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Biting Midges, No-See-Ums *Culicoides* spp. (Insecta: Diptera: Ceratopogonidae)[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

Biting midges (also known as no-see-ums, sand flies, or sand gnats) are tiny bloodsucking flies represented by only a few of the many genera in the family Ceratopogonidae. Biting midges are extremely small insects (Figure 1), and many species are less than one twenty-fourth of an inch (about 1 mm [0.04 in]). Biting midges are important for several reasons. In the United States, especially in coastal areas, these biting insects are often abundant and persistent pests of campers, beachgoers, fishers, and anyone desiring to enjoy the outdoors. Biting midges are also important as vectors (transmitters) of deadly and debilitating pathogens that affect wild and domesticated animals, especially livestock and game animals. Biting midges can even transmit pathogens that affect humans in many parts of the world, especially in South America and Africa.

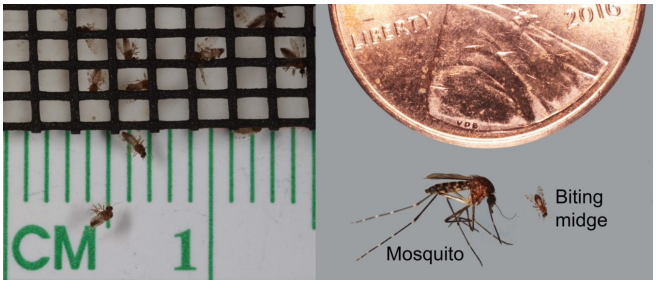

Figure 1. The biting midge *Culicoides furens* shown next to standard window screen (left) and a mosquito (*Aedes taeniorhynchus)* (right) to demonstrate the relative size of adult biting midges.
Credit: Nathan Burkett-Cadena, UF/IFAS

Diversity and Distribution

Biting midges belong to the family Ceratopogonidae in the order Diptera (true flies). Although some genera within this family are known to bite and suck blood, the majority do not bite. The most diverse and widespread genus of biting midges is the genus *Culicoides*, which includes around 1,350 species worldwide (Borkent and Dominiak 2022). In the USA there are approximately 170 species of *Culicoides* (Borkent and Grogan 2009), of which around 50 occur in Florida (Blosser et al. 2024). In addition to *Culicoides*, a few species from other genera within the family Ceratopogonidae are also blood-feeders, including *Leptoconops* (in the subtropics and tropics), *Forcipomyia* subgenus *Lasiohelea* (in tropical rain forests), and two species of *Austroconops* (Western Australia).

In Florida, biting midge diversity is greatest in the northern half of the state. Numerous species of biting midges use water-filled treeholes as their larval habitat, and the trees that have these treeholes are much more common in the temperate hardwood forest of the Florida Panhandle and north-central Florida (Alachua County, for example). In south Florida, hardwood forests and trees with treeholes are less common, so treehole-adapted species are uncommon or absent. Several biting midge species are considered coastal pests and utilize marshes, swamps, and mangroves of coastal Florida as larval habitats. These coastal species can reach incredible densities and be so pestiferous that they drive even the most stout-hearted nature lovers indoors. Other biting midge species are adapted to the prairies of the south Florida interior and develop in low-lying sunny grasslands and marshes.

Description

Adults

Adult biting midges (Figure 2) are tiny, usually 1.0 mm to 2.0 mm (0.04 to 0.08 in) long (Figure 1). Of the 50 or so species that occur in Florida, the average length is about 1.5 mm (0.06 in). The mouthparts of female biting midges are specialized for piercing the flesh of vertebrate animals and sucking their blood (Figure 2). Their mouthparts are elongated to form a proboscis, which consists of multiple elements, including mandibles, which are used for cutting flesh, and a hypopharynx, which transports saliva and host blood. Male biting midges have mouthparts that generally resemble those of the female but are not adapted for piercing skin. The palpi are five-segmented appendages of

