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Effects Of Roadways In Wetlands On Larval Dragonfly And Damselfly Communities

Riley Buley
Environmental Studies
University of Wisconsin-La Crosse
1725 State Street, La Crosse, WI 54601

Faculty Advisor: Dr. Alysa Remsburg

Abstract

Wisconsin wetlands have been affected by a significant amount of roadwork development in the past few decades. The purpose of this project was to observe if the altered shoreline slopes resulting from roadway construction through wetland areas affect larval dragonfly and damselfly (Odonata) communities. By comparing samples taken in shallow waters adjacent to natural wetland shorelines with samples taken adjacent to roadway banks, we expected to find a change in population and species assemblages of dragonfly larva. Odonata samples and vegetation structure measurements were obtained from 22 plots, and 208 specimens were collected within 11 species categories. The suborder Zygoptera showed higher abundances at roadway shorelines. The highest abundance of all odonate larvae was found at plots with emergent vegetation in slightly deeper water and with higher emergent vegetation. This data raises numerous questions about where odonate larvae are most abundant within wetlands.

Keywords: Dragonflies, Wetlands, Communities

1. Introduction

Within the realm of Environmental Science, there is no argument of the importance of wetlands. It is a well-known problem that expansions in agriculture and urbanization have drastically reduced the amount of wetlands present[9]. Urbanization not only affects abiotic factors, but also the biotic factors of wetlands as well. Species richness[16], bird density[17], and aquatic invertebrate abundance[24] are but a few examples of what is affected by wetland quality. Road development next to wetlands alters hydrology, water quality, and wildlife movements in and around wetlands[11].

This study examines how road and pathway development through wetlands affect larval dragonfly density and species assemblages. Surveying the diversity of dragonfly species is desired for the following reasons: 1) Previous studies have indicated the use of dragonflies as the “climate canaries” for river health[5]. Dragonflies are used as Biosentinels of mercury bioaccumulation, a topic of pressing concern in Wisconsin’s wetlands[12]. Researchers often sample larval dragonflies from wetlands near roadways (due to ease of access), and it is useful to understand whether dragonfly communities in these parts of the wetland are different from dragonfly communities in more natural parts of the wetland. 2) Dragonflies are a flagship species (a species known as a popular symbol for a defined habitat) in the Wisconsin area.[25]. 3) Though some studies indicate that shoreline vegetation influences larval dragonfly densities[19,5], no studies have looked at shoreline slope as a factor to influence dragonfly habitat selection, so this process is hardly understood.

Because of the required height of roads and walkways through the marsh and surrounding backwater area, the natural slopes of the littoral and riparian zone have been severely altered. Changes in slope altar the diversity of plant assemblages along with physical factors[13]. Adult dragonflies likely use the shore zone as an indicator of what the near-shore aquatic habitat will be for the larval stage of their offspring[19]. Most larval odonate species move very little from where the eggs are laid, so the area where adults lay their eggs will also be the place where the larva will emerge out of the water a year or more later [1].

. We anticipate that built roadways through wetland areas will reduce native dragonfly's species richness and abundance by the alteration of near-shore habitat.

2. Methods

If changes in shoreline slope affect the depth and emergent vegetation at these places, they could potentially affect the ecology of dragonflies and other aquatic organisms. Since dragonflies are predators as well as prey to other organisms, their population densities are certainly a concern when trying to maintain a healthy wetland

study sites

This study took place at 11 sites located in Myrick Marsh, La Crosse and the Trempealeau National Wildlife Refuge in Trempealeau, Wisconsin. Myrick Marsh is a preserved wetland area located within the city of La Crosse and is positioned around a small area of the La Crosse River. The roadways through the marsh are used for human enjoyment and are on average 3.7m in width. The Trempealeau National Wildlife Refuge is an area of backwater located off the main channel of the Mississippi River. These backwater areas are a mix of wetlands and shallow pond-like regions. Roadways here are used for human enjoyment but also used for vehicle transportation. Two of the sites sampled within the Refuge were near a dike, used for water level management, with a roadway on its top (Table 1). The average width of roadways in the Refuge was 4.7m.

