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Northern Frog Biting Mosquito *Culex territans* (Walker 1856) (Insecta: Diptera: Culicidae)[1]

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The Featured Creatures collection provides in-depth profiles of insects, nematodes, arachnids and other organisms relevant to Florida. These profiles are intended for the use of interested laypersons with some knowledge of biology as well as academic audiences.

Introduction

Culex territans (Walker 1856), also known as the northern frog biting mosquito, is a mosquito species in the subfamily Culicinae, tribe Culicini, and subgenus *Neoculex* (ITIS 2022) (Figure 1). Located in both the New and Old Worlds, the species is found in North America, Europe, and portions of northern Africa and western Asia (Wilkerson et al. 2021). *Culex territans* inhabits a broad range of habitats (Knight and Stone 1977) and prefers to feed on cold-blooded animals (amphibians and reptiles), taking most of its bloodmeals from anurans (frogs and toads) (Bartlett-Healy et al. 2008a, 2009). With this unique blood feeding behavior, this species has been implicated as a vector of various microorganisms, including parasitic *Trypanosoma* and *Hepatozoon* species that infect amphibians (Bartlett-Healy et al. 2008a; 2009). Although *Culex territans* does not frequently bite humans, the species has been hypothesized to influence arbovirus transmission cycles. In the United States of America (USA), collected females have been found to be infected with arboviruses, including eastern equine encephalitis virus (EEEV) (Burkett-Cadena et al. 2008) and West Nile virus (WNV) (CDC 2016) acting as a potential enzootic or bridge vector for these pathogens.



Figure 1. *Culex territans* (Walker 1856) adult female (lateral view).
Credit: Nathan Burkett-Cadena, UF/IFAS

Synonymy

Culex territans (Walker 1856) *Culex saxatilis* (Grossbeck 1905) *Culex frickii* (Ludlow 1906)

Distribution

Culex territans is a mosquito species that is located throughout much of the Northern hemisphere (Knight and Stone 1977) (Figure 2). In the New World, it occurs in Canada, USA, and Mexico. In the USA, its distribution spans from the Pacific coast to the Atlantic coast, and the species is found as far north as Alaska and as far south as Florida, but likely does not occur in southwestern states west of Texas (Darsie and Ward 2008). In the Old World, *Culex territans* has been collected in much of Europe, including Scandinavia, and the Mediterranean region (Wilkerson et al. 2021). *Culex territans* has also been reported from northern Africa and the Arabian Peninsula (Weitzel et al. 2009; Lofti 1973).

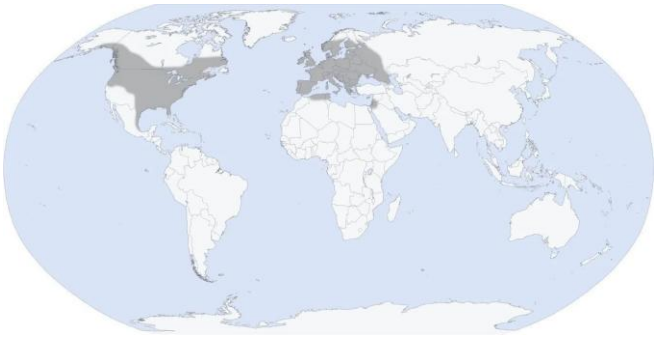


Figure 2. Approximate distribution of *Culex territans* (Walker 1856) (dark gray shading) based on records in Wilkerson et al. 2021.
Credit: Nathan Burkett-Cadena, UF/IFAS

Description

Eggs

Like other *Culex* species, *Culex territans* lays eggs in rafts (Figure 3). *Culex territans* egg rafts may contain approximately 30-150 slightly curved eggs in eight parallel rows (Knab 1904; Banach 1907). The eggs of *Culex territans* appear smooth to the unaided eye, but under high resolution appear fine and granulate in texture (Knab 1904). Like other mosquito eggs, the eggs of *Culex territans* are white in color when laid, darkening to grayish brown after a few hours (Knab 1904).



