A Brief Analysis on the Life of the Mosquito

With over 3,000 known species, mosquitoes (Spanish for “little fly”) are familiar to the entire globe. Classified under the order Díptera and the family Culícidae, the long-horned flies are recognized for their aquatic larval stages, long proboscises, and most of all, their aggravating blood-sucking behavior. Present in Michigan, permanent water mosquitoes such as the malaria-carrying Anolpheles species, as well as the West-Nile virus-carrying Culex species, are found in habitats such as ditches, ponds, and swamps. Floodwater mosquitoes such as the yellow fever-carrying and heartworm-transmitting Aedes species hatch from eggs laid in artificial containers enclosing standing water and summer flood water. Though easily destroyed with a simple swing of a fly-swatter, mosquitoes are extremely hard to eliminate. They are exceedingly successful in simply existing and are currently developing resistance to popular insect repellents.

History

Familiar to the world, the mosquito has also been familiar to history. In 300 B.C.E., Aristotle documented the life cycle and metamorphic abilities of the mosquito, as referred to as “empis” in his “Historia Animalium”. Earliest-known mosquito fossils have been found from the Cretaceous era (150 million years ago), but are believed to have evolved around 170 million years ago during the Jurassic era. They are believed to have evolved in South America, entering the northern tropics after passing through the continent, Laurasia. Fossils found reveal a shorter proboscis, suggesting the female of the fossil species found was a vertebrate blood feeder, as are modern female mosquitoes (Borkent & Grimaldi, 2004).

Feeding Traits

In addition to feeding on insects that feed on sugar and from nectar from plants for energy, like male mosquitoes, female mosquitoes must also feed on blood for their egg development. Female mosquitoes find blood hosts by movement, by detecting infra-red radiation emitted by warm bodies, and by chemical signals and body odors with their odor-sensitive antennae, such as exhaled carbon dioxide or lactic acid, at distances of 25 to 35 meters. Female mosquitoes feed on domesticated animals such as cattle, and horses, and wild animals such as deer, birds, and rabbits in addition to man. Only female mosquitoes have the piercing mouth component necessary for sucking blood. Female mosquitoes "bite" (though not actually a "bite") with their proboscis, and two tubes are stabbed into the host's skin. One tube injects an enzyme that prevents blood clotting, which causes the majority of allergic reactions to mosquito bites, and the other tube sucks the blood. The blood is solely a source of protein for the female's developing eggs. The blood is not used for the female's nourishment, although without a sufficient blood meal, the female mosquito will die before developing her eggs. Contradictory but not common, some mosquito species have adapted the ability to lay viable eggs without a blood meal.

The Mosquito Life Cycle

The metamorphic life cycle of the mosquito is mainly aquatic. Permanent water mosquito females, such as the Anopheles and Culex species, lay their eggs on stagnant water surfaces, such as swimming pools, puddles, and marshy areas. The eggs are laid either singly or on a raft enclosing up to 300 eggs several times a year. (A Culex mosquito is capable of laying a raft of eggs every third night of its life span.) The eggs must be laid on water, otherwise they dry out and become unviable. The eggs hatch in about 24 hours, depending on variables such as

water temperature. Like the Anopheles and Culex species, the Aedes species, a type of floodwater mosquito, will lay it's eggs on a moist surface. But unlike the permanent water species, the floodwater mosquito eggs must dry out before becoming viable. Once the area where the eggs are laid is flooded with rainwater or hide tides, the eggs may hatch. The eggs can remain viable for up to seven years, but Aedes mosquitoes only have one generation a year.

Once hatched, although able to stay submerged for some time, the hatched mosquito larva spends a majority of its one to two weeks of the larva stage at the water surface. Requiring oxygen, the larvae have breathing tubes called siphons, similar to a snorkel. The worm-like mosquito larvae are commonly called "wrigglers", characterizing the movement the larvae possess while swimming through water. The larvae ingest particles from the water in which they were hatched, such as leaf shreddings and smaller larvae of other insects. The mosquito larva will molt its skin four times before its pupal stage, each molting stage being defined as a instar. By the fourth instar, the larvae reach lengths of half an inch.

