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Mosquitoes:
Biology and Integrated Mosquito Management

This publication is to inform Arizona residents, environmental health and pest management professionals

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Introduction

Mosquitoes are the most important insect pests that affect the health and wellbeing of humans and domestic animals worldwide. They can cause a variety of health problems due to their ability to transfer (vector) viruses and other disease-causing pathogens, even in the arid Southwest U.S.

Female mosquitoes usually require a blood meal from a vertebrate animal for egg production. Different species of mosquitoes have particular host animal preferences for blood-feeding. Some specialize on birds, some on humans, and still other mosquitoes feed on a wide range of hosts. During feeding the mosquito injects her saliva into the host's skin, which can generate an itchy reaction. If she has acquired a disease pathogen from an earlier blood meal, and sufficient time has elapsed for the pathogen to develop inside the mosquito (incubation period), the pathogen may be transmitted to a new host. Incubation periods are different for each pathogen and can range from days to weeks.

Mosquito-vectored diseases of humans include: arboviral encephalitis (brain inflammation), dengue fever, chikungunya, Zika, yellow fever, malaria and filariasis. Mosquitoes are not known to transmit blood-borne pathogens such as hepatitis or HIV. Different mosquitoes vector specific diseases, and many mosquito species are not vectors of any human disease.

West Nile virus (WNV) is the most common mosquito-borne disease affecting humans in Arizona, as of this writing. WNV is vectored by *Culex* mosquitoes (described below). The virus is primarily a disease of birds, but can also be transmitted to humans and horses. St Louis encephalitis (SLE) and Western equine encephalitis (WEE) viruses are enzootic (native to and present in animal populations) in Arizona, and can occasionally result in local human infections through the bite of infected mosquitoes. Western equine encephalitis in Arizona has been very rare since 2000, but human cases of SLE have occurred in Arizona in recent years.

West Nile has occurred in Arizona since 2003, and is an endemic (meaning usually found among people or in a region) disease; the other diseases are less commonly reported in humans in Arizona. Currently (2019), dengue, chikungunya and Zika viruses are considered **emerging diseases** in the U.S. A disease is classified as **emerging** when the number of cases has increased over the past 20 years and could potentially increase in the future. Emerging diseases account for more than 12% of all human disease causing pathogens. Dengue, chikungunya and Zika viruses are not currently transmitted by mosquitoes in Arizona, but the mosquito vector, *Aedes aegypti*, is present in many cities and towns in Arizona. The viruses are circulating in Mexico, so there is a risk of outbreak in Arizona.

The most susceptible to the effects of these mosquito-borne pathogens are children and the elderly. However, in some instances life-threatening illness and/or permanent debilitation can occur in infected human hosts of any age.

More information about mosquito-borne viral diseases can be found at https://extension.arizona.edu/sites/extension.arizona.edu/files/pubs/az1744-2017.pdf.

The Mosquito Life Cycle

Understanding the basics of mosquito biology will help you manage mosquitoes and related disease risks. All mosquitoes must have water to complete their life cycle, although some species require very little water and can develop in a thin moisture film. The mosquito life cycle is an example of complete metamorphosis. There are four distinct stages in the life of a mosquito: egg, larva (aquatic feeders), pupa (aquatic non-feeders) and adult (Fig. 1). Like most insects with complete metamorphosis, mosquitoes have developmental stages that look very different from one another.

They begin life as eggs. Female mosquitoes usually lay eggs a few days after acquiring a blood meal. Depending on

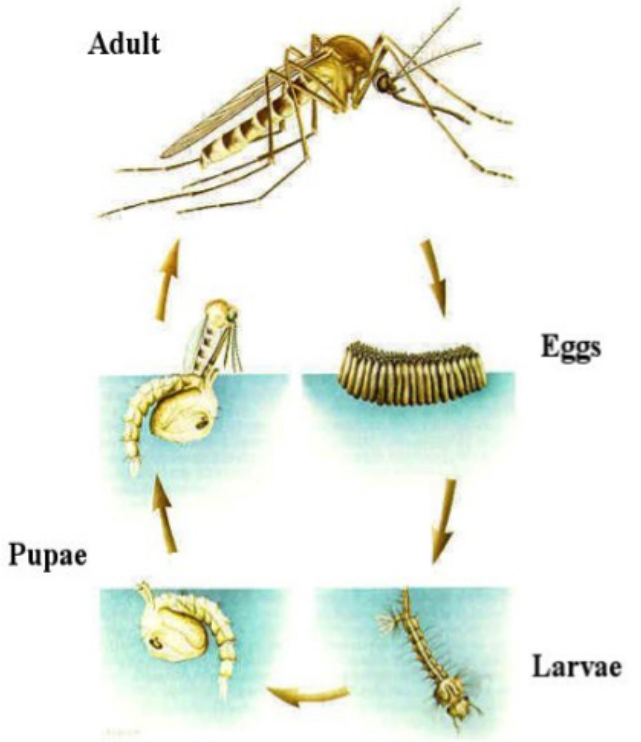

Fig. 1. Generalized mosquito life cycle: Mosquitoes need water to complete their life cycle.