Figure 3. Typical egg raft of a *Culex* species.
Credit: Nathan Burkett-Cadena, UF/IFAS

Larvae

Larvae of *Culex territans* are distinguishable by their small size, prominent antennae, and rather long and thin (length about 6-7 times its width) siphon (breathing tube) (Figure 4). Larvae of *Culex territans* have a head that is wider than it is long and have antennae that are white with black tips (Figure 4). They can be differentiated from other Culex in Florida by the long and unbranched head setae (seta 5-C) combined with the lack of sub-dorsal setae on the siphon (Figure 4).

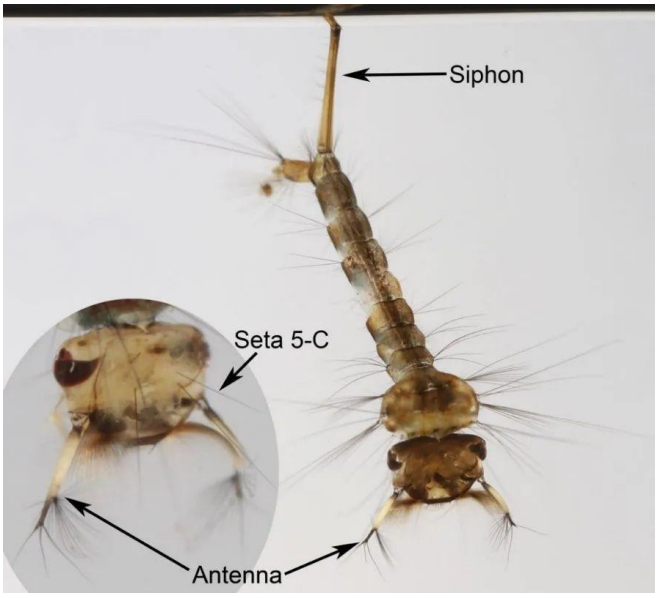


Figure 4. Larva of *Culex territans* (Walker 1856) highlighting features used in identification (dorsal view).
Credit: Nathan Burkett-Cadena, UF/IFAS

Pupae

Pupae of *Culex territans* are similar to that of many mosquito species. They are dark brown in color and have three main morphological characteristics of the eye, breathing trumpet, and posterior paddles used for movement (Figure 5). Pupae of *Culex territans* co-occur with larvae but tend to be less active and rest at the water surface unless disturbed.

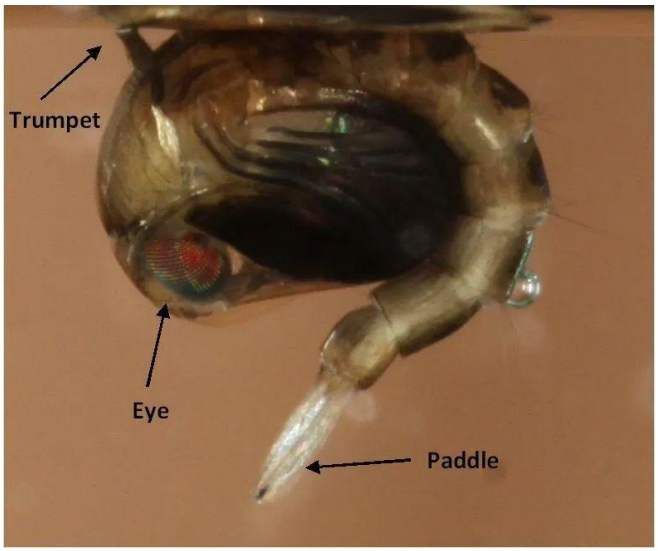


Figure 5. Pupa of *Culex territans* (Walker 1856) (lateral view).
Credit: Nathan Burkett-Cadena, UF/IFAS

Adults

Adult *Culex territans* are a small to medium sized mosquito ranging from light to dark brown in color (Figure 6). Like other mosquito species, males contain bushy or plumose antennae while females have lightly feathered antennae. An adult female *Culex territans* is distinguishable from other *Culex* species using certain characteristics of the head, legs, and abdomen. *Culex territans* is the only *Culex* species in the eastern USA with narrow pale bands that occur apically on abdominal segments (Figure 6), whereas all other *Culex* species in the eastern USA have basal bands or patches of pale scales. Both the palps and proboscis of *Culex territans* are dark in color, with the proboscis being much longer than palps (Figure 6). The tarsi of *Culex territans* are dark in color, without bands of pale scales (Figure 6). The wing scales of *Culex territans* are dark and narrow.

