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PURPOSE

The Juniata Journal of Ecology (formerly Journal of Ecological Research from 1998 - 2024) launched in 1998 as a lab component of Dr. Glazier's General Ecology course to expose Juniata students to the publication process and to archive past research projects. In 2025, we modernized its internet presence for free open-access and expanded the content beyond the General Ecology course to include any ecological research from Juniata undergraduate and graduate students and alumni. The journal focuses on research from the Mid-Atlantic and Appalachian regions, but also includes research from outside our region. The open-access policy makes the journal free for both authors and readers and increases accessibility. Journal operations are managed by a team of students with faculty mentors overseeing the project at Juniata College.

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EFFECTS OF HYDROGEN PEROXIDE ON SEED GERMINATION OF WISCONSIN FAST GROWING PLANTS [*BRASSICA RAPA*]

Abigail Betar and Iqra Rana

ABSTRACT

Hydrogen peroxide is a common pesticide used in agriculture in the United States. However, there are concerns about the ecological effects of hydrogen peroxide on seed germination and growth. Previous research found that hydrogen peroxide prevents oxidative stress which plays a significant role in plant development (Wojtyla et al. 2016). Another article found that hydrogen peroxide behaves as a signaling molecule that mediates biochemical pathways (Nurnaeimah et al. 2020). We used this research to inform our experiment in determining the detrimental hydrogen peroxide concentration on seed germination. In this study, we conducted an experiment to observe the germination of Wisconsin Fast Growing seeds exposed to three different concentrations of hydrogen peroxide: 5 mL, 15 mL, and 30 mL. We conducted an analysis of variance test on our results. We found that at 30 mL, seed germination and growth were significantly inhibited. This suggests that high concentrations of hydrogen peroxide are harmful to seed germination and growth.

Keywords: *Wisconsin fast plants, seed germination, hydrogen peroxide*, Brassica rapa

INTRODUCTION

Agriculture is a major industry in the United States and is the primary source of nutrition for most people (Lindwall 2019). As of 2017, there are 2.04 million farms across the United States (Farmland Information Center 2017). Agriculture has many negative side effects on wildlife such as loss of habitat, wildlife depredation on crops, and competition for rangeland. Agriculture methods produce pollutants that are released into the environment. As defined by the Natural Resources Defense Council, agricultural pollution "is the contamination we release into the environment as a by-product of growing and raising livestock, food crops, animal feed, and biofuel crops" (Lindwall 2019). Agriculture is necessary for producing food, clothing, and jobs for people, however the practices associated with agriculture must be modified to protect the environment.

Hydrogen peroxide has been used in agriculture for pest control and sterilization in water systems. Hydrogen peroxide is a weak acid and has a pH of about 3.5. It functions to control plant bacteria and fungi in the water systems of livestock. At low concentrations, hydrogen peroxide has been found to increase growth in plants, especially in the germination period (Nurnaeimah et al. 2020). However, recent research shows that high concentrations of hydrogen peroxide is toxic and damaging to cells (Wojtyla et al. 2016). This effect is

especially important in seed germination, in which high concentrations of hydrogen peroxide were found to inhibit seed germination. Seed germination is extremely vital to the survival of plants and indicates proper development into mature plants. We wish to provide evidence that inhibition of seed germination due to agricultural pollution can lead to a lower lifespan, and improper development, which can have negative effects on the overall ecosystem (Barba-Espin et al. 2010).

The purpose of this research project is to determine the impact of different concentrations of hydrogen peroxide on seed germination of Wisconsin fast plants. Thus, we are analyzing the effects of pollution on plant species. We hypothesize that seed germination will be delayed or shortened by hydrogen peroxide, a toxin often found in pesticides used in agriculture.