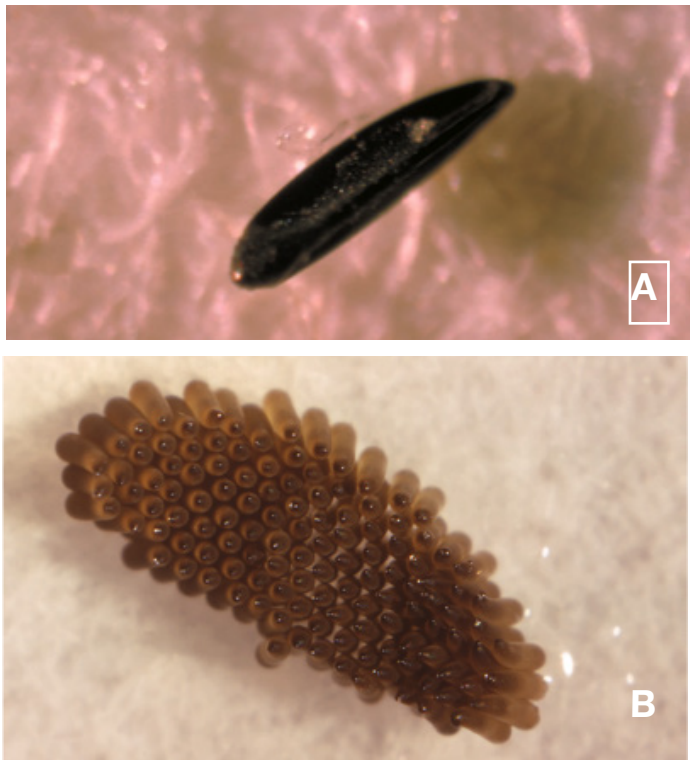

Fig. 2. Mosquito eggs. A, single egg of *Aedes aegypti*; B, eggs of *Culex quinquefasciatus* in rafts. Photos by the Centers for Disease Control and Prevention (CDC) Public Health Image Library; Harry Weinburgh/CDC.

the species the eggs may be laid singly (e.g., *Aedes aegypti*, Fig. 2A) or in rafts (e.g., *Culex* mosquitoes) (Fig. 2B). The eggs are laid on the surface of water, on the sides of containers, or on damp soil.

The eggs hatch into little larvae or "wrigglers" that swim in the water and feed on microorganisms or decaying organic matter. Ingested control agents can be used to kill larvae. A larva goes through four growth stages called instars, in which they grow in size, before reaching the non-feeding pupal stage. The larvae must come to the surface of the water to breath (with the exception of a few specialized mosquitoes). Mosquito larvae have a siphon at the tail end of the body (Fig. 3). The siphon permits larvae to breathe by penetrating the surface of the water to access air directly.

After the fourth larval instar, the pupa forms. Pupae, are often called "tumblers", as they rotate within the water column. Similarly to larvae, mosquito pupae breathe by using their respiratory "trumpets" (Fig. 4) to draw air from the atmosphere directly through the surface of the water. Larvae and pupae can be killed by cutting off their access to air with oils on water surfaces (e.g., CocoBear™). The pupal stage is normally quite short (1-2 days), after which the adult mosquito emerges. The immature stages of mosquitoes are sometimes confused with tadpoles or leeches, and aquatic non-mosquito insect larvae are sometimes mistaken for mosquito larvae. If you are uncertain what you have found and wish to submit specimens for identification, please follow these submission instructions: https://extension.arizona.edu/insect-identification.

Fig. 3. Siphon at the tail end of mosquito larva *(Aedes vexans)*. Photo by Michelle Cutwa-Francis, University of Florida – Florida Medical Entomology Laboratory.

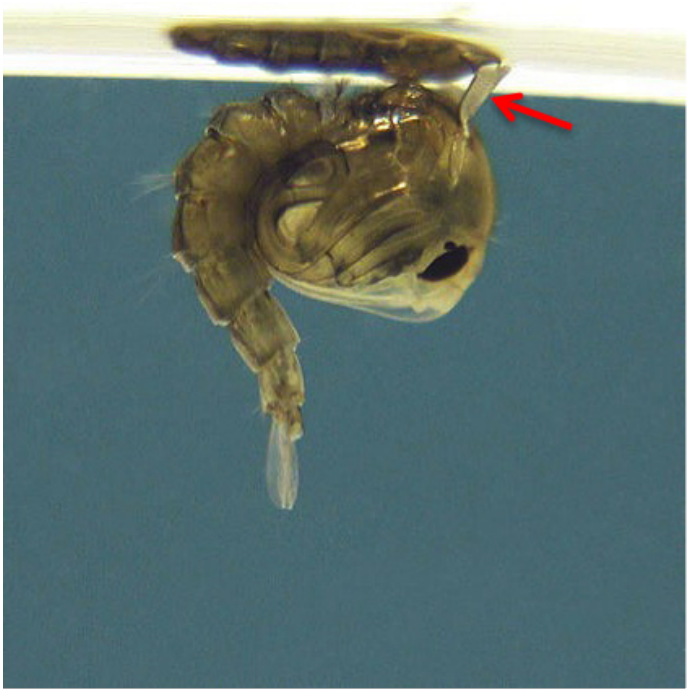

Fig. 4. Respiratory trumpet in mosquito pupa (*Psorophora columbiae*). Photo by Michelle Cutwa-Francis, University of Florida – Florida Medical Entomology Laboratory.

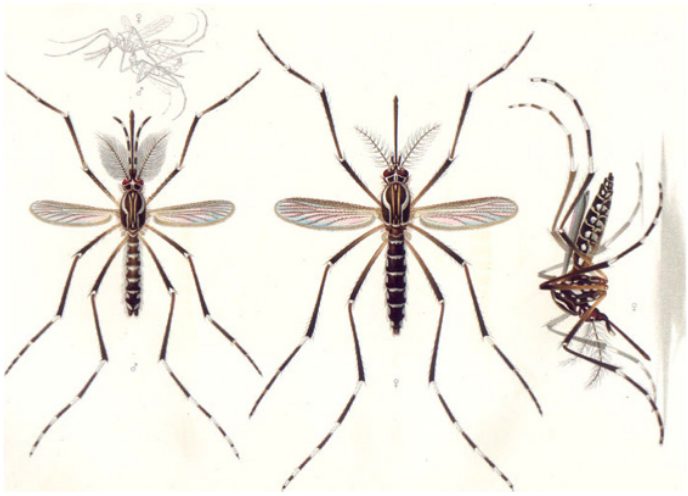

Fig. 5. Color print of the yellow fever mosquito *Aedes aegypti*. The male to the left, the female to the right. Original by E. A. Goeldi (1905). From Wikimedia Commons.

