

Dark Rice Field Mosquito (suggested common name) *Psorophora columbiae* (Dyar & Knab) (Insecta: Diptera: Culicidae)¹

Christopher S. Bibbs, Derrick Mathias, and Nathan Burkett-Cadena²

Introduction

Psorophora columbiae is a member of the broader *Psorophora confinnis* species complex (a group of closely-related species) that occurs across much of North and South America. This mosquito is associated with sun-exposed ephemeral water sources such as pooled water in agricultural lands and disturbed or grassy landscapes. The ubiquity of these habitats among agrarian and peridomestic landscapes contribute to explosive abundance of *Psorophora columbiae* following periods of high precipitation. *Psorophora columbiae* is both a common nuisance mosquito and significant livestock pest.

Common names of *Psorophora columbiae* vary by region. In rice-growing regions of Arkansas, Florida, and Louisiana *Psorophora columbiae* is known as the dark rice field mosquito because of its overall dark coloration and proliferation in flooded rice fields. In the Atlantic Seaboard region *Psorophora columbiae* is colloquially referred to as the glades mosquito or the Florida glades mosquito (King et al. 1960) due to its association with grasslands (glades) in otherwise forested areas.



Figure 1. *Psorophora columbiae* (Dyar & Knab) adult female.
Credits: Nathan Burkett-Cadena, UF/IFAS

Synonymy

Janthinosoma columbiae Dyar & Knab (1906)

Janthinosoma floridense Dyar & Knab (1906)

Janthinosoma texanum Dyar & Knab (1906)

From the Integrated Taxonomic Information System and International Commission on Zoological Nomenclature.

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2. Christopher S. Bibbs; Derrick Mathias; and Nathan Burkett-Cadena; Entomology and Nematology Department, UF/IFAS Extension, Gainesville, FL 32611.

Distribution

Psorophora columbiae belongs to a complex of similar species containing multiple forms of the namesake species (Moncayo et al. 2008), and it is also a representative of an interbreeding group of closely related species that includes *Psorophora confinnis* throughout South America, *Psorophora funiculus* in the northern border region of Colombia and Panama, *Psorophora toltecum* along the Pacific coastal regions of the southwestern US and Mexico, and *Psorophora columbiae*, concentrated around the Gulf Coast and Atlantic Seaboard states of the US (Lanzaro et al. 2015). Functionally, there are no morphological and few other differences between members of the *Psorophora columbiae* complex and the parent *Psorophora confinnis* complex (Moncayo et al. 2008; Lanzaro et al. 2015). As a result, the distributions of complex members, including *Psorophora columbiae*, are typically used in taxonomic identification rather than morphology (Figure 2). Taxonomy within the *Psorophora confinnis* complex is currently in a state of flux; however, contemporary population genetics investigations support the recognition of four distinct species (Lanzaro et al. 2015).

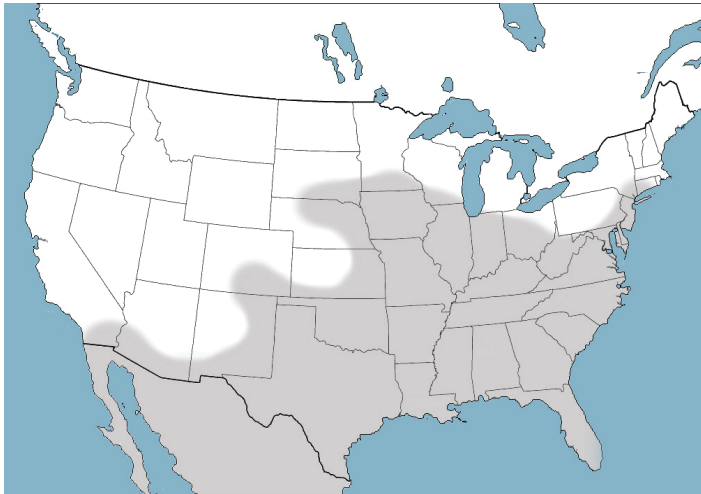


Figure 2. Distribution of *Psorophora columbiae* (Dyar & Knab) in the United States and Northern Mexico.

