

Introduction to mosquitoes and mosquito-borne pathogens

Mosquito: Mosquitoes are small flies that are known for drinking blood. Some species are both a nuisance and a public threat to people but others do not bother humans at all.

Types: There are dozens of different kinds of mosquitoes in the U.S. alone. Many of them do not bite people and pose little to no threat to us in any way. Others will feed off of humans and in doing so can transmit various pathogens that can make people very sick.

Invasive mosquitoes: Invasive mosquitoes are not native to a region and, when introduced, spread rapidly. They can be extremely detrimental to native species--one example being Hawaii's invasive mosquitoes. Hawaii had no native species of mosquitoes and they were not introduced until Europeans brought them in the 1800s. After the introduction of mosquitoes, several native birds started to perish and went extinct because of mosquito-borne avian malaria. Some species survived simply because they lived too high on the mountains and mosquitoes could not survive the cooler temperatures. When mosquitoes are introduced to an area, they may be carriers of parasites or viruses not transmitted in the area which may result in a decline in native animal populations.

Aedes: This egg collection project is focusing on *Aedes* mosquitoes. *Ae. aegypti* and *Ae. albopictus* are of particular interest since they are vectors of chikungunya, dengue fever, and yellow fever viruses and are two of the most invasive mosquito species in the United States. Originally from Africa and Asia, these mosquitoes are used to warm weather but are slowly acclimating themselves to more moderate and cool regions. They are aggressive daytime biters and prefer people and mammals for their blood meals. Since *Aedes* aggressively bite people and transmit diseases, they also pose a risk to public health.

Chart of *Aedes* species: *Aedes aegypti* and *Aedes albopictus* are highlighted since they are the two being emphasized. The table is used to illustrate how numerous mosquito-borne diseases are as well as the variety of the *Aedes* genus.

Culex: *Culex* mosquitoes are another major mosquito in the United States. Some species in this genus can be found all throughout the country. Some species will enter houses in search of a blood meal. Mosquitoes of this species can feed on mammals or birds or both. They are a major vector of encephalitis and some species of *Culex* mosquitoes are considered bridge vectors because they feed on both animals and people.

Diet: Not all mosquito species require blood meals. In ones that do, only the females require a blood meal. Females need to feed on blood in order to produce eggs. Mosquitoes that don't require a blood meal for egg production are called *autogenous*, whereas mosquitoes that do require a blood meal are called *anautogenous*. All mosquitoes need sugar meals—they normally consume the sugar in the form of flower nectar. Nectar offers the mosquitoes sugar for energy.

Blood feeding: Most female mosquitoes will consume blood and nectar. Blood supplies the mosquito with sugar, concentrated nutrients, and proteins essential for egg production. In general, a female will take a blood meal and then wait several days for the eggs to develop, and then she will lay (oviposit) the

eggs and search for a new blood meal. Mosquitoes feed at different times depending on the species. For example, *Aedes* mosquitoes feed during the day whereas *Culex* mosquitoes feed at dusk and at night. Mosquitoes rely heavily on olfaction and heat signals to find blood meals, so certain factors attract mosquitoes to some people more than others. Mosquitoes are greatly attracted to carbon dioxide and compounds in human sweat. Other things such as wearing dark clothing attract mosquitoes as well.

Allergic reaction: A female will inject her saliva into the host she is feeding on. The saliva has anticoagulants that will prevent the blood from clotting and causing a blockage in her proboscis. The itchy bump that follows a mosquito bite is the results of the individual's histamines reacting to the proteins in the mosquito saliva. Some people have an allergic reaction to mosquito bites. This allergic reaction is called Skeeter Syndrome; this is particularly prevalent in children. Its symptoms include rash and fever.

Immature development: Different species of mosquitoes lay eggs in different location. Some will lay eggs in open, fresh water such as ponds, lakes, and marshes while others prefer containers or mud. Container mosquitoes are a particular problem to humans because humans tend to leave out lots of objects in which water can pool and mosquitoes can develop. Pots, barrels, and tires are just a few examples. These objects are normally found near homes and therefore attract mosquitoes to human dwellings. A good preventative measure is to dump pooled water after rains and eliminate open containers outside as possible. *Aedes* mosquitoes will lay their eggs near water. The eggs will go into diapause (period of inactivation and paused growth) when dried out and will only hatch when soaked in water (for example, during a flood).

Life cycle: Egg, larva, pupa, adult (more information on mosquitoes' life cycle will be given in Lesson 2)

Habitat: Mosquitoes can be found in nearly any climate except extreme cold. Since they lay their eggs in stagnant water, they prefer wet areas. Their feeding habits demand that they stay in areas with flowering vegetation or other sources of sugar meals. Mosquito habitats greatly coincide with human and livestock locations and that overlap causes numerous public health and economic issues.

Invasive mosquito collection: With the threat of dengue fever and chikungunya on the rise, it is beneficial to know the distributions of the disease vectors in order to predict locations of possible future outbreaks and take preventative measures.

