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Eastern Treehole Mosquito *Aedes triseriatus* (Say, 1823) (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

Aedes triseriatus (Say, 1823), a mosquito species native to eastern and central North America, is commonly known as the eastern treehole mosquito because its larvae are frequently found developing in water-filled tree cavities within hardwood forests (Barker et al. 2003a). However, it can also be found in human-made objects that hold standing water, such as discarded tires or plastic containers (Bara and Muturi 2015). Due to the potential risk of its introduction and establishment beyond its native range, it is considered a potential invasive species. The transport of containers with immature stages of this species may facilitate spread as was observed for other invasive mosquito container species such as the yellow fever and Asian tiger mosquitoes (Lounibos 2002, Juliano and Lounibos 2005).

Aedes triseriatus is the primary vector of La Crosse virus (LACv), which is the most prevalent cause of pediatric arboviral encephalitis in North America (Calisher 1994). Amplification and spillover of LACv involve small mammals such as chipmunks and squirrels. However, the short viremic period in these hosts may limit their role in maintaining the virus over time (Borucki et al. 2002). Unlike other arboviruses, LACv exhibits high rates of vertical transmission, meaning the virus can be passed from female mosquitoes to their offspring during reproduction. This enables the virus to persist in populations of *Aedes triseriatus* during unfavorable winter conditions (Woodring et al. 1998). Human infections occur when an infected female bites a human. Infections are particularly common in or near wooded areas.

Aedes triseriatus is classified within the subgenus Protomacleaya, which includes only four species in North America: *Aedes triseriatus*, *Aedes hendersoni, Aedes brelandi*, and *Aedes zoosophus*. Notably, the adult forms of *Aedes hendersoni* and *Aedes triseriatus* are remarkably similar, making it difficult to differentiate them without detailed examination of adult or larval morphology or the use of molecular tools.

Synonymy

Ochlerotatus triseriatus (Reinert, 2000)

Culex triseriatus (Say, 1823)

Distribution

Aedes triseriatus is broadly distributed across the eastern United States and parts of southeastern Canada (Burkett-Cadena 2013). In Canada, it has been reported in southern parts of Ontario, Quebec, New Brunswick, and Manitoba (Williams et al. 2007, Koloski et al. 2021). This species is also present in Cuba (Wilkerson et al. 2021) and the Nearctic region of Mexico. It has been recorded in several northeastern states including Chihuahua, Coahuila, Nuevo León, and Tamaulipas as well as in central regions such as Morelos and Tlaxcala (Sánchez-Trinidad et al. 2014) (Figure 1). Beyond its native range, *Aedes triseriatus* has been detected in Greenland and France, although there is no evidence that populations were established in either location (Becker et al. 2012).

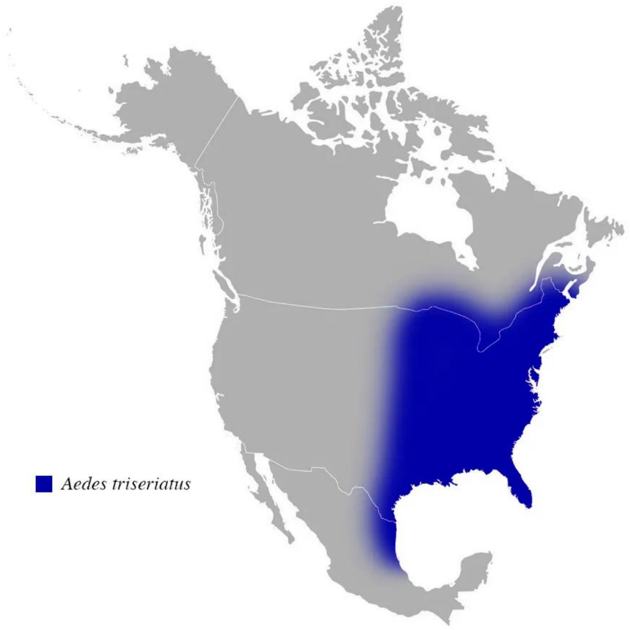

Figure 1. Distribution of *Aedes triseriatus* in North America.
Credit: Sergio Méndez-Cardona, UF/IFAS

The local abundance of *Aedes triseriatus* is influenced by environmental factors such as urbanization and associated habitat fragmentation, which is typically associated with lower population levels. This decline may be further exacerbated by the presence of invasive *Aedes* species that outcompete *Aedes triseriatus* in shared larval habitats, potentially displacing it in parts of its native range (Rochlin et al. 2013).

