# New Mosquito Borne Threats to Michigan

Stephen C. Ireland

The State of Michigan is especially vulnerable to mosquito borne viruses. Without proper control measures in place this threat could continue to grow and have a damaging effect on the economy, ecology, and health of the Great Lakes region in the coming years.

The effects of globalization unfortunately include the dissemination of pathogens via travel and trade that would otherwise have remained sequestered in distant and often remote regions of the world. The Emerald Ash Borer beetle recently introduced from Asia has killed 15 million ash trees between 2002 and 2006 in the Great Lakes region (Maloney et al., 2006). Exotic viruses can also travel great distances and create massive ecological disturbances such as livestock destruction, loss of native wildlife, and serious human disease.

This paper will first broadly define some of the dynamic elements of arbovirus (arthropod-borne virus) ecology and then turn to the discussion of three emerging varieties of mosquito-borne viruses that threaten Michigan. It is important that attention is drawn to these pathogens before they develop. The appropriate control agencies should not be caught off guard to these threats.

## Arbovirus Ecology

The enzoonotic (occurring within animals) lifecycle of arboviruses is heavily contingent upon vector, host, and environmental interactions (Hollidge, 2010). It is helpful to discuss these components to gain an understanding of the arboviral threats to Michigan. The diminutive mosquito takes the lion’s share of the blame for many big name diseases like West Nile virus, La Crosse virus, and Eastern Equine Encephalitis. This is because mosquitoes (family Culicidae) are the primary arthropod vectors for the transmission of these pathogens. The point of contact needed for the transmission of the disease to vertebrates occurs when the female removes a tiny drop of blood from its victim. The small amount of blood she takes provides her with the protein she will need to lay her eggs (Marshall, 2006). It is powerful viruses, not the mosquito however that truly causes disease to develop in non-target hosts. Endoparasitic viruses have made villains out of the ectoparisitic mosquito disproportionate to her crime.

A virus is an association of molecules consisting of a bit of nucleic acid enshrouded by a layer of protein (Raven, 2002). Viruses are on the verge of what is considered to be alive but can reproduce by destroying a host cell in order to make copies of itself. The viruses of concern do not harm their native host, otherwise the symptoms might lead to the end of the host and the virus as well. The native host is termed an “amplifying host” as they are animals that provide the virus “safe harbor” in which to build its numbers. While inside a native host, the virus will multiply until a sufficiently high viremia is met to enable the virus to be picked up by a mosquito during its bite (Morenz, 2004). Usually there is one specific mosquito species called the *amplifying vector* that carries the virus between native hosts, such as birds, rodents, and sometimes humans. The mosquito vector has intricately co-evolved as a virus taxi cab effectively providing speedy transportation from one amplifying host to another. The locomotion, resilience, and vienous delivery achieved by the mosquito is far beyond what a sessile virus would be capable of otherwise.

Once in a new host the whole process can begin again. If the amplifying host or vector species is relocated to a naïve locality, say Michigan, the arbovirus can become a danger to that area. The invasive species will ultimately inoculate dead-end hosts ill-equipped to fight off the virus, leading to sickness and sometimes death. This amplifying host to dead-end host transmission is done by a *bridge vector species* which may or may not be the same as the amplifying vector species. Both native and invasive species of mosquitoes well adapted to

Michigan biomes have shown an ability to carry and transmit viral pathogens (Hollidge, 2010). For these reasons foreign arboviral pathogens present a unique and dangerous potential to Michigan organisms.

**Specific Threats to Michigan**

West Nile virus has produced a high amount of media coverage. This is partly due to its initial high-profile United States outbreak in New York in 1999 which led to 62 cases and seven human deaths (Briese et al., 1999*)*. Before this time it had been seen only in the West Nile region of Uganda. West Nile is categorized as a flavivirus, and leads to an often deadly inflammation of the brain called encephalitis. It is carried in nature by birds which often are asymptomatic. After virus levels in the blood of a host become high, a mosquito will feed and draw some of the virus into its gut. The virus will then undergo a process of leaving the blood meal and gut of the mosquito. A period of time passes called incubation as the virus permeates through to the hemolymph and shortly thereafter enters the salivary glands of the head. At this point if the mosquito lands on a human being to finish a blood meal or perhaps to begin a second gonadotropic cycle, the virus may be administered via the subcutaneous input of saliva. West Nile virus is a severe neurological illness and an infected human can have varied symptoms ranging from muscular weakness, paralysis, and in some cases death (Petersen & Marfin, 2002). Not all mosquito species are suited to carry West Nile virus.