The last stage of development is the only stage involved in disease transmission, and the most difficult to manage. Adults fly and adult females bite to take a blood meal. Male and female mosquitoes also feed on flower nectar. Male mosquitoes look similar to females but can be identified by their feathery antennae (Fig. 5). The long hairs on their antennae help them to locate flying females. Male mosquitoes travel shorter distances from breeding sites than female mosquitoes. So if you find male mosquitoes, the breeding site is likely nearby.

Key Mosquito Species in Arizona

Although there are about 180 species of mosquitoes in the U.S. and more than 40 in Arizona, only a few are problems for residents, the *Culex* and *Aedes* mosquitoes being of greatest concern because of the disease-causing pathogens they vector. Here we focus on mosquito species of concern:

1) Western encephalitis mosquito, *Culex tarsalis*
2) Southern house mosquito, *Culex quinquefasciatus*
3) Yellow fever mosquito, *Aedes aegypti*
4) Western malaria mosquito, *Anopheles hermsi*
5) Inland floodwater mosquito, *Aedes vexans*
6) Dark ricefield mosquito, *Psorophora columbiae* form toltecum
7) Asian tiger mosquito, *Aedes albopictus*

Females of both *Culex* species deposit their eggs on water surfaces in tight groupings or rafts (Fig. 2B). Females prefer egg-laying habitats including most standing water sources ranging from mud-puddles, bird baths, outdoor trash cans, landscape ponds, pet water dishes/troughs, and empty flower pots, to larger sources such as school playing fields, over-irrigated lawns, drainage ditches, septic tanks and wells (Gouge 2004a, b). Agricultural fields and other flood-irrigated fields also can support high populations of *Culex* mosquitoes (Gouge 2004a, b).

1) Western encephalitis mosquito, *Culex tarsalis*

Culex tarsalis, or Western encephalitis mosquito (Fig. 6), is an important vector of WNV and SLE. It has a prominent white band across the piercing mouthparts (proboscis) and two white bands across all lower legs.

This mosquito breeds readily in freshwater sources such as ponds and is commonly found in riparian areas and agricultural sites retaining water for weeks rather than days. Females deposit their eggs on water surfaces in tight groupings or rafts (Fig. 2B). Adults can be found in diverse places such as vegetation, ground burrows, barns and culverts. They feed on birds and mammals, including

Fig. 6. Adult Western encephalitis mosquito *Culex tarsalis*. Photo by Joseph Berger, Bugwood.org.

humans. The Western encephalitis mosquito, *Culex tarsalis* is capable of flying 2-10 miles (sometimes much further) in search of a blood meal (Olkowski 1991), so area-wide management of this species is important.

2) Southern house mosquito, *Culex quinquefasciatus*

Culex quinquefasciatus, more commonly called the Southern house mosquito (Fig. 7), is found throughout the southern half of the U.S. It is a vector of West Nile virus and St. Louis encephalitis virus and can also vector heartworms in dogs (*Dirofilaria immitis*). The mosquito is predominately golden brown in coloration with solid colored legs, and a characteristic white-banded abdomen. It is an annoying pest at night, not only due to its bite but also its distinct high-pitched buzz that announces its presence.

The female *Culex quinquefasciatus* mosquitoes lay 6-7 broods (egg clusters) each containing about 300 eggs in her six weeks of life (Marin/Sonoma Mosquito & Vector Control District website, Cotati, CA). *Culex quinquefasciatus* prefers to lay eggs in fetid water with a higher organic content than *Culex tarsalis*. Preferred breeding sites are open septic tanks, storm drains, culverts and abandoned swimming pools. A more urban species than *Culex tarsalis*, *Culex quinquefasciatus* will lay eggs in a wide range of water bodies, including small containers. As adults they have a range of 1-5 miles from their origin (Olkowski 1991).

In Arizona, West Nile, and St. Louis encephalitis viruses are vectored by both *Culex* species from infected birds, and transmitted to humans as incidental hosts (CDC). Humans are considered "dead-end" hosts, because they do not produce sufficient virus in their blood to contribute to ongoing infection of biting mosquitoes. Disease incidence changes each year, during 2018 Arizona Department of Health reported 27 human cases of WNV, while in 2019, January through the August 30th 139 human cases of WNV had been confirmed.

Fig. 7. Color print of the Southern house mosquito *Culex quinquefasciatus*. The male to the left, the female to the right. Original by E. A. Goeldi (1905). From Wikimedia Commons.

Fig. 8. Adult yellow fever mosquito *Aedes aegypti* adult (above) and larva (below). Photos by Muhammad Mahdi Karim. From Wikimedia Commons.

3) Yellow fever mosquito, *Aedes aegypti*

Aedes aegypti, or yellow fever mosquito (Fig. 8), is a vector of several viral pathogens that cause disease in humans, and dog heartworm (*Dirofilaria immitis*) in dogs. Diseases of concern include dengue fever, chikungunya and Zika (all three are periodically brought into Arizona by travelers acquiring the viruses abroad and entering the U.S.). The species is classed as a possible vector of WNV, confirmed by the isolation of West Nile virus from field-collected mosquitoes (Turell et al. 2005).

Aedes aegypti can be identified by the white bands on the hind legs and distinct white lyre-shaped markings on the top of the thorax (back).

The yellow fever mosquito *Aedes aegypti* is not native to the desert southwest, but was introduced to the Western Hemisphere during the U.S. domestic slave trade years, becoming established in many eastern cities during the 18th and 19th centuries. *Aedes aegypti* was responsible for multiple epidemics of yellow fever during the 19th century. Yellow Fever has been eliminated from North America but the vector remains, and has spread across the country into the desert southwest, establishing well in urban areas of Arizona. It is a species that lives in close association with humans, even breeding indoors. Unlike *Culex* mosquitoes, *Aedes aegypti* does not disperse far from breeding sites. *Aedes aegypti* is a "you breed it – you feed it" mosquito. This is probably based on the availability of egg-laying sites and the ability to obtain human blood at distances spanning yards not miles. Its flight range is usually 50–110 yards, although it is capable of flying longer distances (about half a mile according to Reiter et al. 1995).

