dry ice-baited CDC LTs in Harris County. Bolling et al. (2005) used CDC LTs with dry ice to collect adults in Denton County; McPhatter et al. (2009) collected an adult in an algae-infused gravid trap; McPhatter et al. (2012) reported larval and adult collections in Bexar County; and Nava and Debboun (2016) listed *Cx. coronator* as being collected in Harris County. Wise de Valdez (2017) collected *Cx. coronator* in Bexar County using CDC light and BG Sentinel traps.

The early reports of *Cx. coronator* in Louisiana (Hill et al. 1958), Oklahoma (Hayes et al. 1976), and Texas (Hill et al. 1958, Fournier and Snyder 1977, Fournier et al. 1989) suggest that *Cx. coronator* was already distributed throughout eastern Texas and at least making incursions into Louisiana and Oklahoma by the early 1970s, where it was not detected or reported until later (Debboun et al. 2005, Noden et al. 2015). The impact of weather on annual *Cx. coronator* populations has not been studied, but it may have played a role in limiting its population in eastern Texas, Oklahoma, and Louisiana and delaying its eastward and northern spread. The last mentions of *Cx. coronator* in New Mexico and Arizona were by Hayes et al. (1976) and Jones et al. (1977), and updates on the distribution of this species in those states would be of interest.

With 26 Texas county records reported in literature or reports (Table 1), the remaining 101 records came from the Texas Department of State Health Services (DSHS 2002–2017; 37 records),

Table 1. *Culex coronator* records for 127 of the 254 Texas counties by county, collector, date, and city.

County	Collector	Date/city
Aransas	DSHS ¹	2003
Atascosa	Sames WJ, Heimer H	July 7, 2017, Pleasanton
Austin	Sames WJ, Hogue S Jr	November 14, 2017, Bellville
Bandera	Sames WJ	July 7, 2017, Bandera
Bastrop	Sames WJ, Sames M	July 12, 2017, Bastrop
Bee	Sames WJ, Hogue S Jr	November 13, 2017, Beeville
Bell	DSHS	2003
Bexar	Hill et al. (1958)	<1958
Blanco	Sames WJ, DeLeon L	July 12, 2017, Blanco
Bosque	Swiger S	October 10, 2018, Clifton
Bowie	Hill et al. (1958)	<1958
Brazoria	DSHS	July 19, 2002
Brazos	DSHS	2003
Brewster	Olson (unpublished)	July 17, 1972
Brooks	Olson and Grimes (1974)	August 26, 1971
Burleson	DSHS	October 14, 2009, Somerville
Burnet	DSHS	August 15, 2013, Marble Falls
Caldwell	Sames WJ, Hogue S Jr	August 4, 2017, Lockhart
Calhoun	Sames WJ, Meyer R	June 29, 2018, Port Lavaca
Cameron	Dyar (1921)	August 21, 1920, San Benito
Cass	Bosworth A, Galloway F	September 6, 2017, Avinger
Chambers	DSHS	July 5, 2002
Collin	DSHS	2003
Colorado	Sames WJ, Hogue S Jr	November 14, 2017, Columbus
Comal	Sames WJ, Hogue S Jr	2017, New Braunfels
Concho	Sames WJ	November 10, 2017, Eden
Cooke	DSHS	September 27 2016, Gainesville
Coryell	DSHS	October 1, 2008, Fort Hood
Crockett	Sames WJ	November 9, 2017, Ozona
Dallas	McCleskey (1951)	<1951
Denton	Bolling et al. (2005)	June 14, 2002
Dewitt	Sames WJ, Hogue S Jr	November 13, 2017, Cuero
Dimmit	Eads et al. (1951)	May–October 1946
Duval	DSHS	2005
Edwards	Sames WJ, Hogue S Jr	August 2, 2017, Rocksprings
El Paso	Fournier and Snyder (1977)	<1977
Ellis	DSHS	2003
Erath	Dacko N, Swiger S	December 1, 2017, Stephenville
Fayette	Sames WJ, Hogue S Jr	November 14, 2017, Schulenburg
Fort Bend	DSHS	May 10, 2002
Frio	Sames WJ	October 30, 2017, Pearsall
Galveston	DSHS	June 8, 2003, San Leon
Gillespie	Sames WJ	August 28, 2017, Fredericksburg
Goliad	Sames WJ, Heimer H	July 8, 2017, Goliad
Gonzales	Breland OP	May 14, 1947, Palmetto St Park
Grayson	DSHS	June 19, 2017, Whitesboro
Gregg	DSHS	August 23, 2002
Grimes	Sames WJ, Sames M	July 13, 2017, Iola
Guadalupe	Sames WJ, Hogue S Jr	July 3, 2017, Seguin
Hardin	Burton R	October 8–16, 2005, Kountze
Harris	Parsons (2003)	2001, Houston
Hays	DSHS	July 22, 2015, Kyle
Henderson	DSHS	2003
Hidalgo	Eyles DE	August 18, 1943
Hill	Sames WJ	September 4, 2018, Hubbard
Houston	DSHS	2003
Hunt	DSHS	September 17, 2013, Commerce
Jackson	Sames WJ, Stafford B	June 29, 2018, Edna
Jefferson	DSHS	2004
Jim Hogg	Sames WJ, Hogue S Jr	November 13, 2017, Hebbronville
Jim Wells	Sames WJ, Hogue S Jr	November 13, 2017, Alice
Johnson	Tarrant County Public Health	September 29, 2015, Burleson
Karnes	Sames WJ, Heimer H	July 8, 2017, Karnes City
Kendall	Sames WJ	August 4, 2017, Boerne