Credits: Nathan Burkett-Cadena, UF/IFAS

Psorophora columbiae often reach peak abundance in June and July, depending on the availability of suitable larval habitats (Bolling et al. 2005). Rain within a preceding two-week period and a lack of canopy cover over standing water are strongly associated with rapid population growth of these species (Bolling et al. 2005), especially for the two closest in form, *Psorophora columbiae* and *Psorophora toltecum*, throughout the southern and eastern US. (Ruiz-Garcia et al. 2006).

Description

Adults

Adults of *Psorophora columbiae* are generally medium-sized mosquitoes (Burkett-Cadena 2013), with wing length approximately 4.0–4.5mm (Carpenter and LaCasse 1955). The body tends to be dark brown, dark gray, or dull black in color with numerous patches of pale scales (Figure 1). Diagnostic characters include a broad band of pale scales on the proboscis (Figure 3); palps with white tips (Figure 3); patches of pale golden scales on the apical half of abdominal segments (Figure 4); dark and pale wing scales in no definite pattern (Figure 5); and pale bands at the base of each tarsal segment, in the middle of the first tarsal segment, and near the apex of the femur (Figure 6). Males are differentiated from females by having plumose, or noticeably feather-like, antennae as opposed to the wire-like antennae of the female.

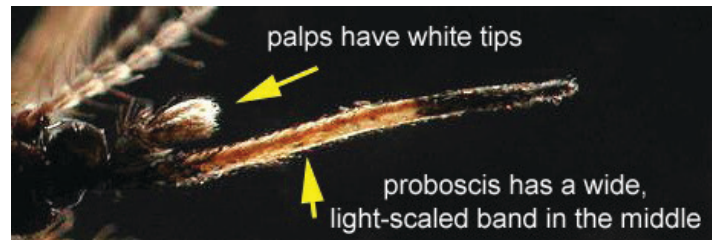


Figure 3. Adult *Psorophora columbiae* (Dyar & Knab) proboscis displaying a distinctive pale band that encircles the mouthparts alongside white tips on the palps, which are typically short in all members of the genus *Psorophora*.

Credits: UF/IFAS

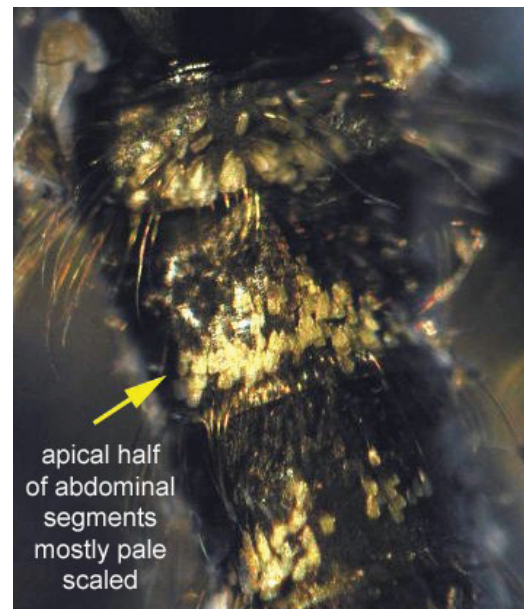


Figure 4. Adult *Psorophora columbiae* (Dyar & Knab) abdomen viewed from the top, with the thorax oriented at the top of the image. Pale patches, sometimes appearing as a non-uniform assemblage, are visible on the apical portions of abdominal segments (arising from the edge farther from the thorax). The arrow points to a contiguous pale patch.

