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The Mosquito[1]

Jorge R. Rey[2]

Mosquitoes are some of the most versatile organisms on earth. They can reproduce in virtually any natural or man-made deposit of water, and have been found in mines deep below the surface, in mountain peaks, in highly polluted water bodies, in snow pools, and even in crab holes (O' Meara, 2000). They occur throughout the globe and can survive in most of earth's climates.

Although mosquitoes can be annoying and some are serious health threats, they can play an important role in natural communities, particularly as filter feeders in aquatic communities, and as a food source in both aquatic and terrestrial food chains.

What is a Mosquito?

Mosquitoes belong to the insect order Diptera, family Culicidae (Figure 1). The Diptera includes true flies, gnats, horseflies, blackflies, midges, crane flies, and others. Approximately 167 species of mosquitoes belonging to 13 genera are found in the United States; of these, 80 species occur in Florida. It is estimated that there are more than 2500 species of mosquitoes worldwide. Mosquitoes can be identified by noting that as all true flies they only have one pair of functional wings (most insects have two), and that

Figure 1. The Florida SLE mosquito *Culex nigripalpus*
Credits: Jim Newman

they have a long, piercing proboscis, and scales on the veins of their wings.

Mosquitoes have a complex life cycle which includes the egg stage, several larval stages (or instars), a pupal stage, and an adult stage. All of the immature stages are aquatic, and adult females return

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2. Jorge R. Rey, professor, Entomology and Nematology Department, Florida Medical Entomology Laboratory, Vero Beach, Cooperative Extension Service, Institute of Food and Agricultural Sciences. University of Florida, Gainesville, FL 32611

All chemicals should be used in accordance with directions on the manufacturer's label.

to water to lay their eggs. The name mosquito comes from the Spanish "musketas," meaning "little fly". The native Hispanic-Americans called them "zancudos", a term that is still used in parts of South and Central America; it means "long-legged".

Mosquito Life Cycle

Eggs - Depending upon the particular species, the female mosquito lays her eggs either individually (Figure 2) or in groups called rafts. Any water-holding area, such as tree holes, ponds, puddles, ditches and artificial containers such as discarded tires and flower pots can serve as a mosquito breeding site.

Figure 2. Mosquito eggs. Credits: Michele Cutwa

Some mosquitoes (floodwater mosquitoes) lay their eggs in moist substrates without standing water. These eggs are usually resistant to dessication (drying) and hatch when flooded by rainfall, tides, or water diversion to the area. Other species (pool breeders, standing water mosquitoes) lay their eggs only upon standing water and the eggs are not usually resistant to drying. The eggs are placed directly upon the surface of the water or along the edges pools or reservoirs. In either case, water must remain on the surface long enough for the mosquitoes to hatch and complete development (see below).

Larvae - After hatching from the egg, the mosquito larva (Figure 3) undergoes a series of growth stages with continuous feeding that eventually will transform the insect from a swimming aquatic form to a flying terrestrial one. Because the larvae are covered in a hard protective skin called the cuticle, they must undergo a series of molts in order to grow. Essentially, the larvae are enclosed in a hard inflexible envelope that is absolutely essential for larval survival, so it can't just be discarded. In order to grow, mosquito larvae grow a new exoskeleton under the old one. This new exoskeleton is soft and flexible at first, thus allowing the larvae to grow. When ready to molt, the larvae then shed the old exoskeleton and the new one hardens when exposed, to protect the larvae's internal organs.

Mosquito larvae, also known as "wrigglers" undergo four such molts. The stages between molts are called instars and are numbered from I to IV.

