

SCIENTIFIC NOTE

NEW COUNTY RECORDS DEMONSTRATING A NORTHERN EXPANSION OF *MANSONIA TITILLANS* IN SOUTH CAROLINA, USA

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ABSTRACT. New county records in South Carolina suggest an expansion of the recorded northern distribution of *Mansonia titillans* in the USA. New location records of *Ma. titillans* in Beaufort County, as well as new county records in Berkeley, Clarendon, Colleton, and Georgetown counties are reported. Taxonomic notes are presented that provide 100% identification accuracy. Adult *Ma. titillans* were collected between August and December 2017 from 8 locations in 5 counties in South Carolina. Distribution records for floating water hyacinth (*Eichhornia crassipes*) and water lettuce (*Pistia stratiotes*), the aquatic plants normally associated with immature *Ma. titillans*, are documented in relation to new records of *Ma. titillans* adults.

KEY WORDS *Mansonia titillans*, South Carolina, taxonomic characters, water hyacinth, water lettuce

Few historical records depict the distribution of *Mansonia titillans* (Walker) in South Carolina. Mosquitoes of the genus *Mansonia* Blanchard were first collected in South Carolina as single adult specimens of *Ma. dyari* Belkin, Heinemann, and Page (Darsie and Hager 1993) and *Ma. titillans* (Goddard and Harrison 2005) in Beaufort County in 1993 and 1995, respectively. Beaufort County is the second-most southern county in South Carolina and is located along the eastern side of the state, bordering the Atlantic Ocean. *Mansonia titillans* was not reported in Beaufort County again until 2015, after which sporadic collections were made. *Mansonia titillans* has been detected in multiple counties in Georgia since 1997, including Chatham County whose border ranges from 2 to 10 mi SW of Beaufort County (Smith and Floore 2001). New county records of *Ma. titillans* reported here expand the recorded northern distribution of this species in the USA. These new county records can be attributed partially to the statewide arbovirus surveillance program conducted by the South Carolina Department of Health and Environmental Control and mosquito control programs within the state.

Adult specimens were collected by using 3 trap types with 3 types of attractants: 1) Centers for Disease Control and Prevention light traps baited with dry ice or a combination of dry ice and BG-Lure (Biogents, AG, Regensburg, Germany) (Beaufort,

Clarendon, and Colleton counties); 2) BG-Sentinel 2.0 (Biogents) traps baited with a combination of BG-Lure and dry ice or BG-Lure and carbon dioxide gas (Berkeley, Clarendon, and Georgetown counties); or 3) encephalitis vector survey traps baited with dry ice (Beaufort County). Surveillance for immature stages of *Ma. titillans* was conducted using a telescoping dipper and a 3-part mesh sieve.

Mansonia are medium sized, dark, and speckled with dark and light scales throughout the body, with pale basal bands on the tarsomeres. Although both *Mansonia* and *Aedes* adult mosquitoes have postspiracular setae, *Aedes* have a narrow or pointed abdominal apex while *Mansonia* have a blunt or rounded abdominal apex (Belkin et al. 1970, Harrison et al. 2016). Separation of *Mansonia* species from *Coquillettidia perturbans* (Walker) may be difficult the 1st time *Mansonia* is encountered. *Coquillettidia perturbans* is common in the Mid-Atlantic region, particularly in late spring and early summer (King et al. 1960), and shares similar characters with *Mansonia*, such as the same size, posture, large pale and dark scales on the wing, a broadly rounded abdominal apex, and pale basal bands on the abdomen. Unlike *Mansonia* though, *Cq. perturbans* are lighter in color, lack postspiracular setae, have a broad median pale band on hindtarsomere 1, and have a distinct preapical pale band on the hind tibia (King et al. 1960, Burkett-Cadena 2013, photo, p. 127).

Specimens reported here were identified using Darsie and Ward (2005), Burkett-Cadena (2013), and Harrison et al. (2016). *Mansonia dyari* and *Ma. titillans* adults can be difficult to differentiate. Three of the characters used to identify adult females of *Mansonia* species in the USA can be ambiguous due to individual variation or slight differences between the species. These ambiguous characters are: 1) the length of the palpi in relation to the proboscis (Burkett-Cadena 2013, Harrison et al. 2016); 2) the

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ventral surface of the proboscis with a patch of pale scales or being mostly dark-scaled (Darsie and Ward 2005); and 3) the arrangements of peg-like spiniform setae on the lobes of abdominal tergum VIII.