Credits: UF/IFAS

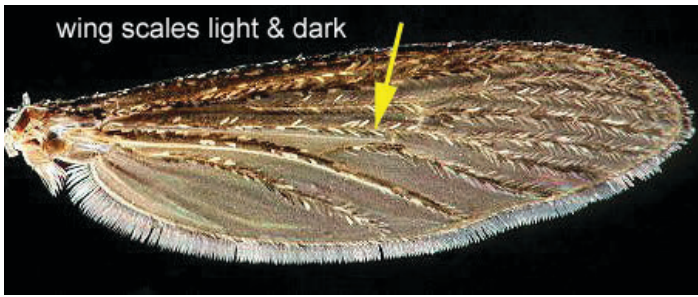


Figure 5. Adult *Psorophora columbiae* (Dyar & Knab) right forewing, with the attachment to the thorax oriented on the left of the image. Thin, elongate scales on all wing veins are typically a mixture of dark and pale scales, giving a “salt and pepper” appearance.
Credits: UF/IFAS

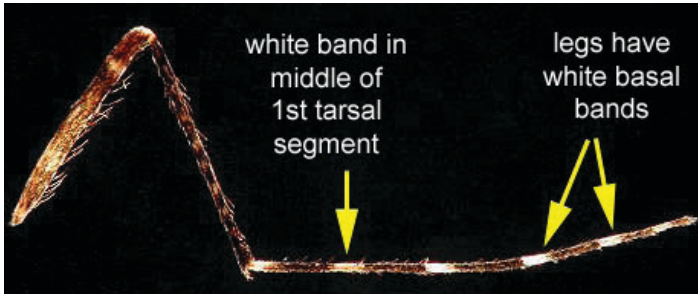


Figure 6. Adult *Psorophora columbiae* (Dyar & Knab) hind (or third) leg, oriented with the femur on the left of the image, which attaches through the trochanter and coxa to the thorax. Following the mostly dark scaled tibia, the tarsomeres display basal pale bands (arising from the segment edges closer to the thorax). *Psorophora columbiae* bears a distinctive additional pale band in the middle of the first tarsomere following the tibia.
Credits: UF/IFAS

Pupae

As with other mosquitoes, pupae of *Psorophora columbiae* rest at the surface of the water with the aid of an air pocket within the underside of the cuticle (Foster and Walker 2018). Gas exchange occurs through respiratory trumpets that arise from the dorsolateral surface of the thorax, above the eyes (Figure 7). The pupa is mobile, quickly escaping down into the water column when disturbed. The pupal stage of *Psorophora columbiae* is relatively short, with only 36–48 hours in this stage before emerging as an adult (Foster and Walker 2018). Generally, *Psorophora* pupae can have one or more of the following characters that help distinguish them from *Aedes*, *Culex*, and *Culiseta*: spines on the posterior corner of the fourth abdominal segment, lobes on the posterior edge of the eighth abdominal segment, and/or a seta (hair-like structure) arising from the paddle on the posterior tip of the pupa (Figure 8, Barr and Barr 1969). The *Psorophora confinnis* complex tends to bear a diagnostic feature that the seta arising from the paddle is no more than $\frac{1}{6}$ the length of the paddle it is attached to, appearing relatively short in length for that particular seta when compared to other members of the genus (Figure 8, Barr and Barr 1969).



Figure 7. *Psorophora columbiae* (Dyar & Knab) pupa, oriented with the dorsum (back) facing upwards towards the surface of water.
Credits: UF/IFAS

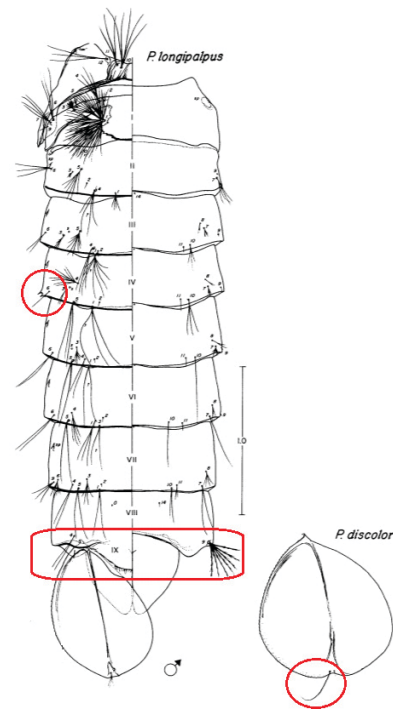


Figure 8. Figure of pupal *Psorophora* characteristics, by Barr and Barr (1969). Key features for the genus are circled in red: spine on the posterior (leading away from the thorax) corner of the fourth abdominal segment, lobes on the posterior edge of the eighth abdominal segment, and a seta (hair-like structure) arising from the paddle on the posterior tip of the pupa.