Table 1. description of study sites. only sites where species were encountered are listed.

Site Name/Number	Location	Date Sampled
Marsh Entrance Gravel(5 and6)	La Crosse, WI	7/13/14
Natural Bench Site(7and 8)	La Crosse, WI	7/14/14
Marsh Paved Site(9 and 10)	La Crosse, WI	7/16/14
Boat Landing Refuge(11and12)	Trempealeau, WI	8/2/14
Refuge Office Site(13 and 14)	Trempealeau, WI	8/2/14
Refuge Entrance(15 and 16)	Trempealeau, WI	8/2/14
Dike Mountain Site(17and18)	Trempealeau, WI	8/16/14

The 11 sites each consisted of two, 10m lengths plots of open water shoreline containing similar aquatic conditions, for a total of 22 plots. Paired plots could be no closer than 10m together and sites had to be at least 50m apart. The first of each paired plot was a natural shoreline with a slope that had no apparent alteration by human development. The second was an altered shoreline with a slope created by a roadway or path embankment. Littoral slope (slope under the water line) was not measured, but the embankment slope leading up to a roadway was. Paired shorelines were exposed to very similar environmental conditions, taking into account variables such as water depth, sediment composition, and vegetation status. These vegetation variables included; amount of coarse wood present, total number of trees and shrubs within a plot, and the amount of emergent aquatic vegetation. The average depth at the line where the emergent vegetation ended was estimated from three measurements across the 10m plot. The line of emergent vegetation was a focus of the plot depth description because odonate density and diversity were expected to be highest in these areas. Though sites had various water depths from 0.5 to 1.5m, the natural and altered paired plots had comparable depths at the line of emergent vegetation.

2.1 Sampling Procedures

Natural shoreline width was measured from the water's edge to the point where the shoreline embankment turned into a naturally flat area. The altered shoreline bank width was measured from the water's edge to where the roadway (or path) clearing began. Bank height was also measured. Natural and altered shoreline heights were both measured from water surface to the apex of the embankment. The slope of the shoreline was measured in degrees. This task was completed by laying a 2m length of PVC piping along the slope and then using a compass with a clinometers. The average slope was recorded from three locations along the plot.

Tree and shrub counts were taken for any woody vegetation located within the 10m plot area from the waters edge back 2m. Woody vegetation meant trees having a stem larger than 6 centimeters in diameter and shrubs with the base of the stem less than 6 centimeters in diameter. Average emergent aquatic vegetation stem counts were taken from three areas within the 10m plot. Counts were taken at the point where emergent vegetation ended and preceded into open water. This area, and the three counts taken there, was termed "mean emergent vegetation line" (Figure 1). A hula-hoop with a diameter of 1m was put in the water and the emergent stems within that area were counted. Aquatic coarse wood was considered to be any fallen woody vegetation or floating logs, located within a plot.