Similar to the egg and larvae stages of its life cycle, the mosquito's pupal stage is also aquatic. During this time, the mosquito undergoes metamorphosis and its mouthparts, legs, and wings are developed in a comma-shaped "shell". Since it lacks functional mouthparts during metamorphosis, the mosquito pupa does not feed during the pupal stage, which lasts two to three days. Like the larva's siphon, the pupa has two breathing tubes called trumpets to take in oxygen. Because of heavy predation by fish and birds of the eggs, larvae, and pupae, out of the 100 to 400 eggs laid by a mosquito female, only a few adults develop successfully.

Mosquitoes, cold-blooded insects, cannot survive through the cold and harsh winter. Mosquitoes function best at 80^{o} F, and cannot function below 50^{o} F. Species must either

hibernate (over winter), or their eggs or larvae over winter and resume their life cycle when the warm weather of spring arrives. Permanent water mosquitoes such as the Anopheles and Culex species typically over winter as mated females, as flood water mosquitoes such as Aedes species over winters in the egg stage. Mosquito adults who over winter either hibernate in animal burrows, hollow logs, or basements and then emerge in the spring, get a blood meal, and lay their eggs. Over wintering eggs are usually immersed in ice and when water temperature rises in the spring, they hatch. Larvae that over winter, though not as common as over wintering adults and eggs, are usually buried in mud of freshwater swamps over the winter and resume their life cycle when spring arrives.

After emerging from the pupa stage or from over wintering, female mosquitoes immediately begin to seek a blood meal to feed on for several days. Male mosquitoes mate with the female mosquitoes one to two days after emerging. The “buzzing” hum of the females wings while flying attracts males. After breeding, the female lays her copious amount of eggs and resumes host-seeking. Male mosquitoes generally live for one week, as females can live two or more weeks.

Resistance Evolution in Mosquitoes

Because mosquitoes can transmit deadly diseases such as Malaria and the West-Nile Virus, many lengths are taken to eliminate and fend off mosquitoes. Unfortunately, (or fortunately to mosquitoes) some mosquitoes have evolved resistance to said lengths. N,N-Diethyl-meta-Toluamide [DEET], a common insect repellent, is believed to be losing its effectiveness against mosquitoes. The insect repellent is said to “block” neurons in mosquito antennae, which possess odor-sensing cells that are known to sense DEET and other chemicals

that cause human odor. However, a study by James Logan and colleagues at Rothamsted Research in Harpenden, UK showed 13% of a laboratory population of Aedes species females were indifferent to the DEET, and would land on arms covered in the insect repellent. Though previous research had weak evidence that DEET resistance could be passed on through genetics, Logan's study showed 50% of females in the first generation of breeding resistant females with untested males were resistant to DEET, just like their mothers. "…the study further affirms that repellents like DEET may lead to resistance over time if used to control mosquito-borne disease on a large scale", stated Logan. (Weaver, 2010)

Dichlorodiphenyltrichloroethane [DDT], a now Environmental Protection Agency-banned [EPA] insecticide, was widely used in the World War II era to combat malaria, typhus, and other insect-borne diseases among military and civilian population. (EPA, 1972) "The decline (of DDT use) was attributed to a number of factors including increased insect resistance…" (EPA, 1972) The once highly effective insecticide lead to insect resistance because of over-use. E.F. Knipling (1952) stated the problem during the era in Culex and Aedes species of mosquitoes. "Moreover, some of the species have developed resistance to substitute insecticides used for their control, including toxaphene, benzene hexachloride and aldrin." If mosquitoes evolved resistance for these popular insecticides because of overuse in the past, who is to say they will not develop resistance to modern repellents such as DEET today?

Conclusion

Mosquito resistance to chemicals used to control mosquito population such as DEET can overall lead to larger problems such as an increase in mosquito-spread diseases such as Malaria and the West-Nile Virus. Though the said resistance would assist the population of mosquito

species, the resistance will generally impact the human population negatively. Methods such as eliminating still water sources to prevent mosquito breeding and continuation of the life cycle are one of the few “safe” ways to successfully decrease mosquito population without subjecting mosquitoes to the opportunity to evolve resistance.

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