The mosquito which is considered to be the primary bridge vector of West Nile is *Culex pipiens* (Fonseca et al., 2004). *Culex pipiens* is widespread in the United States, including in Michigan where it has a widespread distribution (Darsi, 2005). There are various behavioral and morphological characteristics of *Culex pipiens* which implicate it as the primary carrier of WNV. The species is commonly present in urban environments (Vinagradova, 2000). This is due to its unique environmental tolerances and efficient reproductive cycle. *Pipiens* also has an uncommon tendency to be indiscriminate in its biting preferences, and will inflict a bite on both humans and birds. These traits, in addition to the physiology *Culex pipiens*, make it the primary bridge vector for West Nile. Michigan has a lush habitat which is home to one of the most diverse avian populations in the US, and is located along the migration routes of many birds. Consequently the potential for this virus to undergo outbreaks in Michigan is high.

La Crosse encephalitis belongs to the Bunyaviridae strain of viruses. It was first detected domestically in a young girl in the eponymous La Crosse Wisconsin. Most cases of La Crosse effect children under the age of 15 (McJunkin et al., 2001). Although La Crosse is relatively rare in the United States, the insect-borne malady has the potential to spread rapidly because there are two widespread mosquito vectors. The mode of transmission via the saliva of a bridge vector is almost identical with West Nile, except that LCE has different amplifying hosts and bridge vectors. La Crosse's amplifying hosts are chipmunks and squirrels which do not exhibit any illness. One native mosquito to Michigan *Aedes triseriatus*, and an invasive mosquito, *Aedes albopictus* both have the ability to spread the virus by assuming the role of amplifying vector (Hollidge, 2010).

La Crosse encephalitis has characteristics that seem well suited for invading Michigan. Its original documentation in the U.S. is in an area that has a climate and local fauna remarkably similar to that in Michigan. The *Aedes trisariatus* is a widespread native species of mosquito in both states that reproduces in tree holes. It has adapted well to urban environments and spawns in tires and other urban pools. In addition Aedes *triseriatus* feeds in the daytime when human beings are also active. *Aedes albopictus* or the Asian Tiger is another aggressive day biter that was probably imported in a load of tires from Japan. It is still rarely reported in Michigan, however climate changes and seasonal shifts in weather patterns could result in this secondary vector establishing itself in Michigan. Another important aspect of La Crosse encephalitis is that it is transovarian; i.e., it can be transmitted vertically from adult female to her eggs. This is an important component to virus occurrence in Michigan. It provides a means for the virus to over-winter in mosquito eggs during a severe Michigan winter. This characteristic provides La Crosse with a launching pad in the spring, and also it could boost bridge vector feeding throughout the year. La Crosse encephalitis has potential to become a serious threat to Michigan.

The remaining disease to be considered here that poses an upandcoming threat to Michigan is Eastern Equine Encephalitis (EEE). This virus is a mosquito borne Alphavirus that was first isolated in 1933 from infected horses in Virginia (Zacks & Paessler, 2010). The amplifying host of EEE, like West Nile are passerine birds. But unlike West Nile, *Culiseta melanura* is the primary amplifying vector. The disease presents a threat to some mammals including humans and horses. The Eastern Equine virus is the most deadly arbovirus that currently threatens Michigan. As its name suggests one major group of animals vulnerable to EEE are horses. When infected these animals have a mortality rate of 70% to 90%. Humans also have a high mortality rate ranging from 50% to 70% (Zacks & Paessler, *2010*) A study by Villari et al (1995). showed that the economic impact of a single case of encephalitis and the treatment for resulting disorders was $3 million, at that time.

Many mosquito bridge vectors for EEE have been implicated. *Aedes vexans*, *Coquillettidia perturbans*, *Aedes sollicitans* are among those indicated (CDC, *2006*). During times of virus outbreak these species will typically transfer the virus from birds to horses and humans. *Culiseta melanura* is the primary amplifying vector of EEE because it is better at carrying the virus, but rarely feeds on mammals. Michigan could suffer from this virus because of our having native populations of virtually all of the primary EEE bridge vectors. Michigan also has a number of horse farms, particularly in the western side of the state. During peak mosquito seasons vector populations spike, particularly *Coquillettidia purturbans*. At these times bridge vectoring is highly probably as mosquito swarms become widespread, competition increases and indiscriminate feeding becomes more widespread.

## Conclusion

The life-cycles of some specialized non-native viruses are intimately intertwined with that of the mosquito, and are a testament to the diversity and ingenuity found in nature. Viruses are an assailant capable of serious destruction and should be carefully studied and controlled. Unfortunately the arrival and resurgence of such threats may be an inevitability due to the conditions present in Michigan. Only through understanding, judicious use of control measures, and outreach can these nefarious unwelcome guests be eradicated and the mosquitoes reputation as merely an annoyance be maintained

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