the mouthparts that possess a sensory organ (on the third segment) used to locate host animals. The antennae of biting midges have 15 segments. The basal 10 segments are usually short, while the apical five segments are much longer. Adult biting midges, like other Diptera, have two wings. The wings have veins, which give the wing its rigidity, and cells made of membranous exoskeleton. The wings of most biting midge species are patterned with dark and pale spots characteristic of the species (Figure 3). These "wing patterns" are extremely important in identifying biting midges to species. The halteres are the remnants of hind wings, used as flight stabilizers. Biting midges have three pairs of legs, and each leg has five segments (coxa, trochanter, femur, tibia, tarsus) that terminate in robust claws. The abdomen of a biting midge is segmented and terminates in the copulatory (mating) appendages. In females, the copulatory appendages are barely visible, while in males, the copulatory appendages appear as grasping structures.

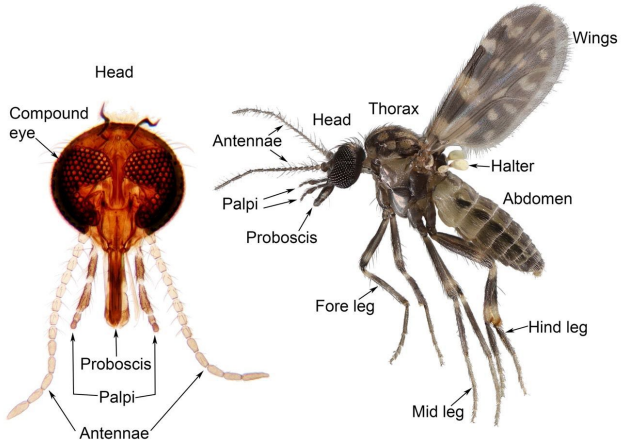

Figure 2. Head and body of adult biting midge, with major characteristics labelled.
Credit: Nathan Burkett-Cadena, UF/IFAS

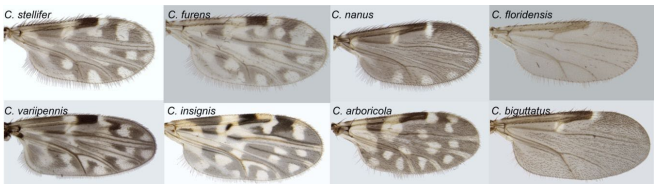

Figure 3. Wings of some biting midge species showing the variation in pale and dark spots that create variable patterns useful for identification.
Credit: Nathan Burkett-Cadena, UF/IFAS

Eggs

Eggs of biting midges are extremely small (about 0.25 mm or 0.01 inch long) and crescent shaped (Figure 4). The eggs are white when newly laid but then darken to brown as they mature (Blanton and Wirth 1979).

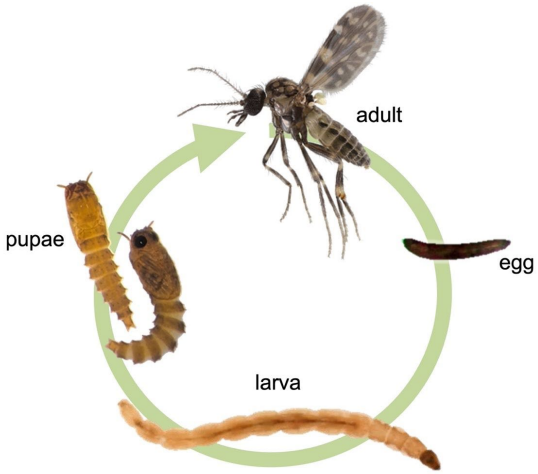

Figure 4. Generalized life cycle of biting midges.
Credit: Nathan Burkett-Cadena, UF/IFAS

Larvae

Biting midge larvae are typically long and very slender, generally resembling a tiny worm (Figure 4). Like adults, they are extremely small (2 mm to 5 mm [0.08 to 0.2 in] long when mature). The head is typically brown or tan and much darker than the rest of the body (Figure 4), which is usually milky or translucent. Segments of the thorax (three segments) and abdomen (nine segments) are roughly cylindrical, about twice as long as they are wide, and similar in size. At the tail end of the body are four pairs of setae (bristles) that are used for locomotion and a pair of narrow papillae (fingerlike projections) that may be visible or retracted into the rectum. Larvae generally lack spiracles and respire through their exoskeletons. The mouthparts of biting midge larvae are composed of several elements that are used for scraping, chewing, seizing prey, and/or filtering food particles. The shape of the mandibles and other mouthparts, can be important in identifying biting midge larvae to species (Blanton and Wirth 1979; Mullen and Murphree 2019).