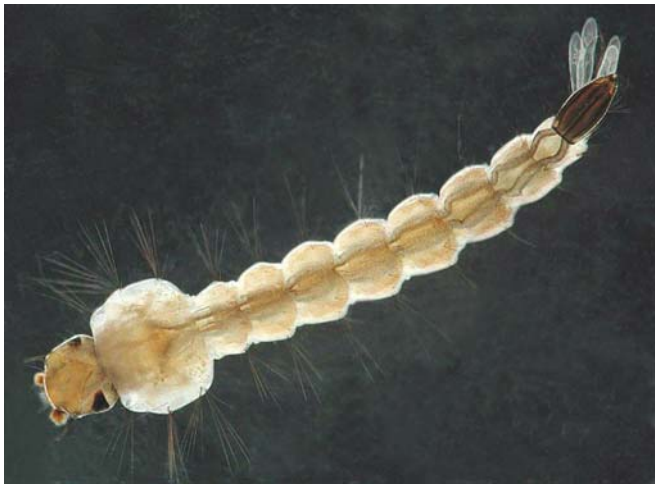

Figure 3. Mosquito larva (*Aedes albopictus*) Credits: Michele Cutwa

Pupae - After the fourth instar, the development of the future mosquito adult is about to start. The process involves the breakdown of the larval organs and their replacement with the adult ones. During this process, the mosquito takes a new shape; the pupa (Figure 4). The pupa can be considered to be a sealed envelope, where the adult organs are developed from larval tissues. The pupa does not feed or eliminate waste products. Its only contact with the outside is through breathing tubes located on the thorax. After 3 or 4 days, the adult mosquito emerges from the pupa (Figure 5), and after a period of rest, unfold its wings and flies away.

Adults - The male mosquito will usually emerge first, and will linger near the breeding site, waiting for the females. On average, a female mosquito will live 3-6 weeks, but can live up to 5 months. The

Figure 4. A mosquito pupa (*Toxorhynchites* sp.) Credits: Michele Cutwa

male's life span is much shorter. Both adult male and female will feed on nectar and plant fluids, but it is only the female that will seek a blood meal, which most species need in order to develop their eggs. Female mosquitoes lay multiple batches of eggs and most species require a blood meal for every batch they lay. Females of some species can develop a limited number of egg batches (usually 1) without taking a blood meal, a quality known as "autogeny".

In tropical regions, adult mosquitoes are active throughout the year, but in other areas they become inactive when the temperature drops below 60°F and usually enter hibernation when the seasonal cool temperatures arrive. A few mosquito species hibernate as larvae, usually buried in moist swamp muds, but most overwinter either as eggs laid by the last generation, or as adult, mated females that spend the winter in protected locations such as hollow trees, animal burrows, attics, etc.

Dispersal

Most mosquitoes disperse relatively short distances but the flight range of mosquitoes varies widely with species and ranges from less than a hundred meters to tens of kilometers.

Figure 5. Adult mosquito emerging from the pupa. Credits: Jim Newman

Mosquito Bites

As mentioned above, mosquitoes suck blood to obtain proteins and other nutrients necessary for egg development, so only female mosquitoes "bite". Actually, mosquitoes do not really bite; "sting" is probably a better term. Once it locates a host, the female will probe the skin for a blood capillary then insert its very thin and sharp proboscis through the skin into the blood vessel and begin sucking blood. In the process, the mosquito will inject a small amount of saliva, which functions both as a lubricant for proboscis insertion and as an anticoagulant (prevents blood clotting). It is the proteins in the saliva that evoke an immune response and cause the swelling and itching.

When a mosquito bites someone, it does not inject its own blood or the blood of an animal or person it has bitten before into the next person it bites. Salivary fluid injection and blood uptake occur through separate passageways. Diseases are transmitted only if the disease organism reproduces in the mosquito, or at least survives long enough to infect the salivary glands.

Mosquito bites are best treated by washing with a mild soap solution and applying over the counter calamine or cortisone containing lotions. Scratching the area should be avoided. A few people may be severely allergic to mosquito bites and should seek medical attention if dizziness or nausea occur.

Avoiding Mosquito Bites

Mosquito bites can be avoided in several ways:

- Around the home: Remove all water holding containers that may serve a mosquito breeding sites. If containers can't be removed, drain them and cover them so that they don't collect water, or flush every 2 or 3 days. Use natural predators such as mosquitofish in ornamental fountains or ponds, or use an approved mosquitocide. (see http://eis.ifas.ufl.edu/prevent.htm for more information).
- Avoid outdoor activities when mosquitoes are most active. Specific times vary with the mosquito species, but the hours around dawn and dusk are particularly important.
- Wear protective clothing (long sleeves, socks and long pants).
- Use repellents that contain DEET (see http://www.acponline.org/journals/annals/01jun98/mosquito.htm).