Two other characters found only on *Ma. titillans*, as described in Belkin et al. (1970), were found to be less ambiguous and more reliable: 1) the presence of a horizontal row of small preapical spiniform setae just before the posterior margin of abdominal tergum VII; and 2) the presence of a median patch of a few large black scales on the 1st antennal flagellomere. The presence of these 2 characters, which were found to be 100% accurate based on the examination of numerous specimens from Mississippi, Georgia, and South Carolina (Harrison et al. 2016), were used to identify specimens in this study, including badly rubbed specimens. The row of small preapical spiniform setae found on tergum VII of *Ma. titillans*, but not *Ma. dyari*, must be examined under at least 55× magnification for visibility and can be obscured by large apical scales, which normally need to be removed to reveal the spiniform setae underneath them. These tergal VII setae are illustrated in Darsie and Ward (2005, fig. 473), Burkett-Cadena (2013, illus. on p. 39), Varnado et al. (2014, fig. 6a), and Harrison et al. (2016, fig. 267). The abdominal tergum VII spiniform setae are found only on *Ma. titillans* and should not be confused with abdominal tergum VIII setae, which are used by females of both species during oviposition to clear detritus from the leaf surface to allow proper adhesion of eggs to the leaf (Linley 1989). Linley (1989) hypothesized that tergal VII spiniform setae are found only on *Ma. titillans* because the setae might be needed to stabilize the abdomen's position on the leaf to prevent tergal VIII setae, which on *Ma. titillans* are larger and more organized than those found on *Ma. dyari*, from damaging the leaf surface during oviposition. The tergal VIII setae on *Ma. titillans* might be larger for the purpose of clearing the more heavily detritus-laden undersides of aquatic plant leaves (Linley 1989). *Mansonia titillans* deposits eggs only on the underside of leaves of free-floating plants, whereas *Ma. dyari* will deposit eggs on the upper- or underside of leaves (Lounibos and Dewald 1989).

Similar to *Cq. perturbans*, *Mansonia* larvae do not surface to obtain oxygen, but instead obtain oxygen by using a pointed siphon to pierce roots of aquatic plants (Horsfall 1955, King et al. 1960). Water lettuce (*Pistia stratiotes* L.) and water hyacinth (*Eichhornia crassipes* Martius) are free-floating aquatic plants commonly associated with *Ma. titillans* oviposition (Eads 1950, Horsfall 1955, King et al. 1960). These 2 plants are included in the South Carolina Noxious Weed List (SCDNR 2010), making their possession, import, sale, and distribution illegal in the state, though they remain popular water-garden items (SCDNR 2008).

The United States Geological Survey (USGS) keeps records of reported nonindigenous aquatic

species, accessible via an interactive map. Because the USGS relies on publications, state or local reporting, and citizen science to track invasive aquatic plants, some plants from smaller ponds and remote coves might not be reported (USGS 2017). According to the South Carolina Department of Natural Resources, water hyacinth existed in South Carolina prior to 1980, with the largest concentration in water bodies near Charleston (Fig. 1). Water hyacinth has since spread south to the Savannah River, north to the Waccamaw and Pee Dee rivers, and northwest to upper Lake Marion (SCDNR 2008) (Fig. 1).

Water lettuce was first found in Georgetown County on the Waccamaw River near Brookgreen Gardens (Fig. 1) in 1991, although it was presumed to have been unable to survive the cold winter temperatures after its initial discovery. Water lettuce is now limited to the Goose Creek Reservoir in Berkeley County (SCDNR 2008) (Fig. 1). Leaves of water hyacinth and water lettuce can be killed at freezing temperatures; however, water hyacinth is able to regrow from stem tips below the water's surface, whereas water lettuce must rely on regrowth from its seeds, which can only survive for approximately 2 months in submerged water at 4°C (Jacono et al. 2018, Thayer et al. 2018). In tropical locations like Central and South America and the Florida Keys, USA, other mosquito species are also associated with water lettuce, including *Culex erraticus* (Dyar and Knab) (Lounibos and Escher 1985), *Aedeomyia squamipennis* (Lynch Arribalzaga) (Burkett-Cadena and Blosser 2017), and *Cx. panocossa* Dyar (Blosser and Burkett-Cadena 2017).