Females typically lay their eggs in man-made water-containers such as old tires, flower pots, barrels, cans, and various containers that hold a limited quantity of water (Bennett et al. 2003). Eggs are laid singly (Fig. 2A) on a moist surface just above the water line, and they hatch when water level is raised by rain, or an overhead sprinkler, etc. *Aedes aegypti* eggs are very resilient. They can withstand dry conditions for several months and under ideal conditions, up to a year, resuming development when water becomes available (Womack 1993). Once they hatch, the larvae develop in a relatively short time depending on the temperature. Adult females often bite around the ankles throughout the day, especially early evening. During 2017 *Aedes aegypti* was reported by the following tribes and counties in Arizona: Cochise, Fort McDowell Yavapai Nation, Graham, Greenlee, San Carlos, Maricopa, Pima, Pinal, Santa Cruz, Yavapai, and Yuma.

4) Western malaria mosquito, *Anopheles hermsi*

Malaria was eliminated as an endemic disease in the U.S. during the 1950's in part due to integrated mosquito management (IMM) strategies that have enabled us to keep this mosquito under control. However, in Arizona and California the Western malaria mosquito (see related species Fig. 9) *Anopheles hermsi* is still a potential vector of the malaria parasite. The mosquito has also been implicated in the transmission of avian malaria to birds, and the myxoma virus that causes myxomatosis in rabbits. This species and others transmitted malaria in the U.S. until the 1950's, and in recent years the Centers for Disease Control and Prevention (CDC) reports indicate an increasing number of travel related cases in the U.S. An increasing number of cases still occur in Arizona due to travelers or immigrants arriving from malaria-endemic areas.

Larvae of this species prefer clear, fresh seepage water in sunlit or partially shaded pools. Roadside ditches and grassy fields provide overwintering sites for adults. The Western malaria mosquito feeds aggressively on humans, and it bites rabbits, cattle, horses, and dogs also.

Fig. 9. This female *Anopheles* mosquito, is taking a blood meal from a human host. Photo by James Gathany/CDC.

5) Inland floodwater mosquito, *Aedes vexans*

Aedes vexans, or the inland floodwater mosquito (Fig. 10), is one of the most widespread mosquito pests in the world and is found throughout the continental U.S. The species is not considered to be an important vector of West Nile virus, but may be a secondary vector (Goddard et al. 2002) of WNV, as well as other encephalitis causing viruses, but plays a more significant role in the transmission of dog heartworm (*Dirofilaria immitis*) and myxoma to rabbits. Inland floodwater mosquitoes are vicious biters and are responsible for a large proportion of mosquito nuisance complaints. They are recognized as a pest species due to their abundance, widespread distribution and breeding potential in floodwater habitats. This mosquito is most active at sundown when they attack humans and other animals in swarms. The adults are brown with pale V-shaped marks on their abdomens (Fig. 10).

Aedes vexans eggs are laid on soil in areas that have a history of intermittent flooding, where they can lay dormant until flooded by water from the next rain or irrigation, allowing the eggs to hatch and larvae to grow and develop in temporary pools. Often only one generation is produced per flooding. Larvae can be numerous in floodwater habitats, and where irrigation or rainwater ponds and stands for more than three days, such as over-irrigated or poorly leveled yards and pastures, tail-water ponds, desert ponds, stock tanks, backed up washes and flood control drainage areas. In most cases, this abundant mosquito will dominate these floodwater habitats. *Aedes vexans* has a propensity to disperse and can cause nuisance far from its breeding habitat. They may fly more than 10 miles from their larval development sites in search of blood meals. Both *Aedes vexans* and the *Psorophora* species described below are floodwater species characterized by synchronized emergence. Since the hatch of eggs is triggered by a water inundation event, then larval development and adult emergence is closely synchronized, resulting in huge increases in numbers over-night. *Culex* mosquitoes, by comparison, increase in numbers much more gradually.

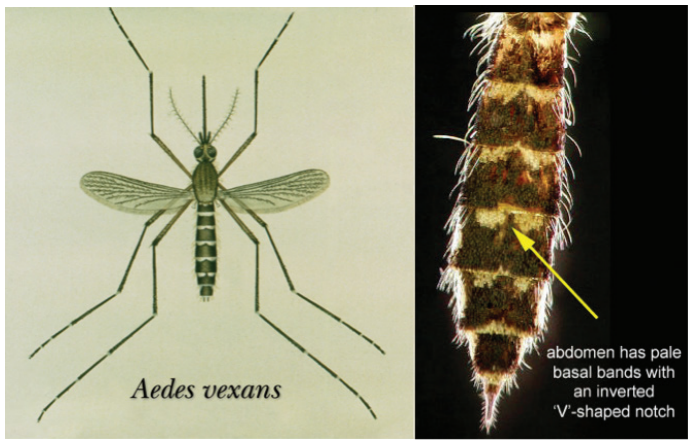

Fig. 10. Left: Illustration of an adult *Aedes vexans* mosquito from the Centers for Disease Control and Prevention; Right: Dorsal view of *A. vexans* abdomen, showing the pale V-shaped marks. Photo by Michelle Cutwa-Francis, University of Florida - Florida Medical Entomology Laboratory.

6) Dark ricefield mosquito, *Psorophora columbiae* form toltecum

Psorophora columbiae, or the dark ricefield mosquito (Fig. 11), has a broad range of warm-blooded animal hosts including humans and cattle. It has been reported to kill livestock when they are in large enough numbers (Meisch 1994). The females are furious biters during day or night. Well-documented studies of cattle have demonstrated severe losses in weight gain and milk production resulting from the blood-feeding activity of this mosquito. The mosquito is considered an occasional vector of West Nile virus (Pitzer et al. 2009), a passive vector of anaplasmosis (caused by a rickettsial pathogen) in cattle, and a potential vector of Venezuelan equine encephalitis virus (common in various forms in animal reservoir species and equines).