Pupae

Biting midge pupae are small (2 mm to 4 mm [0.1 to 0.2 in]) and elongate with a mobile and flexible body. The head and thorax are fused into a "cephalothorax," which bears the eyes and respiratory organs, called "horns," that arise near the dorsal anterior portion of the body (Figure 4). The abdomen is distinctly segmented and typically spiky or pointed. Pupae move with a distinctive swaying motion of the abdomen. When the pupa is fully mature, features of the adult biting midge, such as the wings, legs, eyes, and mouthparts, can be seen through its exoskeleton.

Life Cycle and Ecology

Adults

Like other flies, biting midges are holometabolous, which means that they pass through four complete life-stages: egg, larva, pupa, and adult (Figure 4). As adults, biting midges of many species fly relatively long distances (2 km or about 1.2 miles) for insects that measure only a few

millimeters. For instance, *Culicoides variipennis* females have been found to fly up to four kilometers (about 2.5 miles) (Lillie et al. 1981). Other species, like *Culicoides mohave,* have been found to fly up to six kilometers (3.7 miles) in California (Brenner et al. 1984).

It is very difficult to study the lifespan of a tiny insect in the wild, so our understanding of how long biting midges live is mainly based on the results of laboratory studies. For example, *Culicoides obsoletus* adults survived more than 90 days in the laboratory (Barcelo and Miranda 2021). In general, very little is known about how long adult biting midges live in nature, but adults of most species probably live at least one month. Adult male and female biting midges feed on nectar as a source of carbohydrates (Mullen and Murphee 2019). During their lifespan, females of most species feed on vertebrate blood to obtain nutrients for egg development. Some species can produce at least one batch of eggs without taking a bloodmeal. As a group, biting midges bite all four classes of terrestrial vertebrates (amphibians, reptiles, birds, and mammals). Most species that have been studied bite primarily mammals, but other species bite birds, and a few species bite amphibians and/or reptiles (Mullen and Murphree 2019). One species, *Culicoides testudinalis* Wirth and Hubert, mainly bites turtles (Jamnback 1965).

Most biting midge species generally bite during dusk, night, or morning (Kettle 1962). However, much variation in the time of day that species bite is recognized. During cold weather, for example, and in coastal areas, many biting midge species will bite in broad daylight. *Culicoides arboricola* Root & Hoffman*, Culicoides edeni* Wirth & Blanton, and *Culicoides knowltoni* mostly bite their host animals (birds) within one hour after sunset (Garvin and Greiner 2003). On the other hand, *Culicoides tissoti*, a species that utilizes freshwater springs as larval development sites, bites aggressively in the daytime (Blanton and Wirth 1979).

Eggs

Generally, females lay eggs within a week after taking a bloodmeal, with the number of eggs per batch varying between species. For example, egg batches of *Culicoides sonorensis* can contain up to 179 eggs (Jones 1967), while *Culicoides variipennis* have been shown to produce up to 243 eggs per batch and up to 1,143 eggs throughout their lifespan (Jones 1967). *Culicoides furens* can lay 50 to 110 eggs per clutch, and *Culicoides mississippiensis* Hoffman 25 to 50 eggs per clutch. Eggs are generally deposited on moist substrates (Blanton and Wirth 1979). Typically, the eggs hatch within a few days of being laid, for example, between two to five days for *Culicoides sonorensis* (Jones 1967); two to four days for *Culicoides furens*; and five to seven days for *Culicoides barbosai* (Linley 1966). While eggs of biting midges cannot survive drying, the eggs of many species can remain dormant for months waiting for appropriate hatching signals (e.g., temperature, moisture).

