THE INFLUENCE OF PLANT COMPOSITION ON MOSQUITO POPULATION GROWTH AND SURVIVAL

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Abstract. Mosquitoes are known to spread diseases like Zika and West Nile viruses. These viruses are transmitted when the mosquito, a vector, carrying the virus drinks the blood of a host animal. Blood meals are only taken by female mosquitoes in order to reproduce, however all mosquitoes depend on plants early in life. Mosquito larvae consume plant detritus in aquatic habitats and adult mosquitoes feed on plant nectar. Although some plants are known to repel adult mosquitoes, little is known about how different plants consumed during the larval stage affect survival and emergence of adult mosquitoes. The main objective of this study was to examine the effects of different plant communities on mosquito growth and survival. We set up ovitraps in Poughkeepsie City at sites including vacant lots with unmanaged plant communities and in managed, residential neighborhoods to monitor where female mosquitoes lay eggs. We then evaluated population growth and survival of larvae in water with urban plants from either unmanaged vacant or managed residential lots, collected in Poughkeepsie, NY. We found that mosquitoes were more likely to lay eggs in sites with unmanaged plant communities. However, mosquito larvae reared in unmanaged plant water had significantly greater mortality and were less likely to emerge as biting adults. Overall, mosquitoes have a tendency to lay more eggs in vacant lots, surrounded by invasive plant species, but seem to live longer in the presence of ornamental plants.

INTRODUCTION

Mosquitoes are vectors for various diseases such as West Nile Virus and dengue. Vector-borne diseases are a growing problem in urban environments. This is largely due to invasive container breeding species, such as those in the *Aedes* genus. Man-made breeding habitats, such as standing water in tires, facilitate the growth of invasive populations. Populations of *Aedes albopictus* (Asian tiger mosquito) and other container breeding mosquitoes are difficult to control because they can breed in a variety of places and reproduce quickly (Unlu *et al.* 2016). Mosquitoes lay their eggs in water and spend their early lives in water until they emerge as adults. A study conducted by Banerjee, *et al.* concluded that individual fitness of adult mosquitoes (*Aedes aegypti* and *Aedes albopictus*) is affected by pupal size. Small pupae become small adults and are less fit compared to larger mosquitoes of the same species.

Female mosquitoes rely on blood meals from host mammals for nutrition during egg production. Plants are an important factor of the mosquito life cycle. Water quality, determined by plant detritus, affects larval growth and survival. Adults gain energy from drinking nectar. Plants also provide optimal microclimate conditions for mosquitoes in all life stages. Female mosquitoes of some species, *Anopheles minimus* in particular, prefer to lay their eggs in water among small-leaved plants, than in grasses or soils (Overgaard 2007). They typically live in cool, shaded regions with access to open water and flowering plants.

High levels of plant species diversity may even negatively affect mosquito populations (Greenway *et al.* 2003). Higher species diversity among plants attracts an array of macroinvertebrates. Dense insect populations indicate that predation will also be high (Greenway *et al.* 2003). Mosquito larvae are more likely to get eaten in these environments, causing adult population size to decrease.

Urban areas are variable landscapes with patches of habitat conditions that support different plant and animal communities. The numbers of vacant versus occupied lots vary between neighborhoods. Vacant neighborhoods are often home to unmanaged plant communities, characterized by overgrown and often undesirable plants. Invasive plant species are popular and often dominant in these areas. Managed plant communities are often found in well populated neighborhoods. Nonnative ornamental plant species are present in these areas. Unlike vacant areas, managed communities consist of large open spaces. Some opportunistic invasive plant species may be better competitors and more numerous than the native species, providing mosquito larvae with various food sources. Some plant species provide optimal conditions for mosquito larval growth, while some repel mosquitoes. Some plants have adverse effects on mosquitoes, which may then lead to an overall decrease in individual fitness. There are plant species that also repel or even kill mosquitoes. In a recent paper, Tisgratog, *et al.* lists some plants that repel mosquitoes which include lemongrass, turmeric, black pepper, and ginger. My questions for this study are:

1. Is larval growth and survival influenced by the presence of managed versus unmanaged plant species?

2. Does adult oviposition differ across unmanaged and managed urban lots?

I hypothesize that there will be higher rates of oviposition and larval growth in unmanaged lots, but that this will ultimately lead to smaller adults.