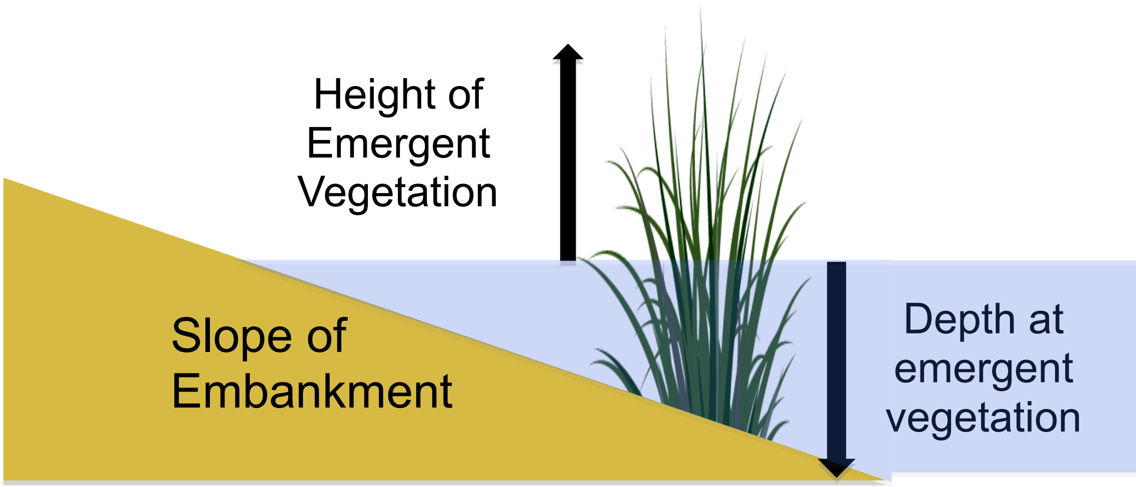

Figure 1. diagram of typical shoreline embankment with selected terms of interest.

Sampling for larval odonates was accomplished using a D-net with 1 mm mesh, and retrieving benthic sediment samples from each plot. Systematic sampling included a procedure with D-net sweeps in deeper water (0.5 to 1 m depth), mid water (0.5- 0.2m), and then right at the shoreline (0.2-0m). Specimens from all depths were pooled together within each plot. 30 minutes of sampling took place using a timer; ensuring that each plot received equal sampling efforts. If it took less than 30 minutes to sample deep, mid, and shoreline water from one side of the 10m site to the other, the sampler took more sample sites in the 10m area in a random fashion, focusing attention on mid water and shoreline areas.

2.2 Categorization And Statistical Analysis Of Odonate Specimens

Odonate specimens were identified down to their species using a dichotomous key and dissection microscope[4, 15]. Species richness and abundance counts were taken from each paired plot, and specimen body lengths were measured.

The statistical software SPSS was used to perform all analyses. First, Spearman Correlations tested natural and roadway shorelines to for any possible significance. Then, the Wilcoxon signed-rank test was used to compared species richness as well as abundance of 11 different odonate species at natural and roadway shoreline sites. A Wilcoxon signed rank test was used to determine if there were significant differences in *Anax junius* body length between water depth at the line of emergent vegetation, the amount of trees, and the amount of shrubs.

To gain an understanding of any trends occurring overall in Odonata communities, linear regression tests were performed on total richness and abundance against independent vegetation and geographical variables. Because of their groupings large abundances, linear regression models for *Anax junius* and the suborder Zygoptera.

3. Results

Spearmen Correlations found that the water depth at the line of emergent vegetation was greater at roadway embankments ($r_S = 0.627, P < 0.0005$). While water depth was negatively correlated with trees ($r_S = -0.638, P < 0.0005$) and shrubs ($r_S = -0.723, P < 0.0005$).

A total of 208 specimens and 11 different odonate species were collected (Table 2). No significant difference was observed in the distributions of species richness between natural and roadway sites (P = 0.357), but results showed there was a significant difference in abundance within species *Anax junius* and the suborder Zygoptera.

Regression model outputs of all odonate specimens collected showed that two habitat variables were best predictors of total odonate abundance: height of emergent vegetation ($r_S = -0.555, P < 0.044$) and the depth at emergent vegetation ($r_S = -0.666, P < 0.020$). A positive linear relationship (1) occurred between Total Abundance and Depth at Mean Emergent Vegetation Height (Figure 2), and can be displayed in the following model:

$$\textit{Total Abundance} = -4.146 - 0.555 * \text{Veg Height} + 0.666 * \text{Depth} \quad (1)$$

The suborder Zygoptera showed a higher abundance at roadway embankments (Z= -2.201, P= 0.028), but showed no significant relationship with vegetation and geographical variables due to its low sample size. Next, it was found that the median length for *A. junius* was larger at roadway shorelines to that of natural areas (r_s=*0.411*, *P=0.028)* (Figure 3).

Anax junius body length was analyzed in further to see if specific vegetative and geographical variables displayed significance as potential predictors of length.