The adult *Psorophora columbiae* is a large dark mosquito with white or yellowish markings on its abdomen (Fig. 11). The legs and mouthparts are dark brown and banded with white scales. The hind femora have an apical white band and white knee spots. The first segment of the hind tarsus is brown with a white ring in the middle. The wings are speckled dark brown and white.

Female mosquitoes lay eggs on moist soil that is subject to flooding by water from rainfall or irrigation. The larvae mature rapidly during the hot summer, often developing from first instar to pupa in as few as 3.5 days. The larvae develop in temporary shallow freshwater pools and puddles where there is vegetation and may occasionally be found in slightly brackish water. Ideal sites for production of larvae are bermudagrass fields, citrus orchards, lawns and athletic turf, grassy roadside ditches, and grassy swales (Meisch 1994).

7) Be on the lookout for the Asian tiger mosquito, *Aedes albopictus*

The Asian tiger mosquito *Aedes albopictus*, has expanded its range within the continental U.S. since it was first reported in Texas in 1985. The species has been found in Arizona periodically, usually associated with "Lucky Bamboo" and foliage displays originating in the far-east. It is not currently established in Arizona, but is highly invasive, and is established in several counties in California, New Mexico and Mexico (CDC 1989). Mosquito entomologists and community based scientists actively hunt for this species each summer.

Aedes albopictus is characterized by its black and white striped legs, and a distinct median dorsal white stripe (Fig. 12). It has become a significant pest in many communities in coastal and southern states, and closely associates with humans. *Aedes albopictus* is a more aggressive daytime feeder compared with *Aedes aegypti* and is more cold tolerant, so may become established in northern areas of the state. The mosquito feeds mainly during the day but also during evening and morning hours. *Aedes albopictus* is a competent vector of several viral pathogens, including yellow fever, Zika, dengue fever and chikungunya, as well as several filarial nematodes such as dog heartworm (*Dirofilaria immitis*).

If you think you have seen *Aedes albopictus* around your home, please contact your county Vector Control office or Department of Health.

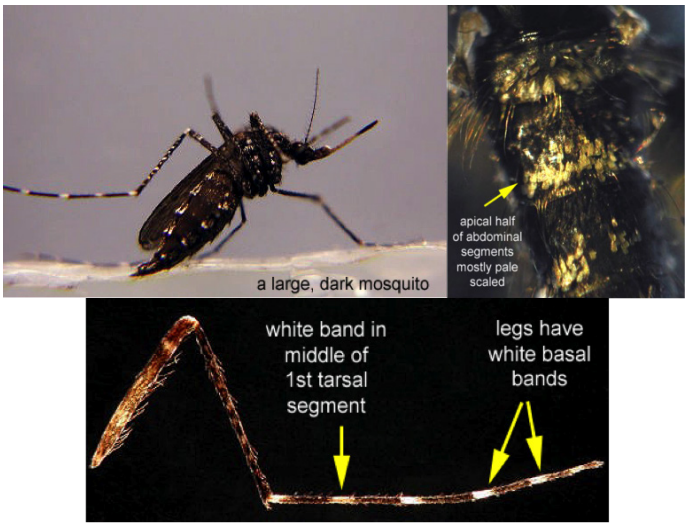

Fig. 11 Dark ricefield mosquito *Psorophora columbiae* adult, abdomen segments and leg. Photos by Michelle Cutwa-Francis, University of Florida - Florida Medical Entomology Laboratory.

Integrated Mosquito Management (IMM) — Fight the Bite!

Maricopa County residents can report mosquito bites by calling or emailing: Call (602) 506-6616 OR File a Complaint Online https://www.maricopa.gov/FormCenter/Environmental-Services-16/Environmental-Services-Complaint-Form-82.

Fig. 12. Asian tiger mosquito *Aedes albopictus* adult. Photo courtesy of CDC.

Prevention

Mosquitoes need water to complete their life cycle. Humans create a lot of opportunities for mosquitoes to exploit. Many of us have mosquitoes developing in our neighborhood and even in our own backyards. Standing water left from monsoon rains or irrigation water will support increasing mosquito populations. Stagnant water in neglected swimming pools is another ideal habitat for many species, though mosquitoes cannot live in a well-maintained swimming pool. **Some important vectors breed in "cryptic" breeding sites, utilizing very small amounts of water in tree-holes, artificial containers and even leaf axils.**

The most effective strategy for mosquito management in communities in general is prevention. The best way to prevent mosquito-borne diseases is to eliminate their breeding sites in the first place. Here are some tips on what you can do to manage mosquitoes and eliminate mosquito-breeding sites around you.

1. Eliminate standing water in plant pots, bird-baths, fountains, tires, tarpaulins covering boats or other objects, and backyard trampolines and other items (Fig. 13A, D). Check for standing water after every rain or at least once per week, twice per week is ideal.
2. Remove unnecessary clutter. Keep rain gutters free of leaves and other debris that prevent water from draining. Store boats, canoes and other objects so they do not collect rainwater. Saucers placed under potted plants are a favorite breeding site for *Aedes aegypti*. They should be drained after watering, or removed entirely. If eggs are suspected, they need to be scrubbed away, otherwise they remain viable for months, and will hatch at a later date.

Fig. 13 A. Flush out birdbaths periodically. B. Keep roadside ditches and drainage areas clear of debris so that storm water drains off easily. C. Discard containers that may collect water. D. Avoid prolonged flooding of playing fields. Organic acids can be used to improve turf drainage.