Table 1. Continued.

County	Collector	Date/city
Kenedy	Olson and Grimes (1974)	August 26, 1971
Kerr	Sames WJ	July 21, 2017, Kerrville
Kimble	Sames WJ, Hogue S Jr	August 2, 2017, Junction
Kinney	Sames WJ, Grant E	September 1, 2017, Brackettville
Kleberg	Fournier and Snyder (1977)	<1977
La Salle	Sames WJ	October 30, 2017, Cotulla
Lampasas	Sames WJ	October 24, 2018, Lomita
Lavaca	Sames WJ, Hogue S Jr	November 14, 2017, Hallettsville
Lee	Sames WJ, Sames M	July 12, 2017, Giddings
Liberty	DSHS	July 5, 2002
Live Oak	Hill et al. (1958)	<1958
Llano	Sames WJ, Osbourne J	August 23, 2018, Llano
Mason	Sames WJ	August 23, 2018, Mason
Matagorda	Sames WJ	June 29, 2018, Bay City
Maverick	Breland OP	October 3, 1953, Quemado
McCulloch	Sames WJ	October 24, 2018, Brady
McLennan	Duhrkopf RE	September 4, 2003, Waco
McMullen	Sames WJ, Heimer H	July 8, 2017, Tilden
Medina	Sames WJ	July 21, 2017, Hondo
Menard	Sames WJ	November 10, 2017, Menard
Milam	Hill et al. (1958)	<1958
Mills	Sames WJ	October 24, 2018, Goldthwaite
Montgomery	DSHS	July 14, 2002
Nacogdoches	DSHS	2003
Nolan	Fournier and Snyder (1977)	<1977
Nueces	Sudia et al. (1971)	1971, Corpus Christi
Orange	Fournier et al. (1989)	<1989
Palo Pinto	Dacko N	September 30, 2017, Palo Pinto
Parker	Dacko N	September 30, 2017, Springtown
Polk	DSHS	2003
Potter	DSHS	2003
Presidio	Easton ER	July 24, 1966, Marfa
Rains	DSHS	2003
Real	Clancy T, Sames WJ	June 17, 2017, Leakey
Refugio	Sames WJ	June 28, 2018, Refugio & Woodsboro
Rockwall	DSHS	September 10, 2013, Royse City
Runnels	Sames WJ	November 10, 2017, Ballinger
San Patricio	Foley (1972)	<1972, Sinton
Schleicher	Sames WJ	November 9, 2017, Eldorado
Smith	DSHS	September 6, 2004
Starr	Eads et al. (1951)	<1951, April–August 1946
Sterling	Sames WJ	November 10, 2017, Sterling City
Sutton	Sames WJ, Whitworth S, Hernandez P	November 9, 2017, Sonora
Tarrant	Fournier et al. (1989)	<1989
Taylor	DSHS	September 15, 2015, Abilene
Tom Green	Sames WJ	August 15, 2018, Christoval
Travis	McHugh et al. (1987)	1987, Austin
Uvalde	Sames WJ	December 31, 2004, Concan
Val Verde	Fournier et al. (1989)	<1989
Van Zandt	DSHS	2003
Victoria	DSHS	July 5, 2002
Walker	DSHS	2003
Waller	Sames WJ, Hogue S Jr	November 14, 2017, Hempstead
Washington	Sames WJ, Hogue S Jr	November 14, 2017, Brenham
Webb	Rueger and Druce (1950)	October 1, 1945, Laredo
Wharton	DSHS	2003
Wichita	DSHS	July 15, 2005
Willacy	Hill et al. (1958)	<1958
Williamson	DSHS	October 9, 2013, Georgetown
Wilson	Sames WJ, Heimer H	July 8, 2017, Floresville
Wood	DSHS	2003
Zapata	Olson and Grimes (1974)	August 26, 1971, Zapata
Zavala	Ogden and Lindsay Coll.	September 24, 1949