Larvae

Biting midge larvae pass through four stages, called instars, which each last a few days. The growth and development of biting midge larvae is rapid and generally is completed within two weeks. For example, *Culicoides variipennis* can develop from egg to adult within 16 days in laboratory conditions. However, some species can remain in the larval stage for long periods—up to one year—especially when conditions are not optimal, for example, due to low food availability or low temperatures.

As a group, larvae of biting midges can develop in a wide array of habitats where they have access to water, air, and food (Blanton and Wirth 1979), including the edges of streams, marshes, ponds, puddles, and treeholes (Table 1). Each species, however, is usually found in just one or two types of larval habitats. The species that develop in wet treeholes, for example, do not develop in marshes or ponds. Some species, such as *Culicoides loughnani*, have very specific larval habitats, like rotting cactus. Larvae of biting midges are not fully aquatic but do require substantial moisture for their development. Biting midge larvae feed on microscopic organisms like other insects, nematodes, tardigrades, and bacteria (Hribar and Mullen 1991).

Pupae

A fully developed larva transforms into a pupa, the stage in which a holometabolous insect undergoes dramatic morphological changes before emerging as a flying adult capable of feeding and reproducing. Because they do not feed or move long distances, the pupae of biting midges are generally found in the same habitats as the larvae. The pupal stage is sometimes as short as 1.5 days, but can be much longer, especially when substrate moisture or temperatures are low (Vaughan and Turner 1987).

Medical and Veterinary Significance

Dozens of species of biting midges are important as significant biting pests and transmitters of human and animal pathogens around the world. Most people are probably familiar with the annoying and persistent nuisance “no-see-ums” that bite and can reach incredible densities in coastal areas. Reactions to bites generally consist of localized stinging or burning sensations with defined red areas surrounding bite sites. While discomfort usually lasts for minutes to hours, individuals who are hypersensitive to bites may itch for two to three days (Mullen and Murphee 2019). In some areas of Sub-Saharan Africa and the American tropics, biting midges are known to transmit dangerous human pathogens including filarial worms in the genus *Mansonella*, which cause mansonellosis, and the potentially deadly Oropouche virus (OROV) (Downes et al. 2014). Mansonellosis presents with mild fever, dermatitis, and skin lesions (Lima et al. 2016; Simonsen et al. 2014). Biting midges are a cause of concern for livestock farmers because they transmit viruses that

can affect horses, cattle, sheep, and deer. Additionally, biting midge bites can trigger "sweet itch," a form of allergic dermatitis often seen in horses (Anderson et al. 1993).

Culicoides paraensis is one of the principal vectors (transmitters) of Oropouche virus (OROV) in South America and the Caribbean (Dixon et al. 1981; Pinheiro et al. 1981a). While antibodies to OROV have been detected in monkeys and wild birds, sloths are the only known natural virus reservoir for OROV (Pinheiro et al. 1981b). Recently, OROV has spread beyond South America to locations like Haiti, Cuba, and Dominican Republic where sloths do not occur. Scientists speculate that the expanding strains of OROV are mutated forms of the virus, and the mutation allows the virus to use humans as hosts and some mosquito species as vectors (Scachetti et al. 2024). Oropouche virus causes a potentially deadly illness in humans known as Oropouche fever. The most common symptoms are fever, chills, headaches, muscle and joint aches, malaise, dizziness, nausea, vomiting, and light sensitivity. Although the illness is generally mild, more severe symptoms such as spontaneous bleeding or meningitis may occur, particularly in immunocompromised individuals and children (Sakkas et al. 2018).

Biting midges in the genus *Culicoides* transmit hemorrhagic disease viruses, such as bluetongue virus (BTV) and epizootic hemorrhagic disease virus (EHDV) to wild and domestic ruminants like sheep, cattle, and deer. These lead to substantial losses in productivity and animal deaths each year and cost ranchers and farmers millions of dollars. The diseases caused by BTV and EHDV are clinically indistinguishable from one another, with symptoms in animals including swelling and bluish discoloration of the tongue, hoof inflammation, hemorrhaging, and death (Mullen and Murphee 2019; McGregor et al. 2022). In the United States, *Culicoides sonorensis* and *Culicoides insignis* are the confirmed *Culicoides* vectors of BTV and EHDV (McGregor et al. 2022). More information on Bluetongue can be found in the Bluetongue Ask IFAS publication available on https://edis.ifas.ufl.edu.