Description

Adults

Adult *Aedes triseriatus* are medium-sized mosquitoes with a predominantly dark body characterized by silvery white scales in specific areas (Figure 2). The proboscis, palps, wings, and legs are distinctly covered with dark scales. Unlike some other well-known *Aedes* species such as *Aedes aegypti*, *Aedes triseriatus* lacks pale scale bands on its legs (Figure 3). On the thorax, silvery scales form a distinctive pattern on the dorsal surface, known as the scutum, where narrow silvery stripes along the lateral margins are separated by a broad black stripe notably wider than the pale lateral patches (Burkett-Cadena 2013). The extent of the black stripe varies regionally and tends to be wider in populations from Florida (Figure 4). Additionally, patches of pale scales occur laterally on the abdomen at the base of each segment.

Figure 2. Lateral view of a live adult female *Aedes triseriatus*.
Credit: Nathan Burkett-Cadena, UF/IFAS

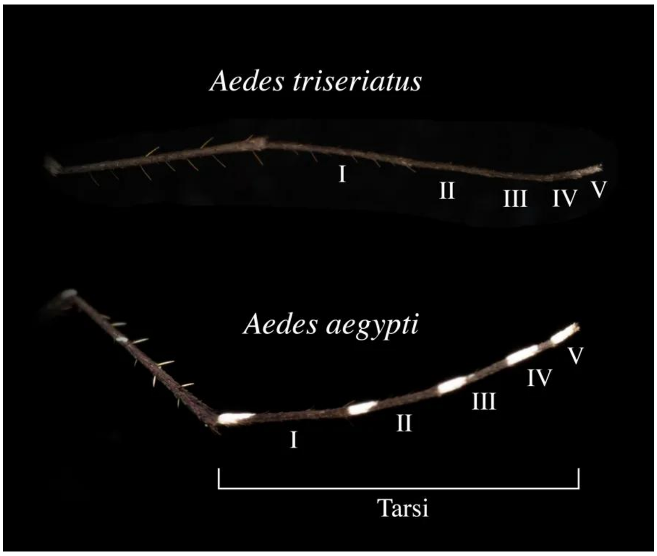

Figure 3. Comparison of the terminal segments of the legs (tarsi) of *Aedes triseriatus* and *Aedes aegypti*, illustrating absence of pale bands in *Aedes triseriatus*.
Credit: Sergio Méndez-Cardona, UF/IFAS

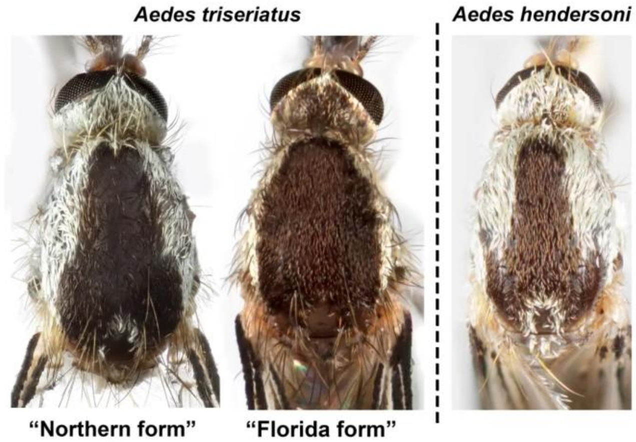

Figure 4. Dorsal view of the scutum of *Aedes triseriatus*, illustrating regional variation between northern and Florida forms (left), compared with *Aedes hendersoni* (right).
Credit: Nathan Burkett-Cadena, UF/IFAS

