The Benefits of Clear Water and the Sun: Solar Disinfection of Mosquito Larvae

By: Nicole Berry

When thinking of mosquitoes, many people think of the pesky buzzing sound, waking up with itchy bumps on their arms and legs after night outside, and a lot of bug spray. Miami University (OH) researcher Nicole Berry (Fig. 1) thinks about mosquitoes a little differently than most people. In fact, her thesis research which was recently published in PLOS ONE journal, and coauthored by Thomas Fisher, Erin Overholt, and Craig Williamson, investigated the effects of dissolved organic matter (DOM) and solar UV radiation on the survival of the early life stages of mosquitoes (Berry et al. 2020).

Mosquitoes are very abundant carriers of diseases such as West Nile virus and Eastern Equine Encephalitis (Fig. 2). Both of these diseases are increasing in prevalence across northeastern North America in both humans and wild populations of economically and environmentally important birds, such as the ruffed grouse of Pennsylvania. The recent increases in mosquito abundance correlates with an increase in DOM in inland water bodies (a phenomenon referred to as "browning") across northeastern North America. Lacawac Sanctuary is no stranger to browning, as the Williamson lab has dedicated years of research documenting the increases of DOM in Lake Lacawac since the early 90's. From this research, DOM is known to significantly decrease underwater exposure to damaging solar UV radiation and can reduce the ability for solar disinfection of water borne pathogens and diseases (Williamson et al. 2017). However, it is less understood what role browning plays in regulating the prevalence of vectors of disease with aquatic life stages (i.e. the mosquito larvae; Fig. 2).

Nicole Berry, at the time, was a master's student in Craig Williamson's Global Change Limnology Lab and noticed an abundance of mosquito larvae in browner, high DOM waters, but very few larvae in more clear, low DOM waters. Together, Berry and Williamson, with the help of their undergraduate assistant, Trevor Holm (Fig. 1), began investigating the role DOM played in promoting larval mosquito survivorship during the summer of 2017. Fast forward to the summer of 2018, and Berry, along with her undergraduate assistants, William Swales and Alyssa Cassidy (Fig. 1), found themselves funded by the Northeastern Mosquito Control Association, Jobbin's Scholarship, covered in mosquito repellent, and trampling through the woods of Lacawac Sanctuary placing storage containers full of "stinky", high DOM water in the woods in hopes of attracting adult female mosquitoes to lay their eggs for their experiments (Fig. 3). Berry's team would go to the woods daily, collect egg rafts laid the previous night, and raise the eggs in the lab until they hatched as larvae.

The larvae were placed in water with and without DOM and subjected to exposure to damaging UV radiation using both natural UV radiation from the sun (Fig. 3), and artificial UV radiation from UV-B lamps. This design allowed Berry's team to test whether: 1) mosquito larvae were killed by solar UV radiation, 2) the presence of DOM increased larval survivorship, and 3) if the other wavelengths of light found in natural sunlight increased larval survivorship (some wavelengths can activate DNA repair enzymes if present in the organism). Berry's team found that mosquito larvae were intolerant of exposure to UV radiation even when exposed to natural sunlight and that DOM protected the larvae from damaging UV radiation. This novel work suggests that DOM not only acts as a food source as was previously known, but that young mosquito larvae need high DOM water bodies to protect themselves from the sun.

Understanding the mechanisms that naturally control mosquito survivorship is critical for mosquito management. Mosquitoes are present anywhere there is water and mosquito managers are often challenged with resources and person-time, and therefore have to prioritize which habitats are at highest risk of breeding mosquitoes. Berry and her team hope that their findings will help mosquito managers by encouraging them to focus their control efforts on habitats with higher DOM concentrations where mosquito larvae are protected from underwater solar UV radiation.

Figure 1. Miami University graduate student Nicole Berry (left) investigated the impacts of dissolved organic matter on mosquito survival assisted by undergraduate students Trevor Holm (center), William Swales, and Alyssa Cassidy (right).

Figure 2. Three of the four mosquito life stages: egg rafts (left), larvae (center), and adult (right). The egg, larvae, and pupae (not shown) are aquatic.