3. Repair water leaks (leaky pipes, sprinkler systems, and outside faucets). Correct drainage problems in yards and playing fields. Report drainage problems in ditches (Fig. 13B), etc.
4. Empty water containers for pets regularly and check livestock watering troughs and tanks (Fig. 13C). Mosquito eating fish can be added to large (undrainable) water troughs for livestock and horses.
5. Cover rain-collection barrels with insect exclusion netting.
6. Merchant (2016) offers tips on eliminating tree-hole breeding sites:
   - Do not fill tree holes with concrete, gravel or sand. Gravel and sand may hold water in the tree and promote decay. Gravel and concrete pose a real safety hazard for arborists or tree owners if the tree eventually has to be cut down.
   - Drilling drain holes to keep water from accumulating is no longer recommended, as it may open the tree up to infection.
   - Not all tree cavities need to be filled. However, if a tree hole is retaining water, expanding foam may be a good solution. Use a foam with a lower expansion ratio, and inject the foam slowly to protect the tree. It is not necessary to clean out decay from the cavity before filling with polyurethane foam (e.g., Great Stuff Pro™ Gaps & Cracks Foam, Foam & Fill® Expanding Poly Sealant, or similar product).
7. Add *Gambusia* (mosquito eating fish) into personal ponds or stagnant swimming pools to reduce the number of mosquitoes. It is very important to avoid releasing *Gambusia* into natural waterbodies, as these are voracious predators, and can displace native fish. The fish are available free of charge for Maricopa County residents from the Maricopa County Vector Control office. Just call (602) 506-0700 to schedule a pickup time, and bring your own container.
8. Larvicides specifically target the larval life stage of an insect and are generally more efficient control tools compared with adulticides.

Surveillance

Inspect around your home and buildings to reduce or prevent breeding of mosquitoes (Fig. 14).

Avoid Mosquito Bites

When outdoors, consider the following safety tips:

1. Wear light colored clothing with loose fitting long-sleeves, long pants and socks. Use protective clothing when exposure to mosquitoes cannot be avoided.
2. Properly apply insect repellent even if you are outside for just a short period of time, and share your insect

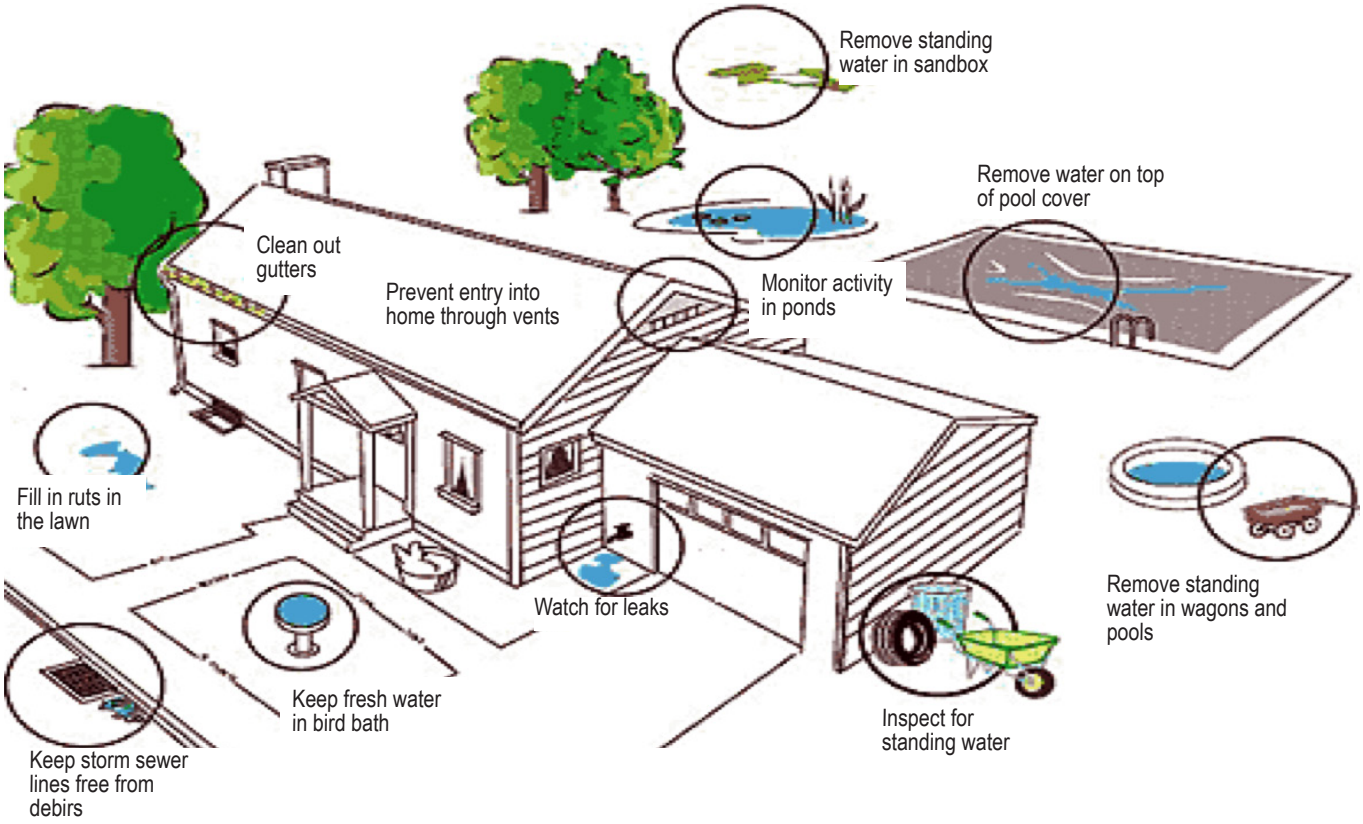

Fig. 14. Illustration of mosquito breeding habitats around buildings. Image by Raul Rivas (Metropolitan School District of Pike Township), enhanced for this publication.

repellent with those around you. For additional help selecting which repellent is right for you, go to the EPA search page: https://www.epa.gov/insect-repellents.