Aedes triseriatus is very difficult to distinguish from its close relative *Aedes hendersoni* in adult form. The primary differences between these species are the number and size of hair-like structures on the scutum, known as setae, and the curvature of the claws at the tip of their legs (Darsie and Ward 2005). Additional distinguishing features include the width of the dark stripe on the scutum and the number of setae within the scutal fossa, a shallow depression on the upper thorax (Figure 4). In *Aedes triseriatus*, the anterior half of the dark stripe is broad, and the scutal fossa contains 1–4 weakly developed setae. In contrast, *Aedes hendersoni* has a narrower stripe and has numerous well-developed setae in the scutal fossa. The two species also differ in the coloration of the scales at the base of the costal vein, being black in *Aedes triseriatus* and pale in *Aedes hendersoni* (Harrison et al. 2016). Because these characteristics can be difficult to observe, distinguishing the two species usually relies on larval traits or molecular identification techniques (Wilson et al. 2014).

Eggs

The eggs of *Aedes triseriatus* are dark, cylindrical, and taper at both ends, with an average length of 0.69 mm (~1/32 in). They are larger and lighter in color compared to those of other common *Aedes* species mosquitoes that develop in tree holes and other natural or artificial water-holding containers (Bova et al. 2016) (Figure 5). The egg surface exhibits a reticulate pattern, forming irregularly shaped cells across the chorion. When cleared and viewed under a light microscope, the eggs of *Aedes triseriatus* can be distinguished from those of *Aedes hendersoni* by the absence of a fine rosette pattern, a feature present only in *Aedes hendersoni* (Zaim et al. 1977).

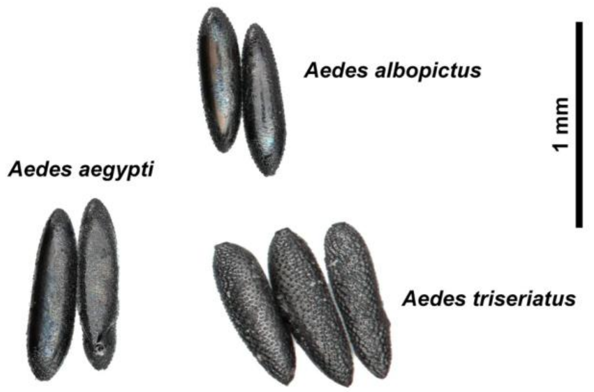

Figure 5. Egg size differences among common container breeding *Aedes* mosquitoes.
Credit: Nathan Burkett-Cadena, UF/IFAS

Larvae

The larvae of *Aedes triseriatus* are usually gray in color and worm-like in appearance (Figure 6) (Grimstad et al. 1974). The body is divided into a head, thorax, and abdomen, each bearing small, hair-like cuticular projections known as setae. These setae are named based on their anatomical location and serve as important morphological markers for species identification (Figure 7).

Figure 6. Mature (fourth instar) larvae of *Aedes triseriatus* suspended in water, breathing through their siphons at the water’s surface.
Credit: Nathan Burkett-Cadena, UF/IFAS

Key diagnostic features used to identify *Aedes triseriatus* are found primarily on the head and abdomen. On the head, seta 1-A, located on the antennae, is simple (not branched) and long (Figure 8A). Additionally, on the dorsal surface of the head, seta 4-C is positioned anteriorly near the midline and typically has more than eight branches (Figure 8B).

On the eighth abdominal segment, spine-like structures known as comb scales (Figure 8C), help differentiate *Aedes* *triseriatus* from other container mosquito species. The comb scales are uniformly fringed with tiny spines, typically 8 to 15 in number, and arranged in a single uneven row (Figure 7 and 8C) (Darsie and Ward 2005).