¹ DSHS, Texas Department of State Health Services.

additional mosquito control districts/sections submissions (1), university collections (4), previously unreported author collections (3), and from collections conducted for this study in 2017–18 (56 records). Of the 127 counties, 56 counties had multiple collection dates, and 71 counties had 1 collection date, even though multiple collections (different sites and/or different containers) on the same day were made for 16 of these counties.

Culex coronator specimens were found in the Texas A&M University (TAMU) Insect Collection, Department of Entomology, College Station, TX, and the University of Texas Insect Collection, 3001 Lake Austin Boulevard, Brackenridge Field Laboratory, Austin, TX. The TAMU collection had 15 *Cx. coronator* specimens from Texas. Eight specimens (Presidio County, July 24–August 11, 1966, collector: E. R. Easton) appeared to be voucher specimens associated with Easton et al. (1968), and 1 specimen (Hidalgo County, August 18, 1943, collector: D. E. Eyles) may be associated with Thurman et al. (1945), in which Eyles was listed as an author. The collection dates in Thurman et al. (1945) were ambiguous, so this record was attributed to the Eyles specimen in the TAMU Insect Collection. Another specimen (Zavala County, September 24, 1949, collector: Ogden and Lindsay Collection) did not appear to have been reported in the literature, and it represented the earliest collection for this species in Zavala County. Five other specimens were considered additional data for *Cx. coronator* in Cameron (4) and Hidalgo (1) Counties.

All *Cx. coronator* specimens in the University of Texas Insect Collection were found in the Osmund P. Breland mosquito collection. Thirty (30) of these specimens were additional data for Cameron County, and 23 specimens were reported for Maverick County (Quemado, TX, October 3, 1953, collector: O. P. Breland), which predated the Olson and Grimes (1974) reporting of this species. Similarly, 39 specimens were collected at Palmetto State Park (Gonzales County, TX, May 14 and 22, 1943, collector: O. P. Breland). These specimens were not reported in his publication (Breland 1948) on *Uranotaenia anhydor syntheta* Dyar and Shannon, specimens for which were collected on the same days and location.

From all sources, the authors accumulated data representing 8,526 collections of *Cx. coronator* in Texas. The Texas DSHS records were from county submissions to DSHS from 2002 through 2017 and consisted of 6,563 collections (47,461 females; no males and no larval collections), of which 3,943 collections (36,009 females) were from LTs, 1,549 collections (4,162 females) were from gravid traps, 810 collections (3,076 females) were from BG Sentinel traps, 24 collections (43 females) were from aspiration, and 237 collections (4,171 females) were reported for which the method of collection was not reported (unknown).

Author-made collections from previous years contributed 18 LT and 5 larval collections from Hardin (LT, Burton, unpublished data), McLennan (LT, Duhrkopf, unpublished data), and Bexar (larval), Cameron (LT), Nueces (2 larval), and Uvalde (2 larval) Counties (Sames, unpublished data). The collections in Hardin, McLennan, and Uvalde Counties are the records for those counties.