MATERIALS AND METHODS

Field Experiment

Seed germination paper was used to line black plastic cups (500ml) that were used as oviposition traps in the field. Each cup was then filled with well water to the bottom end of the paper (~300ml) and left on site for one week. The three sites designated as unmanaged were vacant lots with adequate plant cover. The managed sites included a community park and the yards of houses in urban neighborhoods. One site, Ridgeview Road, was in the front yard of a house, but was labeled neither managed nor unmanaged because it was actually a suburban forest. Two ovitraps were placed at each site, with the exception of Ridgeview Road, which had four ovitraps. Table 1 lists the names of all sites, and number of traps at each. The cups were hidden in surrounding foliage and left out for one week. Upon collection from the field, the water temperature in the ovitraps was recorded, along with presence of mosquito eggs and/or larvae. The papers with eggs were dried for 24 hours and soaked in well water until the eggs hatched. If no eggs hatched after 3 days, the papers were discarded.

Lab Experiment

Aedes albopictus eggs on germination paper were obtained from the Leisnham lab's colony in Baltimore, Maryland. The papers were soaked in well water until larvae hatched (in ~3 days). The newly hatched larvae were then placed in mason jars with nets on top to allow oxygen flow. Leaf teas were mixed using plants collected from the field. Three different common plants each were collected from managed and unmanaged sites and dried in an oven. The dry plant material was weighed and 20.0 g from each site treatment was placed in a water cooler filled with well water. The plants were left to soak for at least 3 days prior to being used. Each jar was filled with 200 mL of managed or unmanaged leaf tea. There were 10 jars for each treatment and 50 mosquito larvae in each. The jars were incubated at 12 hour night/day cycles and held at a day temperature of 30.0°C and a night temperature of 26.0°C. Pupae were removed from the jars every morning and placed into breeders containing water from the corresponding treatment. The breeders were separated by the pupation date of the larvae (in 2-day bins). Adult mosquitoes were taken out of the breeders and placed in the freezer. The adults were separated by sex and wing lengths of the females were measured.

RESULTS

Oviposition Experiment

More eggs were laid in oviposition traps placed in the unmanaged vacant lots than managed yards with ornamental plants (Fig. 1). Eggs were laid at the suburban forest site every week. Species present at each site are shown in Table 2. There was a statistically significant difference in the probability of mosquitoes laying eggs at managed and unmanaged sites (P=0.021). The eggs were hatched in the lab and larvae were reared into adulthood. The total number of adults was recorded for each treatment (Fig. 2), with 50 adults emerging from managed containers compared to less than 10 emerging from the unmanaged containers.

Mason Jar Experiment

Mosquitoes reared in leaf teas brewed from the unmanaged plants experienced a significantly higher mortality rate than their ornamental counterparts (Fig. 3) and were less likely to emerge as biting adults. The average number of pupae in each jar was noticeably higher for mosquitoes grown in managed leaf teas (P=0.02973). On average, there were more live larvae found in managed jars after X days compared to unmanaged (P=0.0425).

DISCUSSION

Overall, mosquitoes laid more eggs in ovitraps placed in sites with unmanaged plant communities that included plant species such as wild lettuce and catalpa. However, despite there being more eggs laid, the eggs from the managed sites had greater survival rates. Ornamental species such as hemlock, golden aster, and rosehip were common in the yards of homes in residential neighborhoods. Most of the eggs laid at unmanaged sites did not hatch. Similarly, most of the *Aedes albopictus* larvae from Baltimore, MD that were reared in unmanaged leaf tea did not reach adulthood. Larvae reared in leaf tea brewed from ornamental plants species lived longer and were able to reach adulthood significantly more often than larvae reared in unmanaged tea.

The eggs laid in the ovitraps did not all come from one species of mosquito. This was noted when the larvae found in each trap were examined and their species determined (Table 2). This may be a possible source of error, as some species differ greatly in terms of their reproductive behaviors. Some species, for example *Aedes japonicus*, lay large numbers of dormant eggs that are resistant to extreme temperature (Andreadis and Wolfe 2010). The dormant eggs will hatch in favorable conditions, perhaps accounting for the vast difference in numbers of eggs found at unmanaged sites and number of live larvae counted at each of these sites. Another source of error stems from plants from multiple sites being brewed together in the leaf teas. Each plant was not individually soaked in water, so it remains unclear which plants in the unmanaged communities were responsible for the low survival of mosquitoes. Larvae may have been dying off because of the presence of one toxic plant, as opposed to a mixture of unmanaged plant species.

Ridgeview Road, unlike the other sites in this study, had characteristics of both managed and unmanaged sites. The ovitraps were placed outside of a house, in the front yard. However, unlike the residential locations of the managed ovitraps, the ones on Ridgeview Road were not surrounded by ornamental plant species. The community at this site consisted mainly of species known to exist in northeastern forests, including mature maple trees and poison ivy.

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APPENDIX

TABLE 1. Chosen sites for oviposition traps.