METHODS AND MATERIALS

We developed our methods from the article published by Sandra Slutz on the Science Buddies website (Slutz n.d.). The materials/equipment needed for this experiment are as follows: hydrogen peroxide (3% concentration), sandwich baggies, Wisconsin Fast Growing Seeds, and paper towels. First, we created hydrogen peroxide solutions of varying concentrations to test on the Wisconsin fast plants. We prepared hydrogen peroxide solutions of low hydrogen peroxide (5mL), medium hydrogen peroxide (15mL), high hydrogen peroxide (30mL) and a control solution of water. We then placed 10 Wisconsin fast plant seeds in sandwich bags with paper towels moistened by the differing solutions. The sandwich bags with the differing concentrations were placed on a flat surface with direct sunlight for a couple of days, or until all concentrations have fully germinated seeds. We measured the seeds every day and monitored for the development of the cotyledon. In the Wisconsin Fast Growing Plant Seed Booklet, it states that the seeds take around 24-48 hours to emerge, and from 48-72 to develop the cotyledons. For our purposes, we will determine that a plant has fully germinated normally if the seeds successfully develop the cotyledon in 48-72 hours. Those that germinated were planted in soil and sprayed with their respective hydrogen peroxide concentration solutions.

Growth was compared among the treatment groups by using an analysis of variance test (SYSTAT 10, SPSS Inc., Chicago, IL).

RESULTS

A preliminary test was run on the Wisconsin Fast Plants with the varying hydrogen peroxide samples to determine how quickly germination occurred. Once this was done, the experiment was reset, and measurements were taken of seed germination over a course of 95 hours. We took measurements of each seed (root and/or stalk) to determine the mean of growth. Table 1 includes this data at 70 hours. Table 2 displays the data at 90 hours. The calculated means for each group over the 4 days are included in Table 3. The data from Table 3 was used to make Figure 1. The graph displays the relationship between seed germination over time per group. Significant differences in seedling growth were found among treatment groups at 70 and 95 hours (Figure 1; Tables 4-7).

Table 1. Seed germination progress in mm at 70 hours.

	Control	5 mL	15 mL	30 mL
Seed 1 (mm)	5	13	0	3
Seed 2 (mm)	5	15	5	4
Seed 3 (mm)	7	12	8	4

Seed 4 (mm)	5	11	7	4
Seed 5 (mm)	4	11	9	3
Seed 6 (mm)	4	10	10	2
Seed 7 (mm)	8	13	7	4
Seed 8 (mm)	7	10	8	3
Seed 9 (mm)	5	12	7	1
Seed 10 (mm)	5	15	5	1

*Seeds were numbered from left to right.

Table 2. Seed germination progress in mm at 95 hours.

	Control	5 mL	15 mL	30 mL
Seed 1 (mm)	20	13	7	5
Seed 2 (mm)	9	15	10	5
Seed 3 (mm)	20	15	9	4
Seed 4 (mm)	5	14	9	7
Seed 5 (mm)	12	13	13	8
Seed 6 (mm)	20	15	13	6
Seed 7 (mm)	18	14	11	8
Seed 8 (mm)	20	12	10	9
Seed 9 (mm)	20	13	13	5
Seed 10 (mm)	10	15	10	3

Table 3. Mean (± 95% CI) seed germination mm over 4 days.

	0 hr	24 hr	36 hr	70 hr	95 hr
Control (mm)	0	0	0	5.5 ± 0.97	15.4 ± 4.15
5 mL (mm)	0	0	0	12.2 ± 1.30	13.9 ± 0.79
15 mL (mm)	0	0	0	6.6 ± 2.00	10.5 ± 1.44
30 mL (mm)	0	0	0	2.9 ± 0.86	6 ± 1.39