In 2017–18, larval collections were made in counties without *Cx. coronator* records. The intent was to acquire records for counties east of US Highway 277 and make these collections from the south to the north. Based upon the lead author's experience, *Cx. coronator* larvae were known to occur in ground pools and within and around livestock watering containers. Hence, areas expected to have livestock watering containers (e.g., rodeo arenas, cattle pens, stables) were targeted for collections, and livestock watering containers and ground pools within those areas were sampled. This resulted in 149 larval and/or pupal collections from 64 counties. Of these, 56 collections represented the first county reports of this species, and the remaining 93 collections were additional data for counties with records. Adult specimens were obtained by allowing pupae to emerge for identification. From these collections, 2,336 larvae, 212 females, and 267 males were identified using keys of Darsie and Ward (2005), Carpenter and LaCasse (1955), and Harrison et al. (2016).

Combining data from author-made larval collections in previous years and in 2017–18 (n=154 collections), *Cx. coronator* larvae were collected alone in 55 samples. In the other 99 samples, they were associated with 24 species (Table 2). Also, 101 larval collections were from a variety of water-trough materials: concrete (33), galvanized metal (22), bare metal (3, i.e., homemade trough made from steel, not treated), commercially produced rubberized material (15, Rubbermaid Structural Foam), a commercially produced outside horse automatic waterer (1), a plastic ice chest (1) used as a water trough, and colored #2 high-density polyethylene plastic tubs (23) or barrels (3) modified for use as a water trough. On 45 occasions, *Cx. coronator* larvae were collected in ground pools. Of these, 26 were classified as natural ground pools such as drainage ditches or depressions in fields. The other ground pools were created by leaking pipes (9), overflowing water troughs (2), decorative fountains or ponds created with a plastic liner (7), and in the depression of a damaged concrete retaining wall (1). *Culex coronator* larvae were collected from 4 rain-filled plastic containers (storage tote [2], a food-storage container, and a fuel spill-containment container) that were not being used as water troughs. They were also collected from a rain-filled canoe (1), a cast-iron kettle (1), a clay pot (1), and a discarded tractor tire (1).

In 2017, rainfall occurred periodically throughout the year, and collections were made in Real and

Table 2. Mosquito species associated with *Culex coronator* in larval habitats.

Species	This study (%) ¹	Combined ²
<i>Aedes aegypti</i> (L.)	4 (2.5)	
<i>Ae. albopictus</i> (Skuse)	9 (5.8)	
<i>Ae. thelcter</i> Dyar	2 (1.3)	
<i>Ae. triseriatus</i> (Say)	1 (0.6)	
<i>Ae. trivittatus</i> (Coquillett)	1 (0.6)	
<i>Ae. vexans</i> (Meigen)	2 (1.3)	X
<i>Ae. epactius</i> Dyar and Knab	12 (7.8)	
<i>Anopheles albimanus</i> Wiedemann		X
<i>An. pseudopunctipennis</i> Theobald	21 (13.6)	X
<i>An. punctipennis</i> (Say)	11 (7.1)	X
<i>An. quadrimaculatus</i> Say	2 (1.3)	
<i>Culiseta inornata</i> (Williston)	14 (9.1)	
<i>Culex apicalis</i> Adams		X
<i>Cx. erraticus</i> (Dyar and Knab)		X
<i>Cx. interrogator</i> Dyar and Knab	1 (0.6)	X
<i>Cx. nigripalpus</i> Theobald	5 (3.2)	X
<i>Cx. quinquefasciatus</i> Say	55 (35.7)	X
<i>Cx. restuans</i> Theobald	9 (5.8)	X
<i>Cx. salinarius</i> Coquillett	2 (1.3)	X
<i>Cx. tarsalis</i> Coquillett	12 (7.8)	
<i>Cx. territans</i> Walker	1 (0.6)	X
<i>Cx. thriambus</i> Dyar	3 (1.9)	
<i>Psorophora ciliata</i> (Fab.)	3 (1.9)	
<i>Ps. columbiae</i> (Dyar and Knab)	4 (2.5)	X
<i>Ps. cyanescens</i> (Coquillett)		
<i>Ps. discolor</i> (Coquillett)	3 (1.9)	
<i>Uranotaenia lowii</i> Theobald	1 (0.6)	X

¹ Number of times collected with *Cx. coronator* (%). *N* = 154; *Culex coronator* collected alone on 55 occasions.