Mosquitoes and Disease

Because mosquitoes tap into the host's blood supply (Figure 6), they can be very efficient in transmitting diseases to humans and animals.

Mosquitoes transmit a large number of diseases, some with minor consequences, and others, like malaria and dengue, that extract an immense toll in terms of loss of life, incapacitation, human suffering and economic losses. For example, malaria is one of the most serious public health problems in the world today. According to the World Health Organization, between 350 and 500 million clinical cases of malaria occur every year, resulting in 1-3 million deaths per year. Approximately 60% of the cases and 80% of the deaths occur in sub-Saharan Africa. Below is a partial description of the most common diseases transmitted by mosquitoes.

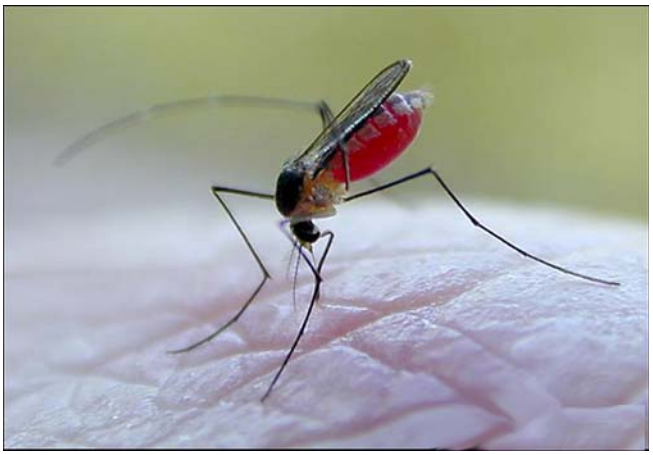

Figure 6. Adult mosquito bloodfeeding Credits: Jim Newman

Arboviral Encephalitides - Arthropod-borne viruses, (arboviruses), are viruses that are maintained in nature through biological transmission between susceptible vertebrate hosts by blood feeding arthropods (mostly mosquitoes, psychodid flies, ceratopogonid midges, and ticks).

Encephalitis is an inflammation of the brain and spinal cord usually caused by viral infection. Diseases such as rabies, polyomelitis, and herpes encephalitis are all caused by virus infections that affect the brain and spinal cord and are transmitted in a variety of ways. Arboviral encephalitis refers to similar maladies that are transmitted by arthropods, mainly mosquitoes.

Although the majority of cases of arboviral encephalitis infection are asymptomatic or have only very mild symptoms, the disease can sometimes damage nerves and can cause lasting damage and even death. Symptoms include sudden fever, headache, vomiting, unusual visual sensitivity to light, stiff neck and back, confusion, drowsiness, clumsiness, difficulty walking, and irritability.

Arboviral encephalitides are maintained in nature in complex life cycles involving a non-human primary vertebrate host and a primary arthropod vector and which usually do not include humans. Humans and domestic animals can contract the disease when the virus escapes the cycle and infects a secondary host. This can happen because of

ecological or demographic changes, or due to population changes in the primary vector, host, or both. Many arboviruses that cause encephalitis have a variety of different vertebrate hosts and some are transmitted by more than one vector.

There are five major types of arboviral encephalitis in the United States:

St. Louis encephalitis - This virus causes the most common mosquito-borne disease in the United States. Like most types of viral encephalitis, it is transmitted to mosquitoes by birds. The mosquito vector of St. Louis encephalitis breeds in areas of standing water, including such places as discarded tires, polluted pools, roadside ditches, and containers such as birdbaths and flower pots.

Eastern equine encephalitis - is the most serious encephalitis virus in North America. As the name suggests, Eastern equine afflicts horses, but it also can affect humans. Eastern equine encephalitis outbreaks occur most commonly in the Eastern United States. This virus infects birds that live near freshwater swamps.