Like related mosquito larvae, *Aedes triseriatus* possesses a breathing tube (respiratory siphon) arising near the terminal end of the abdomen. This tubular structure enables the larva to breathe at the water's surface and bears a row of small spines (called pecten spines) along its lower basal margin (Figure 7). Adjacent to the siphon, abdominal segment 10 features a dark plate of exoskeleton known as the saddle, which partially encircles the segment. On this same segment, seta 1-X is located near the ventral edge of the saddle. In *Aedes triseriatus*, seta 1-X is 4–5 branched, and its length is equal to or slightly shorter than the width of the saddle, whereas in *Aedes hendersoni*, it is 2–3 branched and longer than the length of the saddle. Another seta, seta 4-X, a brush-like seta along the lower margin, consists of six pairs of fan-like setae in *Aedes triseriatus* (Figure 8D), compared to five in *Aedes hendersoni*. Additionally, the anal papillae, paired finger-shaped structures involved in osmoregulation, are distinctly asymmetrical and tapered in *Aedes triseriatus*, with the dorsal (upper) pair longer than the ventral (lower) pair. In contrast, *Aedes hendersoni* displays bulbous papillae of approximately equal length (Burkett-Cadena 2013).

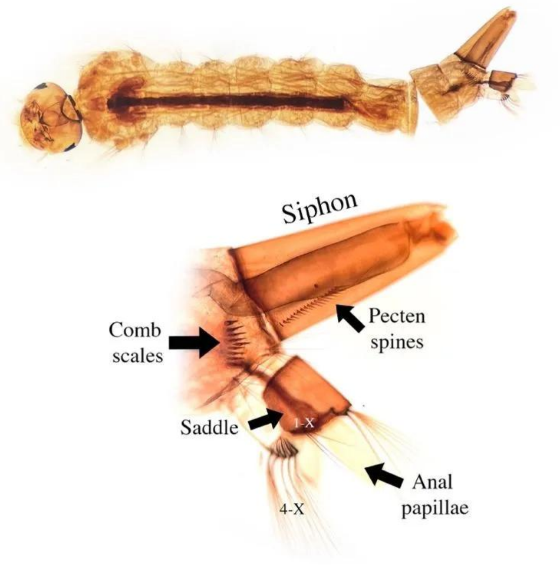

Figure 7. Fourth instar larva (a development stage between molts) of *Aedes triseriatus*, highlighting the terminal abdominal segments and key morphological structures used for species identification.
Credit: Sergio Méndez-Cardona, UF/IFAS

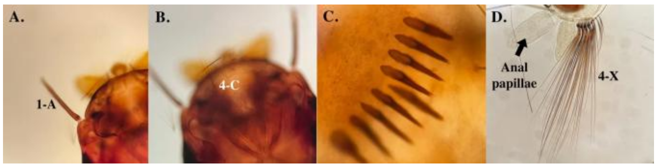

Figure 8. Structures used for identification of *Aedes triseriatus* larvae. (A) Seta 1-A of the antennae. (B) Seta 4-C on the dorsal head. (C) Comb scales on abdominal segment 8. (D) Seta 4-X on abdominal segment X, showing six pairs of fan-like setae.
Credit: Sergio Méndez-Cardona, UF/IFAS

Pupae

In *Aedes triseriatus*, as in other mosquito species, the pupa is distinctly comma-shaped, consisting of a bulbous cephalothorax (a fusion of the head and thorax) and a curved, tapering abdomen (Figure 9). Prominently positioned on the dorsal surface of the cephalothorax are a pair of dark brown, conical respiratory trumpets that allow the pupa to breathe air at the water's surface. The abdomen narrows posteriorly into a pair of oval, paddle-like structures used for locomotion. The paddles are mostly smooth, though fine denticles may be present near the margins and occasionally form small submarginal protrusions (Darsie 1951, Darsie 2005).

Figure 9. Pupae of *Aedes triseriatus* breathing at the water surface.
Credit: Nathan Burkett-Cadena, UF/IFAS

Life Cycle and Biology

Aedes triseriatus mosquitoes undergo complete metamorphosis with four distinct developmental stages: egg, larva, pupa, and adult. Compared to many other *Aedes* species that develop in treeholes or human-made containers, *Aedes triseriatus* requires longer development time to reach its adult form (Ho et al. 1989). Under laboratory conditions, complete development to the adult stage ranges between 16 and 24 days, depending on a combination of photoperiod and temperature (Westby and Juliano 2015). In the field, time to pupation ranges between 7 and 10 days (Ho et al. 1989), with longer time required when larvae experience nutrient limiting conditions.