Larvae

Larvae of *Psorophora columbiae* are typically large in size but vary in color from pale white to black and shades of gray or brown in between (Figure 9). The head is somewhat rectangular in shape, and wider than long (Figure 10). The antennae are shorter than the length of the head, a feature that is characteristic of most species in the *Grabhamia* subgenus to which *Psorophora columbiae* belongs. A symmetrical set of four clusters of setae located on the top of

the head contain more than four branches per attachment point (Figure 11). All branches of the setae are shorter than the antennae (Figure 10).



Figure 9. *Psorophora columbica* (Dyar & Knab) larva.
Credits: Nathan Burkett-Cadena, UF/IFAS

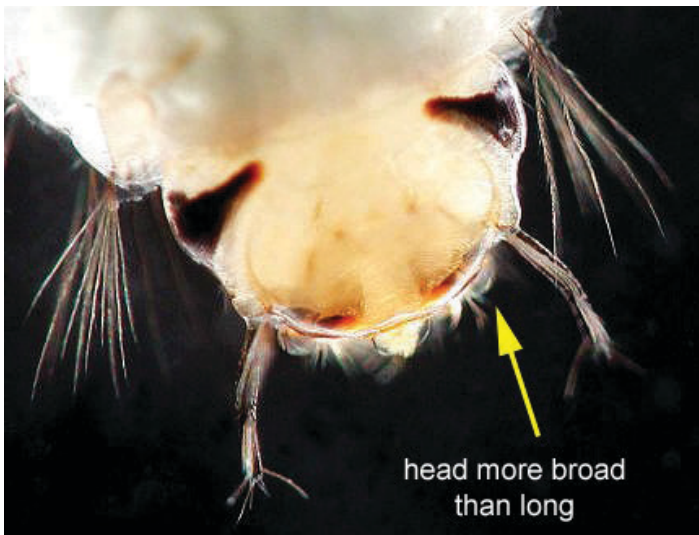


Figure 10. Larval *Psorophora columbica* (Dyar & Knab) head. Head capsule is wider than its length, giving a squashed appearance. Antennae are visible as two arm-like structures extending from the edge of the head, terminating in hair-like structures, or setae.
Credits: UF/IFAS

The siphon and terminal abdominal segment have important features for identifying mosquito larvae. The comb scales, a series of spiny barbs located on the eighth abdominal segment (Figure 12), are thorn-like, with shorter barbs adjacent to the main spine on each individual scale (Figure 12). *Psorophora columbica* has a line or arc of six comb scales (Figure 12).

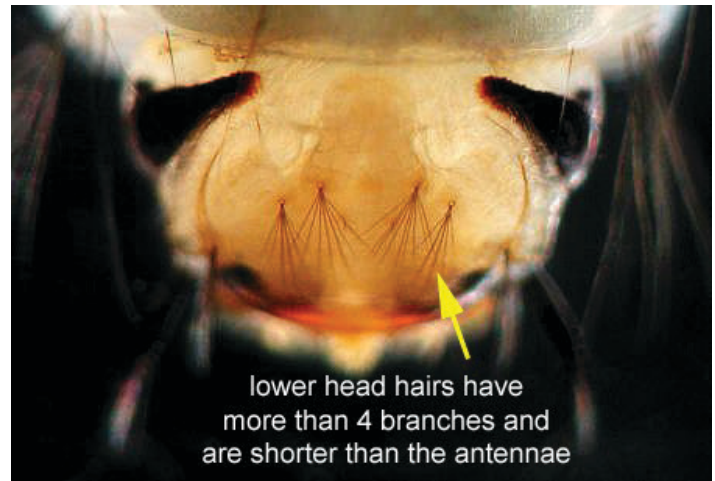


Figure 11. Larval *Psorophora columbica* (Dyar & Knab) head viewed from the top with the thorax oriented at the top of the image. The series of hair-like structures (setae) should contain more than 4 branches per attachment point with the length of each branch being shorter than the antennae.
Credits: UF/IFAS