Western equine encephalitis - Like eastern equine encephalitis, this virus affects horses and humans. Most cases of western equine encephalitis are reported in the central and western plains of the United States. This virus flourishes in birds that live near irrigated fields and farming areas.

LaCrosse encephalitis - has been identified in several midwestern and mid-Atlantic states. During an average year, about 75 cases of Lacrosse encephalitis encephalitis are reported to the Centers for Disease Control. Most cases of Lacrosse encephalitis occur in children under 16 years of age. Vertebrate primary hosts in include chipmunks, tree squirrels. and other small vertebrates that live in forest habitats.

West Nile encephalitis - This virus first appeared in the United States in 1999. It is normally found in Africa and the Middle East and in parts of Europe, Russia, India and Indonesia. The virus is very similar to the St. Louis virus in that birds are its main animal hosts.

Other mosquito-transmitted encephalitides include, Cache Valley, California, Jamestown Canyon, Japanese, Australian, Venezuelan, and Murray Valley.

Malaria - Human malaria is caused by four protozoan parasites of the genus *Plasmodium*; *P. vivax*, *P. ovale*, *P. falciparum*, and *P. malariae. Plasmodium falciparum*, which is found globally but is commonest in Africa, is the most aggressive species, and can cause death through coma or anemia within 24 hours of the onset of symptoms.

Malaria is transmitted to humans by mosquitoes of the genus *Anopheles*. Symptoms of malaria can include, cycles of fever and profuse sweating and chills, headaches, nausea, anemia, bloody stool, convulsions, and coma.

Upon infection, the parasites first invade the liver and then invade red blood cells, causing them to rupture and release hemoglobin into the bloodstream. Symptoms are caused by the invasion of the bloodstream by the parasite, by the destruction of red blood cells (anemia) and by the large quantities of free hemoglobin in the bloodstream.

Travelers to areas with malaria transmission can protect themselves from malaria by taking an antimalarial drug and by preventing mosquito bites. Because of the different species of the parasite, and the development of resistance to certain drugs by species in some areas, the effectiveness of specific drugs will depend upon the region of the world. Up to date information on the subject can be found at the CDC web site: http://www.cdc.gov/travel/

Malaria can be treated with several antimalarial drugs. Most are active against the parasite forms in the blood (the form that causes disease) and include: chloroquine, sulfadoxine-pyrimethamine, mefloquine, atovaquone-proguanil, quinine, doxycycline, and artemisin derivatives

Dengue and Dengue Haemorrhagic Fever - Dengue is a mosquito-borne viral disease found in tropical and sub-tropical regions around the world, predominantly in urban and semi-urban areas. Dengue haemorrhagic fever is a potentially lethal complication. There are four distinct, but closely

related, viruses that cause dengue. Infection by one does not confer immunity against the others.

Dengue is transmitted to humans by *Aedes* mosquitoes. Symptoms of dengue usually start within 5 to 6 days after infection and include high fever, severe headache, pain behind the eyes, severe joint and muscle pain, nausea, vomiting, and skin rash. In addition to the above,Dengue haemorrhagic fever symptoms include damage to lymph and blood vessels and bleeding from the nose, gums, and from under the skin. The latter symptoms may progress to massive bleeding, shock and death (dengue shock syndrome).

There is no specific treatment for dengue fever although bed rest, drinking lots of fluids, and taking medicine to reduce fever can help in the recovery. The Centers for Disease Control recommend not to take aspirin. Acetaminophen or other over-the-counter pain-reducing medicines are safe for most people. For severe dengue symptoms, aggressive emergency treatment with fluid and electrolyte replacement can be life saving.

Yellow Fever - Yellow fever is a tropical viral disease that is spread to humans by infected mosquitoes. Many yellow fever infections are mild, but the disease can cause severe, life-threatening illness. It occurs only in Africa and in Central and South America and is preventable by immunization. Travelers to countries with yellow fever should get the yellow fever vaccine.