Mansonia titillans adults were collected from August to December 2017 at 8 sites in 5 counties in the Coastal Plain of South Carolina (Fig. 1). Twenty-one specimens of *Ma. titillans* adult females were collected from Cottageville (32°55'25.1"N, 80°28'50.96"W) in Colleton County on September 20. Single specimens of *Ma. titillans* adults were collected in South Carolina in 2017 from Manning (33°39'35.87"N, 80°10'20.32"W) and Summerton (33°30'50"N, 80°18'57"W) in Clarendon County on September 5 and October 12, respectively, as well as from Pawleys Island (33°28'22.71"N, 79°06'56.62"W) in Georgetown County on September 13 and Moncks Corner (33°05'02.9"N, 80°01'30.96"W) in Berkeley County on October 2. The locations in Berkeley, Clarendon, and Colleton counties are relatively undeveloped and mainly consist of farmland, forests, and small freshwater ponds. The site in Georgetown County is in a populated area with small, private freshwater ponds.

In addition to the 4 new county records reported here, Beaufort County Mosquito Control collected small numbers of *Ma. titillans* adults from 5 different sites in Beaufort County (Fig. 1). Single adult specimens were collected from Yemassee (32°39'37.38"N, 80°43'01.06"W) and Port Royal

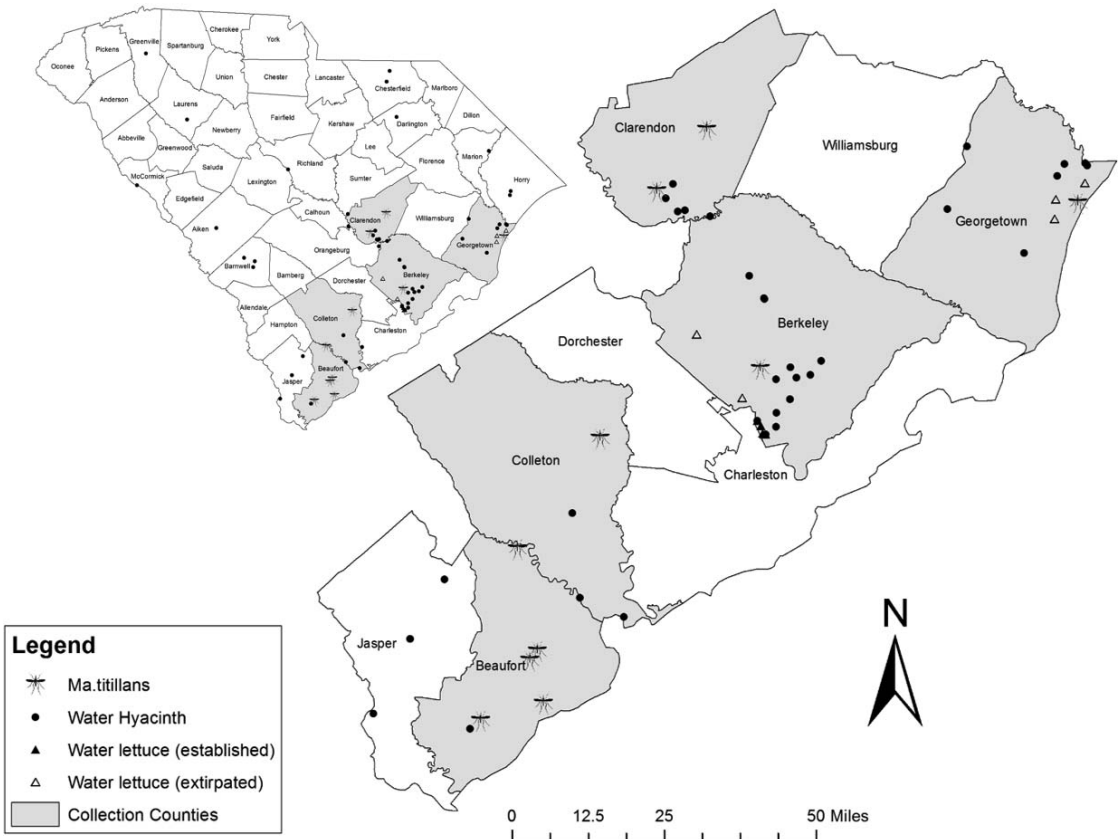


Fig. 1. Adult *Mansonia titillans* collection locations in relation to records of floating water hyacinth and water lettuce that are associated with the larval stage of *Ma. titillans*. Mosquito collections in Berkeley, Clarendon, and Georgetown counties were made in 2017; collections in Beaufort County were made from 2015 to 2017. Highlighted counties indicate the presence of *Ma. titillans*. Water hyacinth and water lettuce data were collected from the US Geological Survey Nonindigenous Aquatic Species program website (USGS 2017). Inset: All recorded locations of water hyacinth and water lettuce in South Carolina.

(32°23'35.51"N, 80°40'58.04"W) on September 15 and November 3, 2015, respectively. Several specimens were collected from St. Helena Island (32°17'26.33"N, 80°38'38.73"W) on July 12, 2016, August 22, 2017, and December 5, 2017. Several specimens were also collected from Bluffton (32°16'49.18"N, 80°48'20.19"W) on September 24, 2017, and Ladys Island (32°24'33.06"N, 80°39'36.66"W) on September 24 and December 12, 2017. Two of the collection sites in Beaufort County are rural with one adjacent to a freshwater swamp, and the other, a salt marsh. The 3 other sites in the county are in populated areas with small, private freshwater ponds.