3. Use a DEET-containing product or a good non-DEET alternative http://www.ncbi.nlm.nih.gov/pmc/articles/PMC4667684/pdf/iev125.pdf and, if you are outside for more than a few hours, reapply repellent frequently. The higher the temperature, the more frequently you must reapply repellent for it to be effective.

   - Apply repellents only to exposed skin and/or clothing (as directed on the product label). Do not use under clothing. Apply over sunscreen after it has dried.
   - Never use repellents over cuts, wounds, or irritated skin.
   - Do not apply to eyes and mouth, and apply sparingly around ears. When using sprays do not spray directly onto face; spray on hands first and then apply to face.
   - Do not allow children to handle the products, and do not apply to children's hands. When using on children, apply to your own hands and then put it on the child.
   - Do not apply repellent on babies under 2 months old. **Insect repellents are a kind of pesticide, please read the label and follow instructions.** Most products specify the youngest age allowable for a given product.
   - Do not spray in enclosed areas. Avoid breathing a repellent spray, and do not use it near food.
   - After returning indoors, wash treated skin with soap and water or bathe. If you suspect that you or your child is reacting to an insect repellent, discontinue use and wash treated skin. Call your local poison control center (800) 222-1222 if symptoms persist.
   - When properly used, personal repellents can discourage biting insects from landing on treated skin or clothing.
   - Using repellent and sunscreen products at the same time is acceptable practice. However, the use of combination products that contain both an insect repellent and a sunscreen is not recommended.

4. Type of repellents: According to the Centers for Disease Control and Prevention (CDC) when used as directed, EPA-registered insect repellents are proven safe and effective, even for pregnant and breastfeeding women. Use a repellent with one of

the active ingredients below:
DEET
Picaridin (known as KBR 3023 and icaridin outside the US)
IR3535
Oil of lemon eucalyptus (OLE)
Para-menthane-diol (PMD)
2-undecanone
https://www.cdc.gov/zika/prevention/prevent-mosquito-bites.html Reactions to DEET are uncommon, but picaridin products are less likely to trigger dermal reactions when used repeatedly over extended periods of time.

More information about mosquito and tick repellents can be found at: https://extension.arizona.edu/sites/extension.arizona.edu/files/pubs/az1761-2018.pdf

Mosquito-Proof Your Home and Yard

Drain Standing Water: Mosquitoes lay their eggs in standing water. Limit the number of places around your home for mosquitoes to breed by getting rid of items that hold water (Fig. 13A, C, D, and Fig. 14).

Install or Repair Screens: Some mosquitoes like to come indoors. Keep them outside by having well-fitting screens on all windows and doors. Offer to help neighbors whose screens might be in bad shape. **Do not prop doors or keep doors open.**

Check for Indoor Breeding Sites: If a female mosquito wanders inside your home she will utilize any water reservoir she can find. Check for wriggling larvae in the toilet cisterns that are not flushed daily. Maintain water in drain traps. Use sticky tape over floor drains, sink over flows, etc. to see if you can catch mosquitoes emerging from areas you cannot see.

After-Bite Care

Consider the following tips for relieving the itch of mosquito bites. The first step is to clean the bite area with soap and water. Topical corticosteroids can reduce the rash, itching, and discomfort. Topical diphenhydramine (e.g., Benadryl® Extra Strength Topical Analgesic, or Allegra® Intensive Relief Anti Itch Cream) and caine-containing derivatives (e.g., Comfortcaine Topical Anesthetic™) should be avoided because of concerns about inducing allergic contact sensitivity. Oral antihistamines can be used effectively to reduce the symptoms of mosquito bites. Use of a cold compress can be helpful, but do not apply ice directly to the skin.

Control

Effective Integrated Mosquito Management (IMM) can often be complex and expensive, and frequently requires the cooperative efforts of communities. Many people are concerned about the harmful effects of pesticides on the environment, their animals and plants, and themselves. Pesticide toxicity and pesticide hazard is not the same thing. "Toxicity" is the "killing power" under experimental conditions, whereas "hazard" is the risk of negative impact when a product is used. **The dosage used, the type of chemical compound, how and when the application is made all determine the hazard level of a pesticide. The correct use of Personal Protective Equipment (PPE) further helps to reduce risk.**

Always read the pesticide label! Always use a pesticide precisely as the label instructs. For more information on options and relative risk contact:

National Pesticide Information Center
1.800.858.7378 npic@ace.orst.edu

Pest management companies offer a variety of around-home adulticide management options. Generally they are more effective than over-the-counter do-it-yourself treatments.

Mosquito control activities are important public health services, and responsibility for carrying out these programs rests with all of us. Maintaining your property in a responsible manner by eliminating standing water and removing containers that can support mosquito breeding is critically important. State and local governments will do some of the adult mosquito abatement. The federal government assists states in emergencies and provides training and consultation in vector and vector-borne disease problems. The current interests in ecology and environmental impact of mosquito control measures, and the increasing problems that have resulted from insecticide resistance emphasize the need for "integrated" control programs. EPA and CDC encourage maximum adherence to integrated pest management (IPM). IPM or Integrated Mosquito Management in this case, is an ecologically based strategy that relies heavily on natural mortality factors and seeks out control tactics that are compatible with or disrupt these factors as little as possible. IMM uses pesticides, but only after systematic monitoring of pest populations indicates a need. An IMM program considers all available control actions, and evaluates the interaction among various control practices, cultural practices, weather, and habitat structure. This approach results in the use of a combination of resource management techniques to control mosquito populations with decisions based on surveillance.

Adulticides

Adulticides are pesticides used to kill adult mosquitoes. Mosquito control districts in Arizona commonly use adulticides such as: sumithrin, permethrin, deltamethrin, and etofenprox. Applications of over-the-counter synthetic

pyrethroids applied to vegetation, tree trunks and walls of buildings and catch basins may help control certain adult mosquito species, but not others. However, it is critical that these products only be used as directed by the label; some pesticides are phytotoxic and can damage or even kill plants if they are not designed for application to them.