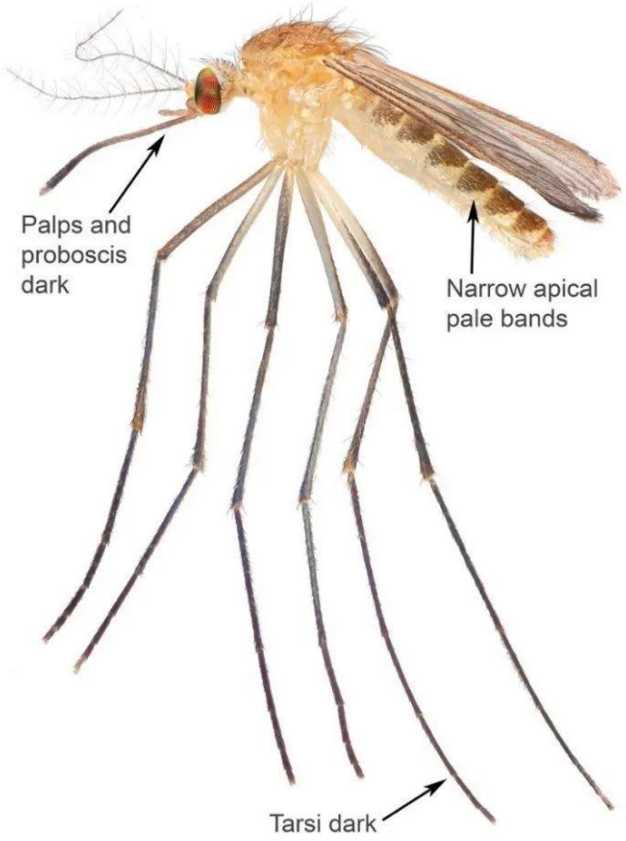


Figure 6. Adult female *Culex territans* (Walker 1856) highlighting distinguishing characteristics (lateral view).
Credit: Nathan Burkett-Cadena, UF/IFAS

Life Cycle

Culex territans follows a holometabolous or full metamorphosis life cycle, going through four distinct life stages: egg, larva, pupa, and adult (Figure 7) (CDC 2020; Benach 1970). The general life cycle of *Culex territans* closely resembles that of other mosquitoes in the genus *Culex.* Females require a bloodmeal to develop eggs, which are laid in floating clusters, called egg rafts. These rafts can be often laid on aquatic vegetation or directly onto the surface of the water. Larvae hatch directly into the water and filter feed on microorganisms and detritus suspended in the aqueous environment (Merritt et al. 1992). They develop over a period of one to two weeks and then transform into pupae, which do not feed. After a few days, adults will emerge from their pupal casing and begin to search for food and mates. From field studies in New Jersey, it has been shown that mated females will feed on carbohydrate sources such as fructose and sugars (Crans 2022). Adult *Culex territans* do not usually fly long distances and stay close to the habitat of their preferential hosts, like amphibians, for suitable reproduction and bloodmeals (Crans 2022). From lab reared colonies, it was observed that *Culex territans* will feed about the same in dark and light and that adult mating in the lab environment is stenogamous, meaning that reproduction between male and female can take place without flight, where adults will mate in cages or small spaces (Benach 1970). In the winter, adult females go through a period of dormancy called diapause, to then emerge in early spring for their first bloodmeals and subsequent egg deposits (Crans 2022). The timing of diapause in *Culex territans* varies geographically and in some locations, like Florida and Alabama, adult *Culex territans* may stay active year-round continuing to blood feed during winter months (Burkett-Cadena et al. 2008; Bingham et al. 2014). Interestingly, egg hatching of *Culex territans* may be delayed due to the unique oviposition behavior of females, which sometimes lay eggs on emergent vegetation near the top of the water line or on a bank, relying on rainfall or rising water levels to wash the eggs onto the water surface for hatching (McIver 1969; Crans 2022). Larvae of *Culex territans* may also have temporal differences. In New Jersey for example, larvae of *Culex territans* are present throughout spring and summer and can be collected through the month of September (Crans 2022). From observations of laboratory reared *Culex territans*, room