There are two types of the disease, jungle yellow fever, and urban yellow fever. Jungle yellow fever is primarily a disease of monkeys and is transmitted mainly to humans that work in tropical rain forests. For example, in parts of Central America, the disease is maintained in red howler monkeys (*Alouatta seniculus*) that live in the rain forest canopy and is transmitted by *Haemagogus* mosquitoes that also live only in the canopy. The disease is passed to timber cutters when the trees are cut down, and infected woodcutters can then pass the disease to other via species of low-flying *Aedes* mosquitoes, thus triggering an epidemic.

Most common symptoms of the disease are fever, muscle aches, headache, and backache. Other symptoms may include a red tongue, flushed face, and reddening of the eyes. The liver, kidneys, and heart may be affected and there may be bloody vomit. jaundice with liver failure (which causes yellow skin color, hence the name "yellow fever") and/or kidney insufficiency and dehydration. There are no specific treatments for the disease. Those affected are given supportive treatment for the symptoms.

Rift Valley Fever - Rift Valley fever (RVF) is an acute, fever-causing viral disease that affects domestic animals and humans. RVF is most commonly associated with mosquito-borne epidemics during years of unusually heavy rainfall. It occurs mostly in eastern and southern Africa, but there have been recent outbreaks (2000) in Yemen and Saudi Arabia.

Ross River and Barmah Forest Disease - Traditionally known as epidemic polyarthritis, they are now considered separately. These arboviral diseases occur mainly in Australia and New Guinea. The symptoms include those of severe arthritis along with fevers and rashes.

Chicungunya Fever - Chicungunya is a viral disease that is spread by *Aedes* and *Culex* mosquitoes. The name is derived from the Swahili word meaning "that which bends up" in reference to the bent over posture developed as a result of the arthritic symptoms of the disease. The disease is not usually fatal, but in 2005-2006, 77 deaths have been reported from the disease from Réunion island in the Indian Ocean. It occurs principally in Southeast Asia and Africa. Symptoms include severe headache, chills, fever, joint pain, nausea and vomiting. The joints of the arms and legs in particular become swollen and painful to the touch. A rash may sometimes occur.

Mayaro virus - The disease is characterized by fever, headache, backache, chills, nausea, rash, muscle pain and joint pain. It has been recorded from South America and the West Indies and the virus has been recorded infecting humans in Central America. Epidemics occur during and around the rainy season.

Mosquitoes and AIDS

Mosquitoes do not transmit HIV.

Mosquitoes digest the virus that causes AIDS and completely destroy any virus particle that could cause an infection. Also, they do not ingest enough HIV particles to transmit AIDS.

Because the virus do not survive or reproduce in mosquitoes, it is not transmitted in the saliva.

See http://www.rci.rutgers.edu/~insects/aids.htm, for a concise review of the subject.

Mosquito Myths

Because of their ubiquitness, there are many misconceptions about mosquitoes some of the more common ones include:

- Bug zappers are effective against mosquitoes - bug zappers do not control mosquitoes and can reduce the populations of beneficial insects.
- Electronic repellers keep mosquitoes away - No they don't; save your money.
- Residential vegetation can produce mosquitoes - They may be resting in the vegetation, but standing water is required to "produce" mosquitoes.
- Bats, owls, and other birds can control mosquitoes - Although they may include mosquitoes in their diet, they do not consume enough mosquitoes to make an appreciable difference in their populations.
- Some mosquitoes can be 2 inches long. - They don't get that big, it was probably a crane fly.
- Mosquitoes nest in vegetation - Mosquitoes do not nest.
- Spraying for adults is the best method of mosquito control - Adulticiding is the least efficient method. Eliminating mosquitoes before they become adults is preferable.
- Mosquitoes can transmit AIDS - False, see above.
- The Citrosa plant repells mosquitoes - Although citrosa oil (citronella) has been used widely as a mosquito repellent, the undisturbed plant itself does not release these oils and is thus not effective as a repellent.

Figure 7. Owls, martins and bats do not control mosquito populations. Credits: Jorge Rey

Additional Information

General information web sites:

Centers for Disease Control and Prevention, Traveler's Health,. http://www.cdc.gov/travel/.

Florida Mosquito Control Association. http://www.floridamosquito.org/.

University of Florida, Florida Medical Entomology Laboratory, Encephalitis Information System. http://eis.ifas.ufl.edu .

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