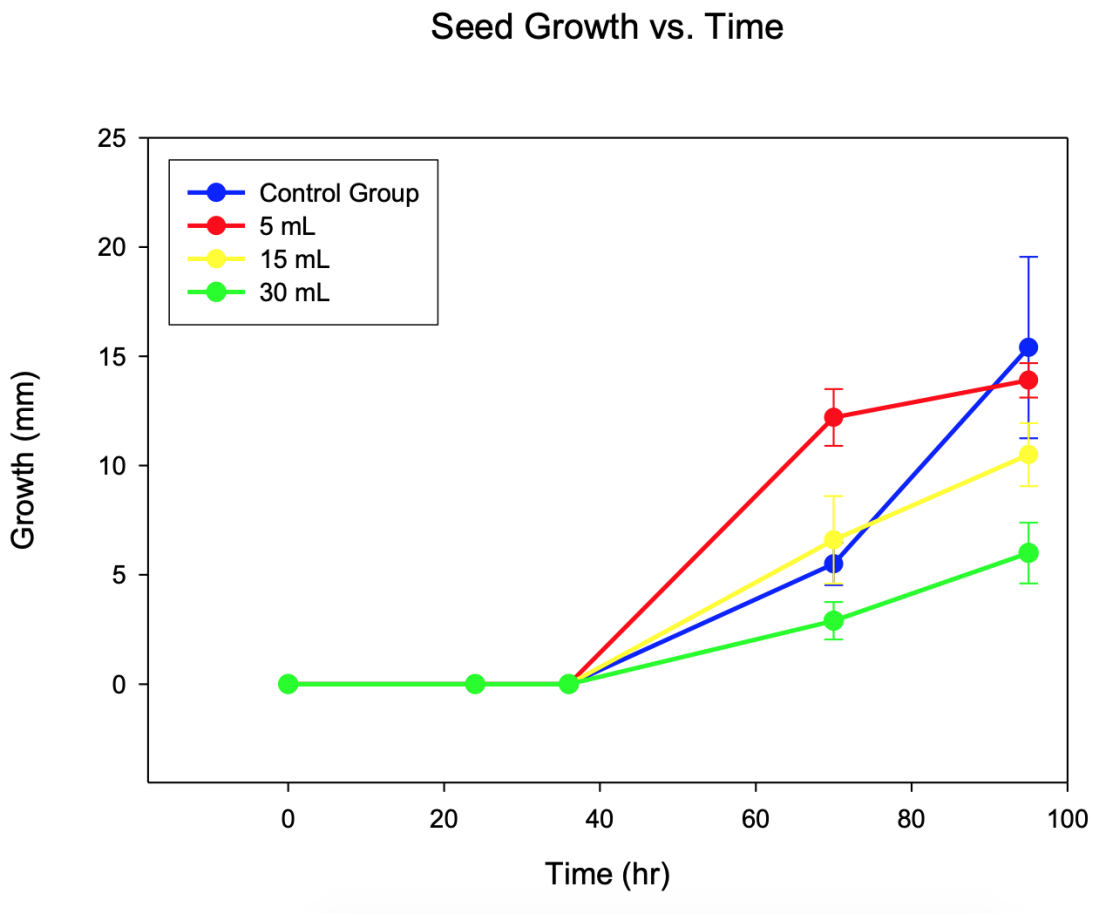

Figure 1. Seed growth (means ± 95% CI) of a control group and three treatment groups with different levels of added hydrogen peroxide (as indicated) vs. time.

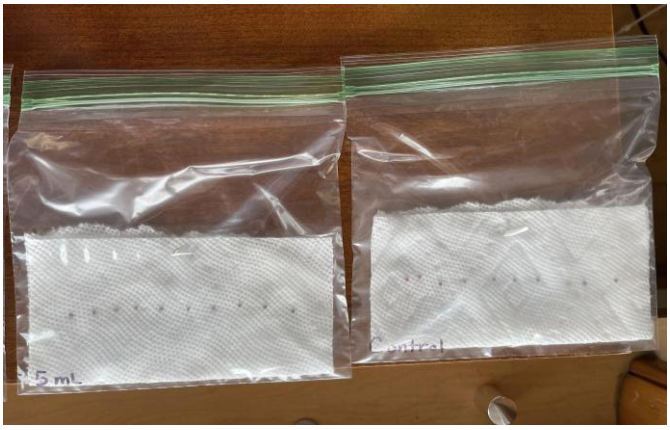

Figure 2. Experiment setup of the control group and 5mL Hydrogen Peroxide samples on Day 1, April 11th, 2022.

Figure 3. Experiment setup of 15mL Hydrogen Peroxide sample and 30mL Hydrogen Peroxide sample on Day 1, April 11th, 2022.

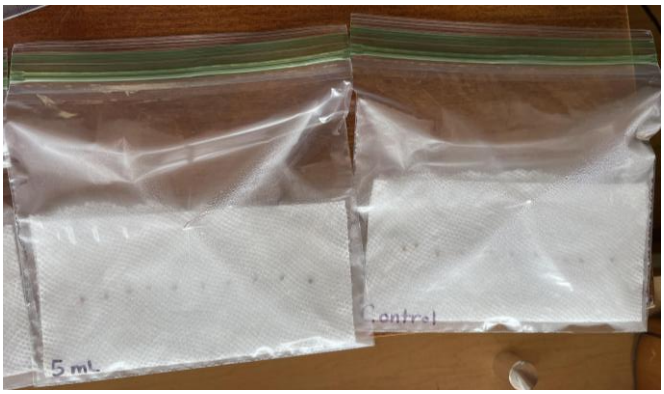

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Figure 5. Experiment setup of 15mL Hydrogen Peroxide sample and 30mL Hydrogen Peroxide sample on Day 2, April 12th, 2022.