Larvicides

Mosquito control districts in Arizona commonly use larvicides such as: alcohol ethoxylated surfactants, (S)-methoprene, aliphatic petroleum hydrocarbons, spinosad, *Bacillus thuringiensis* subspecies *israelensis*, and *Bacillus sphaericus.*

Beyond the elimination of breeding sites, larvicides are the next line of defense against mosquitoes many of **which can be used successfully by residents around their property.**

Bacillus thuringiensis israelensis

Bacillus thuringiensis israelensis, or *Bti*, is a naturally occurring soil bacterium. The bacterium produces proteins in a crystalline form. When the mosquito larvae eat these crystals, the proteins attack their gut wall, killing the larvae. *Bti* has a highly specific mode of action and is of minimal environmental concern. It is non-toxic to humans, is quickly biodegraded and leaves no residue. Always store *Bti* products under cool conditions prior to use. E.g., Mosquito Dunks® and Mosquito Bits®.

Bacillus sphaericus

Bacillus sphaericus (*Bs*) is a common soil-inhabiting bacterium. The bacterium produces a protein toxin that may be used to control mosquito larvae. *Bs* is commonly used to control mosquito larvae in highly polluted water, such as sewage treatment plants. *Bs* is nontoxic to non-target organisms including humans. Some natural recycling of this organism is likely and products usually last for about 21 days. E.g., VectoLex® CG Biological Larvicide.

Spinosad (a mixture of spinosyn A and spinosyn D)

Spinosad insecticide is derived from a family of natural products obtained by fermentation of the bacteria species *Saccharopolyspora spinosa*. This insecticide contains a mixture of two spinosoids, spinosyn A and spinosyn D. Spinosad has high efficacy, a broad insect pest spectrum, low mammalian toxicity, and a good environmental profile. It kills insects via hyperexcitation of the insect nervous system. E.g., Natular™ 2EC.

Methoprene

Methoprene is a synthetic pesticide that mimics the insect juvenile hormone. When methoprene is present, the development of the mosquito larvae is disrupted and they do not develop to the adult stage. Mosquito control districts use methoprene in situations like cisterns and abandoned swimming pools. The breeding site needs to be treated periodically depending upon the formulation of the product used. Thirty day and 150-day briquettes are available as well as granular and liquid formulations (lasting a few days). The compound is not destroyed by heat. Methoprene is toxic to many other insects, but non-toxic to humans and safe to handle. E.g., Altosid® Pro-G Mosquito Larvicide.

Oils and surface films

Oils and surface films are used to control pupae and larvae by interfering with their ability to breathe through the water surface. These products are usually used when an adult emergence will occur without treatment (at this point it is usually too late to use the other options). However, oils and films will not control all immature stages. Larvicidal oils specifically designed as mosquito control products are very effective, safe, cheap, and control both larvae and pupae. However, cooking oil or motor oils are not useful alternatives and should never be used.

Fish

Gambusia are mosquito-eating fish. Some mosquito control districts raise the fish and use them to stock man-made water bodies. These fish will reproduce and continue to eat mosquito larvae. *Gambusia* should never be released into natural watercourses as they out compete native fish species. In areas where *Gambusia* have been released into natural waterways native fish are negatively impacted. Most small minnow fish (such as guppies, flathead minnow and shad) are good at reducing mosquito larvae populations and are suitable for release into garden ponds.

Area-wide Mosquito Control

Because of the complexity of controlling mosquito populations, experienced IMM personnel are often necessary and communities may best tackle issues using an area-wide approach. **The most important element in mosquito control is the residential population**. By reducing mosquito-breeding sites on your property you can significantly reduce mosquito populations.

Pesticide labels provide critical information about how to safely and legally handle and use pesticide products. It is a violation of Federal law to use products in a manner inconsistent with label directions. Reading and understanding pesticide labels is essential to ensuring safe and effective use of pesticides.

The U.S. Food and Drug Administration (FDA) provide consumers with drug use warnings and instructions, either on label or information sheets. It is important that consumers consider warnings and strictly adhere to the instructions. Consult a medical professional to determine which treatment is best for you.

In Summary: Some Final Facts

- All mosquitoes need water to complete their life cycle, but some only need very small amounts.
- The best approach to controlling mosquitoes is prevention, searching for and eliminating breeding sites of standing water in your indoor and nearby outdoor environment and cooperating across neighborhoods, communities and with local district efforts.
- Mosquito-borne illness can be avoided by preventing mosquito bites.
- A single female can lay hundreds of eggs over her lifetime.
- Many mosquito species can develop from egg to biting female adult in under a week.
- Not all species bite humans; some prefer birds, others prefer horses. But even those which prefer birds will feed on humans if the opportunity arises.
- Only females take a blood meal; both males and females feed on plant nectar.
- Some mosquito species fly considerable distances, 20 miles or more. Some species tend to remain close to their larval habitats.
- Adult females can survive several weeks, some months, e.g., *Culex* mosquitoes overwinter as adults.
- Mosquitoes are responsible for more human mortality around the world than any other living creature.

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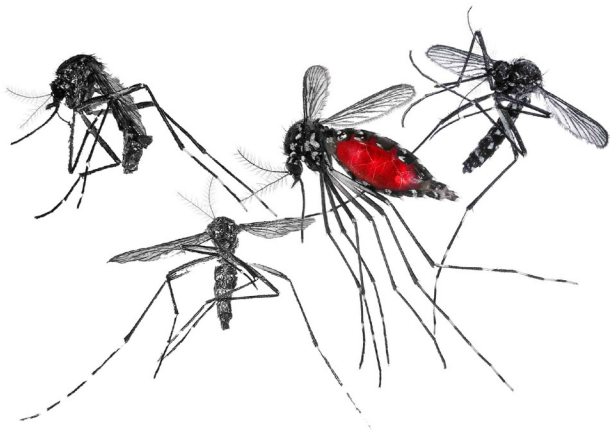

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