Multiple Linear regression models showed that; embankments (r_s=*-0.180*, *P=0.02)*, the number of days since June 1, 2014 *(*r_s=*0.406*, *P* < 0.0005*)*, vegetation height *(*r_s=*0.284 P* < 0.0005), and shrubs *(*r_s= *-.220,P=0.017*) are all statistically significant when predicting the length of *A. junius* (2).

$$\textit{Anax junius Length} = 5.475 + 0.408 * \text{Days} + 11.005 * \text{Vegetation Height} - 0.297 * \text{Shrubs} + 3.562 * \text{Shoreline} \quad (2)$$

where $Shoreline = 0$ for natural shorelines and $Shoreline = 1$ for roadway shorelines. The coefficient of determination (R^2) for this regression model is 0.428 meaning that 42.8% of the variation in *A. junius* length can be attributed to the linear model.

Table 2: Number of Odonata specimens by species from sampling at paired embankments.* All unknown specimens were within the family Zygoptera. Missing extremities, such as caudal gills, prevented specimens to be identified to the species level.

Species	Natural	Roadway	Common Name
Aeshna umbrosa	5	4	Shadow Darner
Anax junius	65	53	Common Green Darner
Argia tibialis	1	2	Blue-Tipped Dancer
Enallagma geminatum	1	30	Skimming Bluet
Ishnura verticalis	0	8	Eastern Forktail
Leucorrhinia frigida	0	4	Frosted Whiteface
Neurocordulia molesta	0	2	Smoky Shadowdragon
Pantala flavescens	0	2	Wandering Glider
Perithemis tenera	0	3	Eastern Amberwing
Sympetrum rubicundulum	6	0	Ruby Meadowhawk
Tramea carolina	3	0	Carolina Saddlebags
Unknown*	1	18	Damselflies

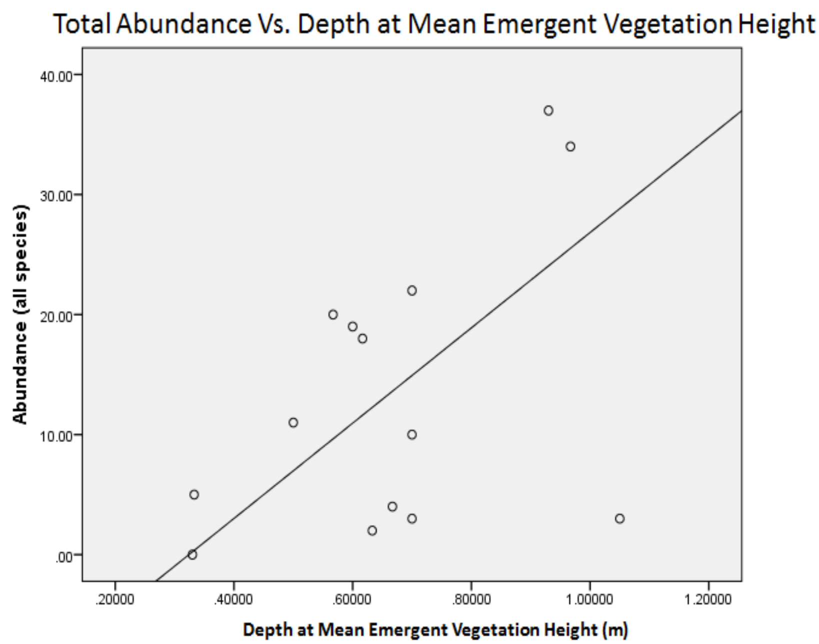

Figure 2: Total Odonata Abundances as a function of depth at mean emergent vegetation.