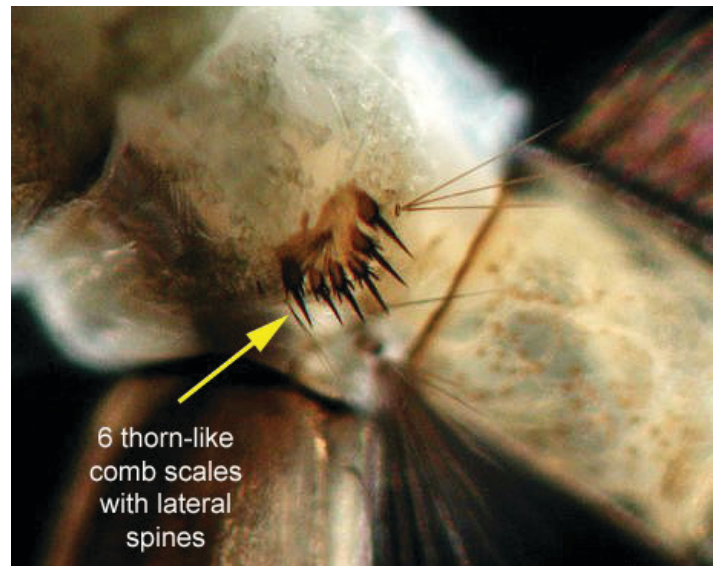


Figure 12. Larval *Psorophora columbica* (Dyar & Knab) terminal abdominal segments viewed from the side with the head and thorax past the top left of the image, the siphon extending past the the bottom left, and the final abdominal segment (anal segment) partially visible in the bottom right. A series of six barbed, thorn-like comb scales is located on the eighth abdominal segment.
Credits: UF/IFAS

The anal papillae, or anal gills, arise from the apex of the tenth abdominal segment, surround the anal opening, and are used in osmoregulation and respiration. The anal papillae (two dorsal and two ventral) of *Psorophora columbica* (Figure 13) are long and translucent, taper to a point, and are longer than the total length of the tenth abdominal segment (Figure 13). The papillae are fragile, frequently breaking off during handling or when preserving larvae in alcohol. If they are not present when examining the larvae for identifying characters, the siphon is the best alternative.

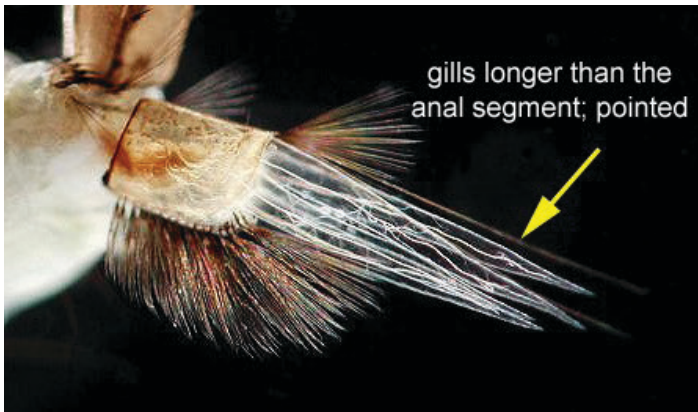


Figure 13. Larval *Psorophora columbiae* (Dyar & Knab) terminal abdominal segment viewed from the side, with the thorax and head oriented towards the left of the image. Translucent, pointed gills are attached to abdominal segment ten (anal segment), which are longer than the anal segment.