Eggs

Aedes triseriatus females typically lay their eggs on the inner walls of tree holes just above the waterline, with oviposition activity markedly higher in forested habitats than in urban or residential areas (Barker et al. 2003b). Like other *Aedes* species, the eggs of *Aedes triseriatus* are highly resistant to desiccation, which enables them to remain viable until environmental conditions support hatching. In temperate regions, egg diapause allows the species to survive through the winter. Egg diapause is induced following completion of embryonic development and when the eggshell is exposed to short daylength (e.g., winter in the Northern Hemisphere, Shroyer and Craig 1980). Remarkably, LACv persists within *Aedes triseriatus* eggs during the overwintering period (Woodring et al. 1998).

Egg hatching in *Aedes triseriatus* begins when tree holes are flooded (e.g., rainfall). A reduction in dissolved oxygen, caused by microbial activity, is considered an important cue initiating this process. However, only a portion of the eggs in a batch hatch at one time (i.e., installment hatching, Novak and Shroyer 1978). The staggered emergence serves as a bet-hedging strategy against brief favorable periods for larval development. Notably, eggs from high-precipitation areas hatch with less delay than those from drier regions, an adaptation that helps the species thrive across the diverse climates in its extensive geographical range (Khatchikian et al. 2009).

Larvae

Larvae of *Aedes triseriatus* filter-feed on organic detritus such as decaying leaf litter, invertebrates, and microbes. Their feeding behavior includes suspension feeding, skimming the air-water interface, brushing surfaces of containers and leaves, and chewing on leaf veins (Walker and Merritt 1991). Staggered hatching plays a key role in minimizing competition for similarly sized food particles, enabling multiple larval cohorts to coexist and develop simultaneously (Edgerly and Livdahl 1992).

Temperature, food availability, and larval density are key factors influencing the larval development time of *Aedes triseriatus* (Teng and Apperson 2000). However, when larvae from different parts of its geographic range are reared under identical conditions, variation in development times persists, suggesting local adaptation shaped by interactions with other species commonly found in tree hole habitats (Livdahl 1984). Under low temperature and low food conditions some populations may diapause as fourth stage larvae, slowing down rate of development until conditions are favorable for pupation (Clay and Venard 1972).

Aedes triseriatus larvae display anti-predatory behaviors, such as reducing risky foraging activity, when exposed to their predators (e.g., *Toxorhynchites rutilus*). These behavioral adaptations may help *Aedes triseriatus* overcome the competitive disadvantages it faces when co-occurring with more efficient larval competitors like *Aedes albopictus* (Kesavaraju et al. 2007). When coexisting with other mosquitoes, the combination of anti-predator behavior and body size can determine how *Aedes triseriatus* competes with *Aedes albopictus*, enabling *Aedes triseriatus* to survive in the presence of both predators and stronger competitors (Alto et al. 2009).

Pupae

After the larval stage, mosquitoes enter a non-feeding pupal stage during which they undergo internal and external transformation. Pupae of *Aedes triseriatus* generally rest motionless at the water surface but dive if disturbed. Pupae often rest where the water meets vertical surfaces of submerged structures within the container, a behavior that likely helps them conserve energy and avoid predation (Shuey et al. 1987).

Adults

Adults are generally diurnal, with peak activity occurring in the early morning and late afternoon. Host-seeking typically peaks in the morning; however, activity patterns vary across its distribution range. A study in eastern Tennessee found that *Aedes triseriatus* are most likely to seek hosts after 5:00 pm, indicating crepuscular or even nocturnal activity (Urquhart et al. 2017).