temperature water was ideal for larval growth and may be applicable to nature (Benach 1970).

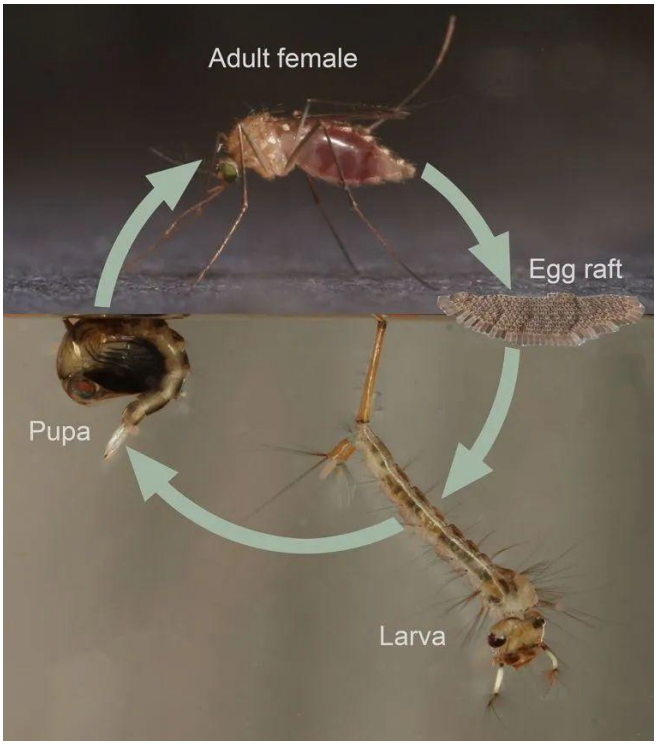


Figure 7. Holometabolous life cycle of *Culex territans* (Walker 1856).
Credit: Nathan Burkett-Cadena, UF/IFAS

Habitat and Hosts

Culex territans is found in a wide variety of habitats but is most commonly associated with freshwater marshes, hardwood swamps, bogs, and ponds or streams with emergent vegetation (Joy and Clay 2002; Bartlett-Healy 2008a; Bingham et al. 2014; Burkett-Cadena et al. 2008; Botello et al. 2013; Crans 2020). All four life stages occur in such locations throughout its range, although immature stages of Culex territans have also been found in discarded tires or other artificial containers in Alabama (Qualls and Mullen 2006) and West Virginia (Joy and Clay 2002, Joy and Sullivan 2005). In Florida, *Culex territans* is typically found in freshwater wetlands including hardwood/cypress swamps, hardwood hammocks, pine flatwoods, and floodplain forests (Edman 1974; Bingham et al. 2014). Due to their presence in a wide variety of habitat types, *Culex territans* shares habitat with many other mosquito species, including those within the genera Aedes, Anopheles, Culex, and Uranotaenia, which have all been collected in similar locations (Edman 1974; Burkett-Cadena et al. 2008; Bingham et al. 2014). Like many other mosquito species, females of *Culex territans* also need a bloodmeal from vertebrate animals to obtain nutrients for their eggs. *Culex territans* across the USA and in other parts of the world have been shown to take bloodmeals from reptiles, birds, mammals (including humans), and amphibians (Table 1). Although *Culex territans* does feed on a variety of vertebrate hosts, it takes a large fraction (over 75%) of bloodmeals from cold blooded hosts (amphibians and reptiles), particularly anurans - frogs and toads (Figure 8; Table 1) (Edman 1974; Bartlett-Healy et al. 2009; Burkett-Cadena et al. 2008; Molaei et al. 2008; Bingham et al. 2014; Hesson et al. 2016). Due to this feeding behavior, *Culex territans* may be commonly encountered in water bodies with cool water temperatures where amphibians are more abundant (Crans 2022). As amphibians are an indicator species of water quality and prefer non polluted habitats, *Culex territans* may also likely be found in these types of areas as well (Bartlett-Healy et al. 2008a; Crans 2022). It has also been noted that due to unique temporal patterns, female *Culex territans* may seek reproductively active frogs, locating the calling males during specific times of their mating behavior (Bartlett-Healy et al. 2008b, Burkett-Cadena et al. 2008).