African horse sickness virus (AHSV) is also transmitted by biting midges in genus *Culicoides* (Mellor and Hamblin 2004). The disease caused by AHSV is endemic to Sub-Saharan Africa, but outbreaks of AHS have also occurred in North Africa, the Middle East, the Arabian Peninsula, Southwest Asia, and the Mediterranean region (Sanchez-Vizcaino et al. 2014). African horse sickness is considered the most economically significant equine disease worldwide and affects horses, mules, and donkeys (Dennis et al. 2019). Three clinical forms of the disease, pulmonary, cardiac, and horse sickness fever, as well as a mixed form, are recognized. These range in symptom severity and fatality rates (Burrage and Laegreid 1994). The mildest form of AHS, horse sickness fever, is generally not fatal. Symptoms of horse sickness fever include low-grade fever, anorexia, depression, and congestion (Faber et al. 2022). The pulmonary-cardiac form of AHS is the most common and lethal form, with a mortality rate of 70% (Dennis et al. 2019).

Lastly, Schmallenberg virus (SBV), first detected in Europe in 2011, is transmitted by *Culicoides* species to ruminants such as cattle, goats, and sheep (Rasmussen et al. 2012; Balengheim et al. 2014). Animals infected with SBV generally exhibit mild symptoms like fever, anorexia, and diarrhea (Davies et al. 2012). Most importantly, milk production of infected animals can be reduced by up to 50%, resulting in high economic losses for dairy farmers (Hoffmann et al. 2011; Muskens et al. 2012).

Management and Prevention

Historically, control strategies for biting midges have focused on nuisance species (Carpenter et al. 2008). However, since biting midges are important vectors of animal and human pathogens, interest in controlling biting midges and their impacts has increased in recent years. Strategies for controlling midges and preventing the diseases caused by viruses transmitted by biting midges include vaccination, adulticide sprays, biological and cultural control, and habitat modification.

Vaccination

Vaccination is often considered the most effective method of preventing diseases caused by viruses transmitted by biting midges (Harrup et al. 2016). However, the development of a vaccine requires extensive research, and vaccines are sometimes not used due to financial, logistical, or trade constraints (Harrup et al. 2016). The use of vaccines against biting-midge-transmitted viruses can also have some additional challenges. For instance, EHDV and BTV vaccines generally protect animals against only one or a few of the many known serotypes of these diseases. In some states in the USA, BTV vaccines are available to protect sheep against BTV serotypes 10, 11, and 17. For EHD, however, no licensed vaccines are available in the USA, though experimental vaccines against EHDV-2 and EHDV-6 are available. Vaccinating some animals can also be especially challenging. Vaccination of deer, for example, may not be practical for wild, semi-wild, or free-ranging animals (Orange et al. 2021).

Adulticide Sprays

Vector control techniques worldwide rely largely on the use of chemical insecticides to kill or deter vectors (Van Den Berg et al. 2021). Various organophosphates and pyrethroids applied as ultra-low-volume (ULV) sprays have been used for the reduction of nuisance biting midges (Carpenter et al. 2008). Pyrethrins and synthetic pyrethroids are the predominant insecticide class for the control of blood-feeding dipterans such as mosquitoes and

biting midges (Walters et al. 2009). The pyrethroid permethrin, for example, is widely used for mosquito control in the United States (EPA 2024) and is the main insecticide used against the biting midges that transmit BTV and EHDV in Florida (Harmon et al. 2020). The popularity of pyrethroids is in part associated with their high insecticidal potency and relative safety for mammals (van Balen et al. 2012).