Female *Aedes triseriatus* mosquitoes require a blood meal from a vertebrate host to produce eggs. Across its range, *Aedes triseriatus* feeds on different hosts depending on their local availability. In the midwestern United States, *Aedes triseriatus* commonly feeds on white-tailed deer (*Odocoileus virginianus*), eastern chipmunks (*Tamias striatus*), and gray squirrels (*Sciurus carolinensis*). In areas where deer are abundant, deer serve as the primary blood meal source (Burkot and DeFoliart 1982). However, in more urbanized settings where deer are less common, eastern chipmunks are more frequently targeted (Nasci 1982). This species will opportunistically feed on humans, although at lower rates than other mammalian hosts (2%–10%, Burkot and DeFoliart 1982; 12%, Nasci 1985; 7.4%, Apperson et al. 2004; 8%, Richards et al. 2006; 4.7% Molaei et al. 2008). In addition to mammals, avian, reptilian, and anuran blood meals have also been documented (Richards et al. 2006). Avian blood meals have been reported in Connecticut (Molei et al. 2006), while in the coastal plain of North Carolina, 75% of *Aedes triseriatus* blood meals were taken from turtles, indicating a substantial regional variation in host utilization (Irby and Apperson 1988).

Medical Importance

Aedes triseriatus is the primary vector of La Crosse virus (LACv), the causative agent of La Crosse encephalitis, a significant arboviral disease in North America. The recognized horizontal transmission cycle of LACv involves *Aedes triseriatus* mosquitoes and small mammal hosts, such as chipmunks and gray squirrels. However, the relative importance of small mammals to the maintenance of LACv in nature remains uncertain, partly due to the short viremic periods observed in squirrels and chipmunks, and the tendency of *Aedes triseriatus* to feed on other hosts, including deer. Humans and deer are considered dead-end hosts of LACv, meaning they do not contribute to onward virus transmission but can become infected through the bite of an infected mosquito and suffer severe neurologic consequences (Figure 10).

La Crosse virus can also be transmitted horizontally between mosquitoes during mating (venereal transmission) and vertically from infected females to their offspring through ovarian infection (transovarial transmission). Vertical transmission of LACv may be the primary mechanism for viral amplification and maintenance, supported by high rates of vertical transmission (98%, Miller et al. 1977) and numerous progeny infected (filial infection, 71%) over the lifespan of vertically infected female parents under laboratory conditions (Miller et al. 1977). LACv infection is also associated with changes in mosquito physiology and behavior. For example, *Aedes triseriatus* females infected with LACv mate earlier and exhibit higher insemination rates than uninfected females (Gabitzsch et al. 2006, Reese et al. 2009). Infected females also produce eggs with greater diapause mortality but higher hatching success among viable eggs (McGaw et al. 1998), while showing no reductions in adult longevity and fecundity (Costanzo et al. 2014). Collectively, these observations suggest that LACv associated changes in physiology and behavior of *Aedes triseriatus* could promote virus amplification and maintenance in nature.

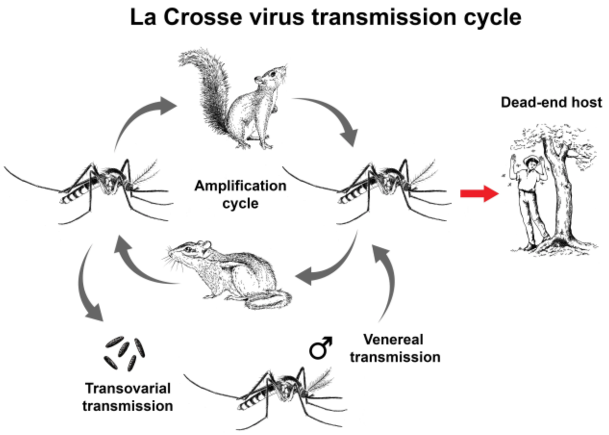

Figure 10. Transmission of La Crosse virus. In the amplification cycle, eastern gray squirrels and chipmunks serve as amplification hosts and *Aedes triseriatus* is the primary vector. The red arrow denotes occasional spillover to humans, who are dead-end hosts. Other transmission mechanisms among mosquitoes are shown, with transovarial transmission from infected females to eggs and venereal transmission through mating.
Credit: Sergio Méndez-Cardona, UF/IFAS

La Crosse encephalitis predominantly affects children, who are at greatest risk for severe neurological complications (Day et al. 2023). The daytime-biting behavior and container-breeding ecology of *Aedes triseriatus* facilitate frequent human contact, especially in forested environments (Clark et al. 1985). While *Aedes albopictus* and *Aedes japonicus* are recognized as competent vectors of LACv (Grimstad et al. 1989; Sardelis et al. 2002), their role as accessory vectors in virus maintenance remains under active investigation (Bara et al. 2016). Effective control of *Aedes triseriatus* relies primarily on source reduction, which involves eliminating artificial container habitats to limit mosquito breeding and reduce human risk (Parry 1983). Successful control programs integrate source reduction with clinical education on La Crosse encephalitis and community outreach efforts that encourage habitat cleanup and public participation (Day et al. 2023).