Figure 8. Engorged *Culex territans* (Walker 1856) adult female feeding on the amphibian host bullfrog.
Credit: Ben Matthews, University of British Columbia, taken at Postdoctoral lab in The Rockefeller University

Medical and Veterinary Importance Surveillance and Management

Because *Culex territans* mainly feeds on amphibians, the surveillance and management of the mosquito species is not a priority of mosquito control or public health agencies. However, as *Culex territans* has been found infected with viruses like WNV and EEEV and has

been shown to occasionally feed on humans, it is crucial to understand more about this species' biology to improve surveillance practices for public/veterinary health and research purposes. Larvae of *Culex territans* are commonly found and collected using a standard mosquito dipper in their typical habitats by skimming and dipping into emergent vegetation in the water or in small cavities (Bartlett-Healy et al. 2008a; Crans 2022). As larvae prefer to rest in shaded water, looking for shady areas on sunny days may improve efforts to collect *Culex territans* larvae (Crans 2022). From studies utilizing adult mosquito collections, *Culex territans* has been sampled with high efficiency using resting-site aspiration, as well as with carbon dioxide-baited CDC miniature light traps or vegetation sweeps to a lesser degree (Savage et al. 2007; Burkett-Cadena et al. 2008; Molaei et al. 2008; Bingham et al. 2014). In these studies, resting adult *Culex territans* have been collected from microhabitats such as tree cavities, storm water sewers, understory vegetation, and researcher-made resting shelters (Savage et al. 2007; Burkett-Cadena et al. 2008; Molaei et al. 2008; Bingham et al. 2014). Female *Culex territans* have been found to be attracted to amphibian hosts via phonotaxis, using vocalizations of frog species to locate these animals for bloodmeals (Bartlett-Healy et al., 2008b). Although more research is needed to fully understand host attraction for this species, phonotaxis could be exploited as a method of attracting *Culex territans* for surveillance or management purposes.

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Tables

Table 1. Bloodmeal hosts (primary and secondary) of *Culex territans* (Walker 1856) by vertebrate class distinguished by USA state or country of collection. *References marked with asterisk break down percentages only by vertebrate class, while other references differentiate all or majority of classes by species level.

Location	Primary host (class)	Secondary hosts (classes)	Reference
Florida, USA	Amphibia / Reptilia	Aves, Mammalia	Edman 1974*
Florida, USA	Amphibia	Aves, Mammalia, Reptilia	Bingham et al. 2014
Alabama, USA	Amphibia	Reptilia, Mammalia	Burkett-Cadena et al. 2008
Alabama, USA	Amphibia	Aves, Mammalia	Burkett-Cadena et al. 2014
Connecticut, USA	Aves	Amphibia, Mammalia, Reptilia	Molaei et al. 2008
Connecticut, USA	Aves	Amphibia	Shepard et al. 2016
North Carolina, USA	Amphibia	Aves, Reptilia	Irby and Apperson 1988*
New Jersey, USA	Amphibia	Reptilia	Bartlett-Healy et al. 2009
Tennessee, USA	Amphibia	Aves, Mammalia	Savage et al. 2007
Germany	Amphibia	Mammalia	Heym et al. 2019

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