Credits: UF/IFAS

Extending dorsally from the eighth abdominal segment is a sclerotized (hardened) breathing tube called the siphon (Figure 14). The siphon is rigid and has several useful structures for identifying mosquito larvae. Near the base of the slightly bulbous siphon, where it connects to the abdomen, a series of pecten spines (also called teeth) arise from the cuticle (Figure 14). The variation in the number of pecten spines was the first character that implied geographically distinct forms or species of *Psorophora columbiae* existed (Bickley 1984). For general identification of *Psorophora columbiae* and the larger *Psorophora columbiae* species complex, a series of three to six pecten spines will arise from the siphon in succession with relatively equal spacing between them (Figure 14). When searching for pecten characters, it is notable that *Psorophora* as a genus typically have rounded, bulbous siphons (Figure 14).

Eggs

Eggs of *Psorophora columbiae* are difficult to find in the natural environment, because they are deposited in humid soil by gravid females. However, they have been described as dark, approximately 0.5 mm × 0.2 mm oblong structures with numerous spine-like tubercles that help adhesion to substrates (Figure 15; Bosworth et al. 1998).

Life Cycle and Biology

Psorophora columbiae females deposit eggs primarily on the damp soil of open, sunny locations subject to temporary flooding (Bolling et al. 2005), which can lead to quick colonization of temporary pools of water in open, exposed fields or marshes after rainfall events (Wagner et al. 2007). For example, hatched larvae have been collected from puddles, flooded tire ruts, and grassy swales (Lanzaro et al. 2015).

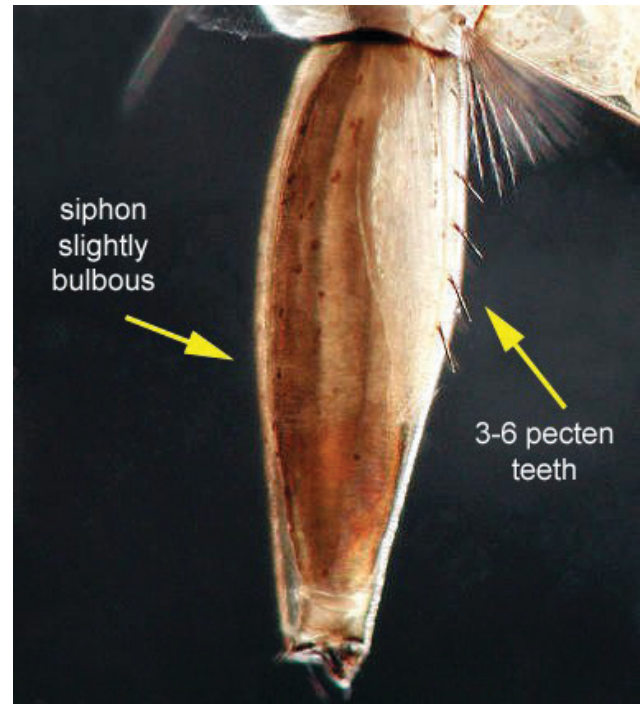


Figure 14. Larval *Psorophora columbiae* (Dyar & Knab) siphon with the head and thorax oriented towards the left of the image and the last abdominal segment (anal segment) in the top right. *Psorophora*, as a genus, typically have rounded, bulbous siphons where the middle portion of the segment is wider than the ends. A series of three to six straight, narrow spines, called pecten spines, is a diagnostic feature of *Psorophora columbiae*.

Credits: UF/IFAS

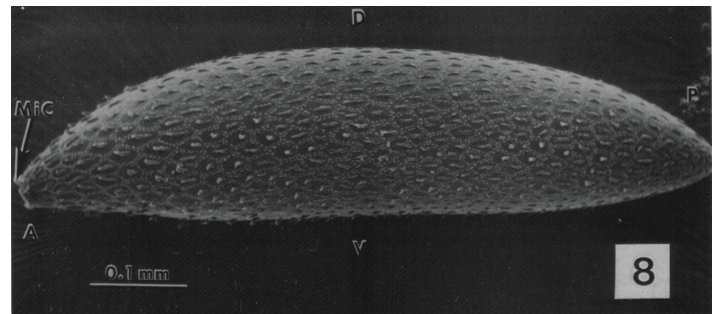


Figure 15. Egg of *Psorophora columbiae* (Dyar & Knab), taken from a scanning electron micrograph figure in Bosworth et al. (1998). The anterior end of the egg is oriented to the left in the image, with the micropyle (or follicular attachment point when in the ovary) denoted with MiC. The posterior end (P), dorsal side (D), and ventral side (V) are also denoted.