The newly documented collections of *Ma. titillans* in northern counties confirms the presumption of Moulis et al. (2015) that *Ma. titillans* populations could be expanding north. Failure to detect *Ma. titillans* in these new, more northern areas prior to now might be due to limited surveillance. Prior to 2017, only the location in Moncks Corner (Berkeley

County) had been sampled routinely in the past 10 years, but no *Ma. titillans* were detected. The seasonality of *Ma. titillans* adults in South Carolina is currently unknown, but comparisons of recent and prior collections to those in Georgia (Moulis et al. 2015) suggest that *Ma. titillans* adults are probably most active in summer and fall (Table 1).

The presence of water hyacinth was visually confirmed in 3 areas within 2 mi of the collection sites in Moncks Corner and Manning, but no *Ma. titillans* larvae or pupae were collected. Although the immature stages of this species are more difficult to collect than most other mosquito species, more extensive larval surveillance should be conducted, considering that this species might be more prevalent in South Carolina than suspected. More research is needed to determine the habitat range, seasonality, and other possible host-plant associations of *Ma. titillans* in South Carolina.

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Table 1. Summary of *Mansonia titillans* seasonality in Georgia and South Carolina.¹

Location		Month						
State	County	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Georgia ²	(multiple counties)	nd ³	nd	nd	nd	nd	nd	nd
South Carolina	Berkeley	0	0	0	0	5	0	0
	Beaufort	0	3	2	0	4	1	nd
	Clarendon	0	0	0	1	5	5	0
	Colleton	0	0	0	21	0	0	0
	Georgetown	0	0	0	2	1	3	0

¹ Numbers indicate individual specimens of *Ma. titillans*.

² Moulis et al. (2015).

³ nd, not determined.

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REFERENCES CITED

Belkin JN, Heinemann SJ, Page WA. 1970. Mosquito studies (Diptera, Culicidae) XXI. The Culicidae of Jamaica. *Contrib Am Entomol Inst* 6:1–458.

Blosser EM, Burkett-Cadena ND. 2017. *Culex (Melanoconion) panocossa* from peninsular Florida, USA. *Acta Trop* 167:59–63.

Burkett-Cadena ND. 2013. *Mosquitoes of the southeastern United States*. Tuscaloosa, AL: Univ. of Alabama Press.

Burkett-Cadena ND, Blosser EM. 2017. *Aedeomyia squamipennis* in (Diptera: Culicidae) in Florida USA, a new state and county record. *J Med Entomol* 54:788–792.

Darsie RF Jr, Hager EJ. 1993. New mosquito records for South Carolina. *J Am Mosq Control Assoc* 9:472–473.

Darsie RF Jr, Ward RA. 2005. *Identification and geographical distribution of the mosquitoes of North America, north of Mexico*. Gainesville, FL: Univ. Press of Florida.