Historically, most human cases of La Crosse encephalitis have been reported in the Midwest states of Illinois, Minnesota, Ohio, and Wisconsin. However, recent decades have seen a notable increase in cases emerging in the Appalachian region (Leisnham and Juliano 2012). This emergence has been partly attributed to the introduction of the invasive mosquitoes *Aedes albopictus* and to a lesser extent *Aedes japonicus* (Leisnham and Juliano 2012; Westby et al. 2015), both of which have been found naturally infected with LACv in this region. More recent research suggests that the rise in LACv cases is multifactorial, influenced by changes in human demographics, wildlife populations, and land-use patterns (Bewick et al. 2016). However, La Crosse encephalitis was recognized in western North Carolina as early as 1964, around the same period it was identified in the upper Midwest (Kelsey and Smith 1978). Thus, the apparent "emergence" in Appalachia may also reflect improved clinical recognition and standardized case reporting, particularly following the implementation of the National Electronic Telecommunication System for Surveillance and national case definitions (Wharton et al. 1990).

Regarding land use, human LACv risk appears to decline with logging activities, as *Aedes triseriatus* abundance is lower in logged areas compared to undisturbed forests, and LACv-positive vectors are more frequently detected in undisturbed sites (Hopkins et al. 2018; Hopkins et al. 2020). In contrast, land-use changes linked to human settlements can elevate exposure in certain contexts. Poorly maintained peridomestic sites with many artificial containers supported greater oviposition, adult abundance, and a higher proportion of gravid or blood-engorged females than adjacent forests, whereas well-maintained sites with fewer containers showed the opposite pattern. Bloodmeal analysis also revealed a higher proportion of human-derived meals in peridomestic areas, consistent with greater host availability near homes (Tamini et al. 2021).

Although LACv is the most significant pathogen transmitted by *Aedes triseriatus*, this species may also contribute to the transmission of other pathogens. *Aedes triseriatus* has been found infected with West Nile virus (WNV) and is considered a potential vector for this pathogen (Erickson et al. 2006; Unlu et al. 2010). Additionally, it is recognized as a possible vector of dog heartworm (*Dirofilaria immitis*), a parasitic disease affecting domestic dogs (Debboun et al. 2005).

Surveillance

The container-breeding behavior of *Aedes triseriatus* has been effectively exploited in the development of traps for their detection. Early oviposition traps for this species consisted of cans lined with black muslin cloth and filled with organic debris (Loor and DeFoliart 1969). These designs were later adapted into black cups with water and lined with filter paper ("ovicups"), which are now the most widely used method for LACv vector surveillance (Day and Fryxell 2025). Ovicups address the limitations of larval surveys that require labor-intensive inspection of tree holes, discarded tires, and other water-holding containers. Notably, this approach has been shown to detect more positive sites for *Aedes triseriatus* while reducing time and labor (Leiser 1980). In addition to ovicups, gravid *Aedes triseriatus* can be targeted with BG-GAT (Gravid Aedes Trap), which passively collect females seeking oviposition sites and provide a complementary method for adult surveillance (Day and Fryxell 2025).

Adult surveillance methods primarily focus on collecting host-seeking females. CO_2-baited Centers for Disease Control and Prevention (CDC) light traps and BG-Sentinel traps are commonly used but are generally less sensitive than ovicups and BG-GAT and tend to underestimate *Aedes triseriatus* abundance (Day and Fryxell 2025). Recent field studies have demonstrated that the BG-Pro trap is substantially more effective for *Aedes triseriatus* surveillance, capturing approximately three times as many specimens as either the CDC light trap or the BG-Sentinel 2 equipped with a lure (Craig et al. 2025).

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