² Larval associates combined from: Rueger and Druce (1950), Beadle et al. (1957), Wiseman et al. (1959), Eads et al. (1961), Johnston et al. (1964), and Goddard et al. (2006).

Smith Counties, where *Cx. coronator* larvae were collected in June and disappeared during a hard freeze in December. Drought conditions started in late 2017 and continued across much of the state until September 2018, when heavy rain fell across much of the state. *Culex coronator* specimens were collected from followed sites in Real County in October and November 2018, but they were not found at previous collection sites in Smith County. In 2017, the Tarrant County Public Health collected 708 *Cx. coronator* females, but in 2018, they collected only 2.

In 2018 (August 15 to September 7, 2018, drought ongoing), larval collections were attempted in 30 counties without *Cx. coronator* records in west, central, and upper northeast Texas. *Culex coronator* larvae were collected from 4 counties: Hill, Llano, Mason, and Tom Green. In September 2018, much of the state received adequate to above normal rainfall. In late October 2018, 4 counties that had been sampled during the drought were resampled, and *Cx. coronator* specimens were collected in 3 of those counties (McCulloch, Lampasas, and Mills, but not San Saba). While the lack of rain impacted collection efforts, it also demonstrated how it might affect annual population fluctuations and the occurrence of

this species in arid portions of west Texas. There are 56 counties east of US Highway 277 that need to be surveyed (37) or resurveyed (19) for the presence of *Cx. coronator*.

Based upon the observation by Dyar and Knab (1906) that *Cx. coronator* individuals do not enter houses, larval collections in this study showed that habitats inside or well under the cover of a building’s roof (even if all 4 sides were open, no walls) and those without direct sunlight hitting the water surface never had *Cx. coronator* larvae or pupae. If the habitat was under, but along the edge of a roof, and sunlight hit the water surface sometime during the day, it might contain *Cx. coronator* larvae. Outside of and away from a building, habitats that were exposed to direct sunlight and that had at least partial shade during the day had a higher likelihood of *Cx. coronator* larvae. George O’Meara, in Connelly et al. (2016), also observed that “*Cx. coronator* larvae tend to be more prevalent in open, sunlit aquatic habitats than those in shaded locations” (p. 195).

In outdoor water troughs during the summer months (June–September), it was observed that at least partial shade during the day favored the presence of *Cx. coronator* larvae. The shade could be provided by various means, but shade in some form and amount appeared to be a necessity. This was especially noted in water troughs that were divided by a fence going over it. The fence allowed the trough to be used by animals in adjacent pens, and during the hot part of the day, the larvae would line up in the shade provided by this fence. During the summer months (June–early September), full water troughs in direct sunlight and no shade rarely had *Cx. coronator* larvae. In the fall (late September until the end of their seasonal presence), *Cx. coronator* larvae were found in water troughs exposed to full sun where no mosquito larvae of any species had been present all year.

The presence of heavy algae growth in any trough appeared to indicate that mosquito larvae were not to be found in it. Troughs that appeared to have been recently cleaned, those that had fish, and those that had visible populations of invertebrate mosquito predators rarely had mosquito larvae of any species.

While collecting along the Gulf of Mexico coast in Calhoun, Jackson, Matagorda, and Refugio Counties, it was observed that seemingly constant winds created turbulent wave action in full water troughs, and larvae were not found in these habitats. However, the water surface in partially filled water troughs was somewhat protected from the wind-derived wave action, and mosquito larvae populations generally were found in those habitats.

Seasonal activity appeared to begin in southern Texas and along the coast and then move north and west. In the fall, the reverse occurred, with a cessation of oviposition and an increase in developmental time due to colder habitat temperatures, followed by the remnants of the larval population presumably reaching the adult stage or being killed

by predators, by extreme cold temperatures, by loss of habitat through desiccation or destruction of habitat, or by repeated sampling by collectors (Sames, personal observation). Further studies are warranted to determine and explain the seasonality of this species across its entire range in Texas. Surveillance in counties with no data will help to determine the geographical range of this species and will provide additional data as to its bionomics and seasonality.

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