Site	Treatment	Number of Replicates
Pershing Avenue	Unmanaged	2
30 Rose Street	Unmanaged	2
31 Rose Street	Unmanaged	2
Murphy Park	Managed	2
Hooker Avenue	Managed	2
Randolph Avenue	Managed	2
Ridgeview Road	Suburban Forest	4

TABLE 2. Mosquito species present at sites where eggs hatched.

	Site	Species Present
Managed	Murphy Park	*Culex pipiens*
	Hooker Avenue	*Aedes triseriatus*
Suburban Forest	Ridgeview Road	*Aedes japonicus*

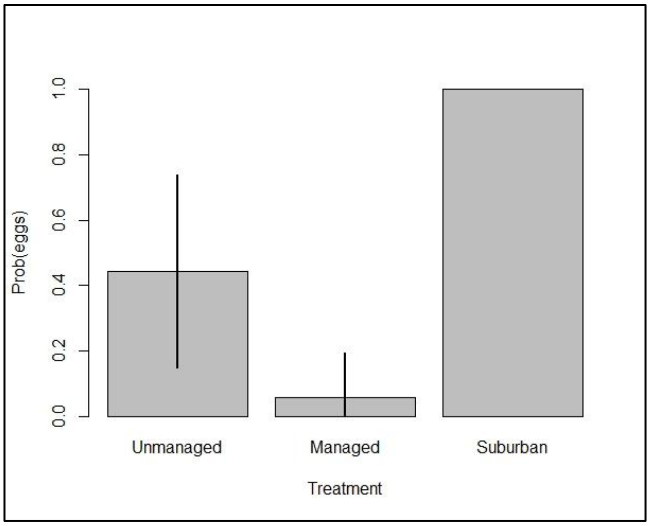

FIGURE 1. Probability of mosquitoes laying eggs in various plant communities. All papers collected from the suburban forest site contained eggs.

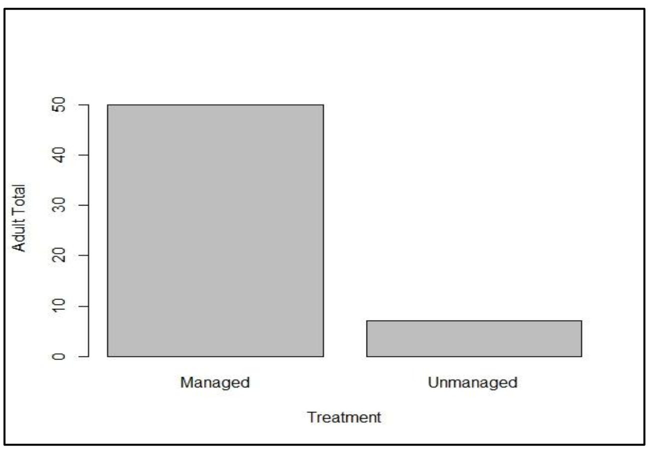

FIGURE 2. Adults emerged from each treatment. After hatching, the mosquitoes were reared in 'leaf teas' of the managed and unmanaged sites.

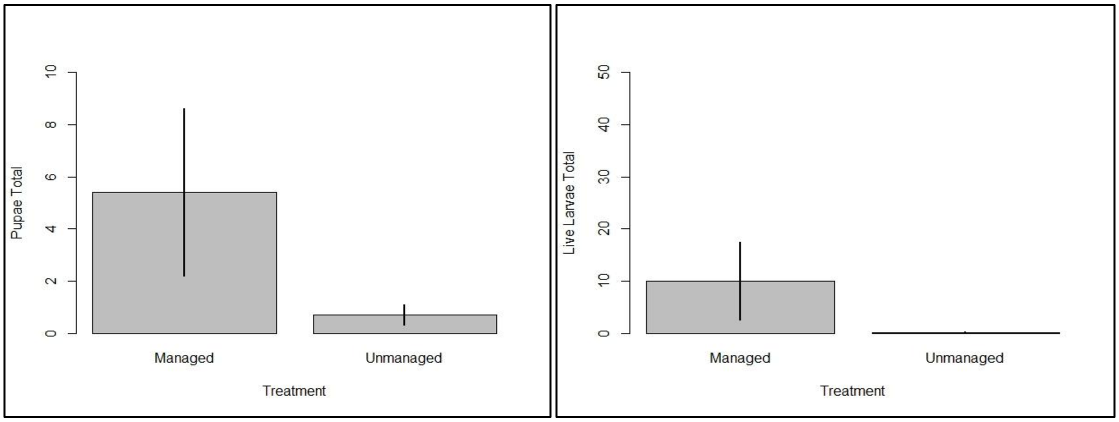

FIGURE 3. Larvae had greater mortality when reared with unmanaged leaf tea.