Regardless, *Psorophora columbiae* have an ephemeral, floodwater-type biology in the US, particularly given that floodplains, runoff areas, and low drainage areas do not retain water permanently (Cleckner et al. 2011). Floodwater mosquitoes quickly occupy temporary standing water, often after the onset of heavy rains and the resulting flooding of low areas that are not necessarily connected to adjoining streams or ponds. As a consequence, the species is frequently found in close association with agricultural wetlands (Botello et al. 2013) such as rice fields or areas

of irrigation runoff (Allen et al. 2010). Flooding of arid habitats in southwest US desert and semi-arid transitional lands, particularly from irrigation, can result in population explosions of *Psorophora columbiae* (Godsey et al. 2012, Britch et al. 2011, Pitzer et al. 2009).

Although not principally a peridomestic mosquito, *Psorophora columbiae* does occur readily amidst developed areas provided that a larval habitat is located in the area. For example, artificial zoological enclosures intended to replicate wetland habitat, such as for alligators, have been found to actively harbor this mosquito (Unlu et al. 2010). The mosquito also has been found incidentally in water-filled tires, but containers do not represent a significant habitat for the species (Qualls and Mullen 2006).

Courtship and mating occur in flight after adult males have congregated around landmarks in the environment (Peloquin and Olson 1985). Flying males attract females by forming curtain-like or funnel-like swarms that then transition into figure-eight patterns (Peloquin and Olson 1985). As with other mosquitoes, males do not blood feed, instead searching out nectar sources from plants and honeydew (Foster and Walker 2018). Adult females frequently take sugar meals as well (Foster and Walker 2018), but are pestiferous when seeking blood meals to nourish eggs.

Psorophora columbiae has historically been described as preferring to take blood meals from large mammalian hosts, particularly livestock such as cattle (Kuntz et al. 1982). However, the mosquito is known to feed on any mammalian hosts, including humans, within the vicinity of its habitat (Britch et al. 2011, Qualls et al. 2011). Exceptionally large outbreaks may even be linked to zoonotic pathogen transmission (Godsey et al. 2012; Pitzer et al. 2014). While livestock are well-recognized hosts of *Psorophora columbiae*, blood meal analysis in Florida showed that more *Psorophora columbiae* blood meals were taken from rabbits (40%) than any other host, including cows (37%) (Edman 1971).

Medical-Veterinary Importance

The range of reported incidence of canine heartworm (Figure 16) overlaps with the range of *Psorophora columbiae* (Figure 2), and *Psorophora columbiae* can carry infective stages of canine heartworm, *Dirofilaria immitis* (Leidy) (McKay et al. 2013). The mosquito has been implicated in transmission of this parasite in areas where multiple mosquito vector species are active concomitantly (McKay et al. 2013, Paras et al. 2014). Because *Psorophora columbiae* populations can reach such high levels after large rainfall

events, the abundance of *Psorophora columbiae* has led to its incrimination as a significant heartworm vector species (Paras et al. 2014). Therefore, precautions, such as prophylactic treatments, should be taken for canine heartworm, particularly in the southeastern US. Despite the importance of *Psorophora columbiae*, as many as 25 species across four different mosquito genera all contribute to the transmission of canine heartworm throughout the same range (Ledesma and Harrington 2012), which reinforces that vectors transmit this pathogen in concert and are not easily targeted for breaking the transmission cycle.