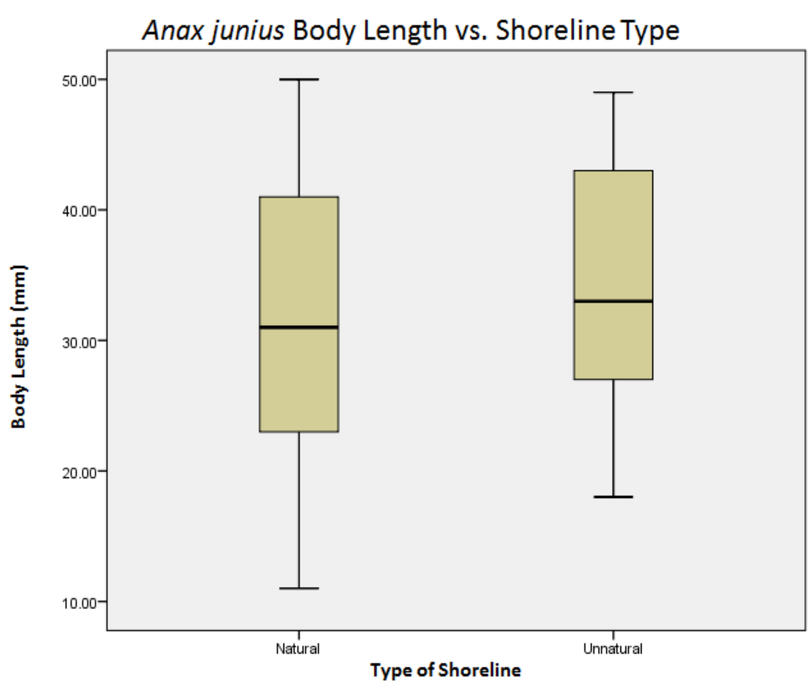

Figure 3: Mean *Anax junius* length comparison between natural and roadway shores.

4. Discussion

It appears that roadway sites have steeper slope above water continuous with a steeper littoral slope located below water, though embankment slope was not measured below the water's surface. Fewer trees and shrubs were also observed at roadway sites. In these areas, aquatic vegetation has the potential for more access to direct sunlight, allowing for a deeper establishment of macrophytes [3]. Because of this increase in macrophytic growth, odonate species richness and abundance could have the potential to be higher in developed areas such as that around roadways and walking paths[27, 2].

The primary analysis performed for this experiment compared Odonate larval species richness and abundance between natural and roadway embankments. No significant difference was observed for either abundance or richness on the species level. Results lacking further significance may be attributed to relatively low numbers of specimens obtained. Gathering a larger sample size is the primary factor to address in the continuation of this project. A longer sampling search period may increase the number of odonata sampled, as could the addition of more survey sites. Increasing the sampling area within each site was generally not possible because shoreline habitat conditions were not consistent for larger geographic areas.

A multiple linear regressions using total abundance revealed that plots with the tallest emergent vegetation had a greater total abundance of odonate species. It has been documented that larval odonate species as well as other aquatic invertebrates rely on submerged vegetation to protect themselves [22, 19]. High Emergent Vegetation abundance can be a good indicator of the vegetation below the surface. Many species use vegetation indicators to find respectable areas for ovipositioning, knowing their larvae primarily dwell in that area until their emergence into adulthood[26, 19].

In larger groupings, the suborder Zygoptera, including 3 species and several unidentifiable Zygoptera specimens, showed a higher abundance in waters adjacent to roadway embankments. All species of Zygoptera, including *Enallagma*, a prominent genus we encountered, are endophytic ovipositors. Studies have shown strong associations with Zygoptera richness and littoral macrophyte abundance[6]. Zygoptera need emergent vegetation for not only endophytic ovipositioning, but also for adults who are perchers[14].

Larger *A. junius* inhabiting areas with increased water depth was a point of interest. Odonate larvae are primarily found in waters less than 1m deep in lentic waterways, but are routinely found in deeper areas when aquatic vegetation is also present[23, 20]. The Ashnidae family, where the genus *Anax* resides, consists of larvae that inhabit on primarily aquatic vegetation where it actively predates while being protected from higher order predators[8]. In addition, *A. junius* uses emergent vegetation when morphing into their adult phase[21]. Data shows that *A. junius* flight season is highest in June and July[25], but these include both migratory and resident populations of A. *junius*. The larvae we sampled likely includes two different populations of *A. junius*. Larger body lengths could indicate the larger migratory instars positioning themselves in shallow water to emerge when they were captured. Additionally, resident *A. junius* larvae may have emerged sooner from natural shorelines when sampling took place. Continued research examining whether later instars occur at different depths needs to be preformed.

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