Knowledge of species distribution: *Aedes albopictus* was accidentally introduced to the United States in 1985 in used, imported tires; a decade later, it had spread to 25 states and since then has spread even further. Since their introduction, and because of their continued geographic spread, there is a continual need to monitor the spread of invasive mosquito populations. A new study on invasive mosquito populations should take place in order to better understand the species distributions and the possible risks they pose to public health. Knowing where the species is concentrated at helps pinpoint areas with the highest risk and where preventative measures should take place.

Mosquito-borne diseases: Mosquito-borne pathogens are bacteria, viruses, and parasites that infect and damage humans and animals while not affecting the mosquito. It is a growing problem throughout the world.

Mosquitoes as vectors of disease causing agents: Mosquitoes are found on every continent except Antarctica and their habitats often coincide with human or livestock activity. They reproduce quickly and can be hard to prevent, avoid, and eradicate. People are a source of blood meals for many species of mosquitoes. Mosquitoes are generally hard to detect on the body until they have already started to feed. For all these reasons, mosquitoes make worryingly efficient vectors of pathogens.

Transmission: Mosquitoes inject saliva into their victims as an anticoagulant measure because clotted blood would cause a blockage in their proboscides. For this reason, many pathogens target mosquitoes' salivary glands. This exchange of fluids is also an exchange of pathogens. An infected mosquito can infect its host and an infected host can infect the mosquito and continue the cycle.

Dengue fever: Dengue fever (from the dengue virus) is an arbovirus spread by *Aedes aegypti* and *Aedes albopictus*. Its symptoms include severe fever and rash. In some cases, dengue hemorrhagic fever develops and those infected can die within 24 hours if not given proper medical care. However, with proper support, death occurs in less than 1% of individuals afflicted with dengue hemorrhagic fever. See <http://repository.searo.who.int/handle/123456789/15892> and <http://www.cdc.gov/Dengue/> for more information on dengue fever.

Chikungunya: Chikungunya (meaning “that which bends up” in the Makonde language), also known as CHIKV, is a virus transmitted from humans to mosquitoes to humans. Symptoms will normally appear a few days after infection; symptoms include fever, headache, rash, and joint pain. In some cases, chronic joint pain is reported up to several years after infection. There are no vaccines or cures for CHIKV, though medicine can be prescribed to treat the symptoms. Chikungunya is not lethal to humans with normal immune systems. CHIKV is transmitted by *Aedes aegypti* and *Aedes albopictus*. CHIKV arrived in the Americas in December of 2013 in the Caribbean and caused over one million cases in 2014. See <http://www.floridahealth.gov/diseases-and-conditions/mosquito-borne-diseases/documents/StaplesChikFL-2014-04-01.pdf> and <http://www.cdc.gov/chikungunya/> for more information on CHIKV.

Encephalitis: In short, encephalitis is inflammation of the brain caused by pathogens. It can be mild (low fever, mild headache) to extreme (seizures, change in mental function). Many mosquitoes transmit viruses that cause encephalitis including St. Louis encephalitis, West Nile virus, eastern equine encephalitis, western equine encephalitis, Japanese encephalitis, and Venezuelan equine encephalitis. See <http://www.ncbi.nlm.nih.gov/pubmedhealth/PMH0002388/> for more information on encephalitis.

West Nile virus: West Nile virus is transmitted from infected birds to humans by mosquitoes. Many people infected do not realize they have been infected because the symptoms can be very mild (abdominal pain, rash, sore throat, etc). However, in some cases, more severe symptoms can occur along with West Nile encephalitis—inflammation of the brain. Those with mild symptoms can expect to fully recover quickly; those with severe symptoms may experience brain damage or death. See

<http://www.ncbi.nlm.nih.gov/pubmedhealth/PMH0004457/> and <http://www.cdc.gov/westnile/index.html> for more information on West Nile virus.

Canine heartworm: Canine Heartworm is a parasitic worm called *Dirofilaria immitis* that is transmitted to dogs by mosquitoes. The worms spend most of their lives inside their host with the mosquito just being a means of spreading to new hosts. Heartworms received their name because they live their adult lives inside the heart and lungs of their host. There can be from 1 to over 200 worms living in a single dog at a time. If left untreated, the parasite can become so numerous in the heart that they block the blood flow. Dogs in this stage will nearly always die from the parasites. See <http://www.fda.gov/animalveterinary/resourcesforyou/animalhealthliteracy/ucm188470.htm> for more information on canine heartworm.

Lymphatic filariasis: Lymphatic filariasis is the result of parasitic worms that live in an individual's lymph system. It can cause elephantiasis (engorgement of the legs) and other disfiguring swelling. Lymphatic filariasis is the leading cause of permanent disability in the world. It is particularly a problem in the 3rd world, where affected individuals are unable to work and care for themselves. See <http://www.cdc.gov/parasites/lymphaticfilariasis/> and <http://www.who.int/mediacentre/factsheets/fs102/en/> for more information on lymphatic filariasis.