In Florida, researchers have tested the efficacy of ULV applications with adulticides containing organophosphates (malathion, naled) and the pyrethroid resmethrin, against the coastal pest *Culicoides furens* (Linley et al. 1987; Linley et al. 1988; Linley and Jordan 1992). Naled was found to be the most effective ULV spray, achieving 90% mortality at distances up to 106 m, compared to 36 m for malathion and 25 m for resmethrin.

More recently, ULV applications with Permanone 30-30 (30% permethrin, 30% piperonyl butoxide) have resulted in complete mortality in field-collected adult biting midges *Culicoides furens* from Florida (Cooper et al. 2025). Additionally, applications of Talstar®, a 7.9% bifenthrin barrier spray product, at the maximum label rate reduced the numbers of *Culicoides furens* (Lloyd et al. 2021).

Other Control Strategies

Alternative control strategies, including biological and cultural control approaches, are commonly used on livestock farms to deter or eliminate biting midges, although their effectiveness remains insufficiently validated. Installing screens on windows and doors may reduce the number of biting midges entering animal enclosures (Harrup et al. 2016). Pyrethroid-impregnated ear tags have also been designed to repel and kill biting midges and other blood-sucking flies (Harrup et al. 2016). Keeping animals indoors from dusk until dawn may offer protection from biting midges (Carpenter et al. 2008; Baylis et al. 2010). Unfortunately, this approach is challenging for large herds or nontame animals like white-tailed deer.

Habitat modification is a method of altering and/or eliminating habitats where the larvae and pupae of biting midges develop (Harrup et al. 2016). The larvae and pupae of biting midges cannot survive desiccation (drying out) (McDermott and Lysyk 2020). Therefore, improving water drainage may reduce the number of larvae present in an area. A study in California tested the impact of removing a wastewater pond complex known to support a large population of *Culicoides sonorensis.* However, no difference on the adult *Culicoides sonorensis* population was found after removing the ponds, despite the elimination of what is thought to be the main developmental site for this species (Mayo et al. 2014). This study highlights the limited understanding of the developmental habitats of biting midges, and the challenges of habitat modification practices for the control of biting midges. The practicality of habitat modification to control biting midges may be limited by the implementation cost and the existence of regulatory issues such as the destruction of wetlands in the United States and the European Union (Pfannenstiel et al. 2015).

Human Protection Against Biting Midges

Window and door screens can be used to prevent the entry of biting midges into indoor areas. The opening size of the screen is an important factor to consider, as regular window screens do not exclude biting midges from indoor areas (Figure 1). The openings of biting midge (no-see-um) screen are small enough to exclude biting midges, but biting midge screen is not typically used as a window or door screen.

DEET-based repellents commonly used to protect humans from mosquitoes are also the main repellent used to repel biting midges (Harrup et al. 2016). However, other products, including those made with essential oils, have gained popularity. For example, the essential oil from *Melaleuca ericifolia* has been shown to achieve 95% repelling efficacy against *Culicoides ornatus* and *Culicoides immaculatus* up to three hours after application in field conditions in Australia (Greive et al. 2010). Essential oils have also been successful in repelling biting midges in laboratory experiments. For instance, essential oils from lemon eucalyptus *Eucalyptus maculata* var. *citriodora* were up to 100% repellent against *Culicoides obsoletus*, performing even better than DEET, which showed 75% repellency (Gonzalez et al. 2014).

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Table 1. Larval habitats of some biting midge species in Florida.

Larval habitat	*Culicoides* species
Wet pasture, prairie or grassland	*Culicoides insignis* *Culicoides knowltoni* *Culicoides pusillus*
Marsh and mangrove	*Culicoides mississippiensis* *Culicoides hollensis* *Culicoides barbosai* *Culicoides furens* *Culicoides jamaicensis*
Wet treeholes	*Culicoides debilipalpis* *Culicoides arboricola* *Culicoides paraensis* *Culicoides hinmani* *Culicoides guttipennis*
Edges of streams	*Culicoides edeni* *Culicoides haematopotus*
Puddle or pond edges	*Culicoides sonorensis* *Culicoides variipennis* *Culicoides stellifer* *Culicoides venustus*
Rotting cactus	*Culicoides loughnani*

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