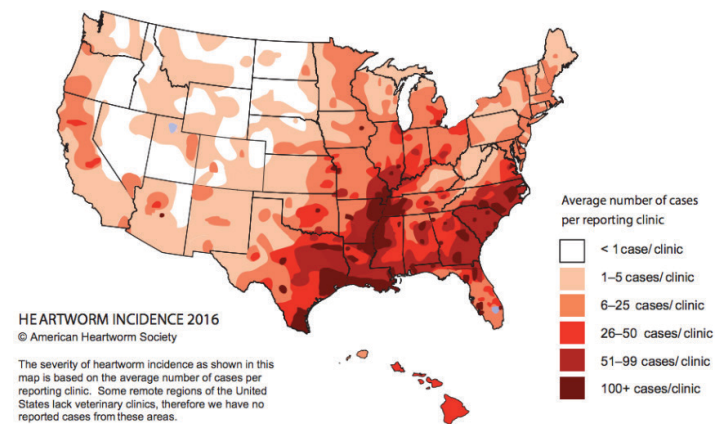


Figure 16. US distribution of 2016 reported incidence of canine heartworm, *Dirofilaria immitis* (Leidy). From the American Heartworm Society.

In field investigations, *Psorophora columbiae* has frequently tested positive for West Nile virus (Unlu et al. 2010), but it has never been implicated as a major epidemic vector responsible for outbreaks of West Nile virus in humans (Godsey et al. 2012). In contrast, *Psorophora columbiae* is considered to be a fully competent vector (has the ability to transmit) of epidemic strains of Venezuelan equine encephalitis virus (Moncayo et al. 2008). However, the eastern forms of *Psorophora columbiae* are less susceptible to infection than *Psorophora toltecum* occurring in Mexico or California (Moncayo et al. 2008).

Rift Valley fever virus is not present in North America, but laboratory infection studies suggest that *Psorophora columbiae* could likely be vectors of Rift Valley Fever virus due to abundance of the species and biting activity in mammalian systems (Turell et al. 2015). Infections would likely arise from frequency of bites rather than high compatibility with the virus because *Psorophora columbiae* possess a salivary gland barrier that limits the amount of virus particles transmitted during a bite (Turell et al. 2015). Large numbers of *Psorophora* have historically contributed to suffocation, anemia, and occasional transmission of anaplasmosis in cattle (Bishop 1933, Howell et al. 1941).

Management

Habitat identification is a critical first step for management. When ephemeral pools, drainage areas, and shallow floodplains are treated with biorational larvicides such as *Bacillus thuringiensis israelensis* (Bti) or Spinosad, the emergence of pestiferous, possibly harmful, adults can be virtually eliminated from the targeted area (Allen et al. 2010; 2008). Otherwise, point-source adulticides applied to harborage sites and along structural barriers that intercept the flight path of *Psorophora columbiae* can effectively reduce human contact with adult mosquitoes (Britch et al. 2011). Treating cattle with topical ectoparasite preventatives, such as a permethrin, can provide a reduction in *Psorophora columbiae* when the mosquitoes attempt to feed on the livestock (Nasci et al. 1990).

In the aftermath of major storm systems, ephemeral pools capable of supporting floodwater mosquitoes, including *Psorophora columbiae*, can be too abundant to manage with point-source treatments alone (Breidenbaugh et al. 2008). Hurricanes, excessive rain, or an otherwise unexpected large-scale outbreak of floodwater mosquitoes can be quickly remediated with area-wide intervention using tools such as aerial adulticiding (Breidenbaugh et al. 2008).

In the event that larvicide and adulticide tools are not an option, there are personal protection measures that can help reduce contact with biting mosquitoes. Mass collection traps, many designs of which are available to consumers, have been demonstrated to catch large numbers of *Psorophora columbiae* when used with appropriate attractants (Allen et al. 2009). In order for trap-and-removal strategies to work, the homeowner must take care to place the trap somewhere outside of normal activity, preferably along harborage such as bushes and other vegetation (Allen et al. 2009). Otherwise, the attractiveness of humans or animals will overpower the trap, leading to aggregation of biting mosquitoes near active areas. Topical skin repellents can reduce biting contact with *Psorophora columbiae* when products are applied correctly (Qualls et al. 2011). As an alternative, stationary tools or portable emanators that deliver spatial repellents can prevent *Psorophora columbiae* bites through a combination of repellency (Dame et al. 2014) and mortality (Bibbs et al. 2015) when mosquitoes fail to escape the area.

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