Eads RB, Menzies GC. 1950. Distribution records of *Mansonia* Blanchard (Diptera, Culicidae) in Texas. *Mosq News* 10:3–5.

Goddard J, Harrison BA. 2005. New, recent, and questionable mosquito records from Mississippi. *J Am Mosq Control Assoc* 21:10–14.

Harrison BA, Byrd BD, Sither CB, Whitt PB. 2016. *The mosquitoes of the Mid-Atlantic region: an identification guide*. Cullowhee, NC: Western Carolina Univ. Publication 2016-1. 201 p. Available from North Carolina Mosquito and Vector Control Association, 3403 Carol Belk Building, Greenville, NC, 27858.

Horsfall WR. 1955. *Mosquitoes: their bionomics and relation to disease*. New York: Ronald Press Company.

Jacono CC, Richerson MM, Howard V, Baker E, Stottlmyer C, Li J. 2018. *Eichhornia crassipes (Mart.)* [Internet]. Gainesville, FL: US Geological Survey, Nonindigenous Aquatic Species Database [accessed January 17, 2018]. Available from: <https://nas.er.usgs.gov/queries/greatlakes/FactSheet.aspx?SpeciesID=11&Potential=Y&Type=2&HUCNumber>.

King WV, Bradley GH, Smith CN, McDuffie WC. 1960. *A handbook of the mosquitoes of the southeastern United States* [Internet]. Washington, DC: Agricultural Research Service, USDA [accessed January 19, 2018]. Agriculture Handbook 173. 188 p. Available from: <https://naldc.nal.usda.gov/naldc/download.xhtml?id=CAT87208686&content=PDF>.

Linley JR. 1989. Tergal spines of *Mansonia titillans* and *Ma. dyari* (Diptera: Culicidae) and their effect on a leaf surface during oviposition. *J Med Entomol* 26:402–406.

Lounibos LP, Dewald LB. 1989. Oviposition site selection by *Mansonia* mosquitoes on water lettuce. *Ecol Entomol* 14:413–422.

Lounibos LP, Escher RL. 1985. Mosquitoes associated with water lettuce (*Pistia stratiotes*) in southeastern Florida. *Fla Entomol* 68:169–178.

Moulis RA, Peaty LF, Heusel JL, Lewandowski HB Jr, Harrison BA, Kelly R. 2015. *Mansonia titillans*: new resident species or infrequent visitor in Chatham County, Georgia, and Beaufort County, South Carolina, USA. *J Am Mosq Control Assoc* 31:167–171.

SCDNR [South Carolina Department of Natural Resources]. 2008. *South Carolina Aquatic Invasive Species Management Plan* [Internet]. Columbia, SC: South Carolina Department of Natural Resources [accessed November 12, 2017]. Available from: <http://www.dnr.sc.gov/invasiveweeds/aisfiles/SCAISplan.pdf>.

SCDNR [South Carolina Department of Natural Resources]. 2010. *Aquatic Nuisance Species Program* [Internet]. Columbia, SC: South Carolina Department of Natural Resources [accessed November 12, 2017]. Available from: <http://www.dnr.sc.gov/invasiveweeds/index.html>.

Smith JP, Floore TG. 2001. New mosquito collection records for Southern Georgia. *J Entomol Sci* 36:114–121.

Thayer DD, Pfingsten IA, Howard V, Li J. 2018. *Pistia stratiotes L.* [Internet]. Gainesville, FL: US Geological Survey, Nonindigenous Aquatic Species Database [accessed January 17, 2018]. Available from: <https://nas.er.usgs.gov/queries/FactSheet.aspx?speciesID=1099>.

USGS [US Geological Survey]. 2017. *Nonindigenous Aquatic Species Database* [Internet]. Gainesville, FL: US Geological Survey [accessed November 12, 2017]. Available from: <http://nas.er.usgs.gov>.

Varnado WC, Goddard J, Harrison BA. 2014. *Identification guide to adult mosquitoes in Mississippi* [Internet]. Revised. Starkville, MS: Mississippi State Extension Service [accessed February 4, 2018]. Publication 2699. 116 p. Available from: https://msdh.ms.gov/msdhsite/_static/resources/4774.pdf.