Figure 6. Experiment setup of the control group and 5mL Hydrogen Peroxide sample on Day 3, April 13th, 2022.

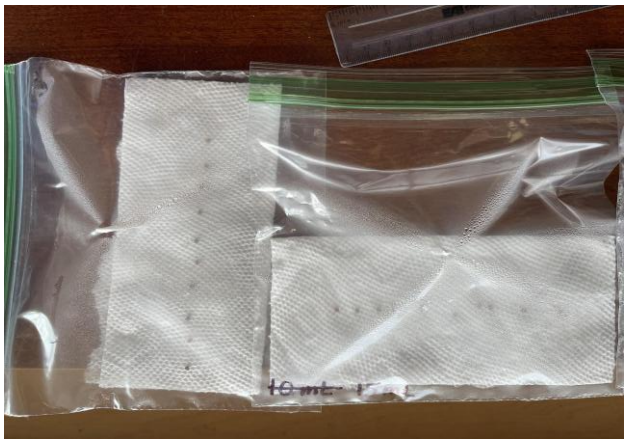

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Figure 13. Experiment setup of 5mL Hydrogen Peroxide sample on Day 5, April 15th, 2022.

Figure 14. Experiment setup of 15mL Hydrogen Peroxide sample on Day 5, April 15th, 2022.

Figure 15. Experiment setup of 30mL Hydrogen Peroxide sample on Day 5, April 15th, 2022.

Table 4. Summary of data for analysis of variance test on seed germination progress at 70 hours.

Summary of Data						
	Treatments					
	1	2	3	4	5	Total
N	10	10	10	10		40
∑X	55	122	66	29		272
Mean	5.5	12.2	6.6	2.9		6.8
$\sum X^2$	319	1518	506	97		2440
Std.Dev.	1.354	1.8135	2.7968	1.1972		3.8908

Table 5. Results of analysis of variance test on seed germination progress at 70 hours

Result Details				
Source	*SS*	*df*	*MS*	
Between-treatments	461	3	153.6667	*F* = 42.75116
Within-treatments	129.4	36	3.5944	
Total	590.4	39		

The *f*-ratio value is 42.75116. The *p*-value is < .00001. The result is significant at $p < .05$.

Table 6. Summary of data for analysis of variance test on seed germination progress at 95 hours.

Summary of Data						
	Treatments					
	1	2	3	4	5	Total
N	10	10	10	10		40
∑X	154	139	105	60		458
Mean	15.4	13.9	10.5	6		11.45
$\sum X^2$	2674	1943	1139	394		6150
Std.Dev.	5.7966	1.1005	2.0138	1.9437		4.8196

Table 7. Results of the analysis of variance test on seed germination progress at 95 hours.

Result Details				
Source	*SS*	*df*	*MS*	
Between-treatments	522.1	3	174.0333	*F* = 16.32413
Within-treatments	383.8	36	10.6611	
Total	905.9	39		

The *f*-ratio value is 16.32413. The *p*-value is < .00001. The result is significant at $p < .05$.

DISCUSSION

We hypothesized that high concentrations of hydrogen peroxide inhibit seed germination in Wisconsin Fast Growing Plants. We can accept this hypothesis through our findings. In conducting an analysis of variance test at 70 and 95 hours of growth, we saw that both of our results were significant. In Table 6, our results concluded an F-ratio value of 42.75116 and a p-value smaller than 0.00001, which is significant at the 0.05 significance level. Looking at Table 3, the highest mean value was 12.2 mm, for the 5 mL concentration group. The lowest mean value was 2.9 mm for the 30 mL concentration group. Previous hydrogen peroxide research found that low concentrations were beneficial to agriculture (Nurnaeimah et al. 2020). Therefore, the seeds with 5mL concentration of hydrogen peroxide may have had an advantage over the control group. In addition, the seeds exposed to the 30 mL concentrations of hydrogen peroxide grew the least which supports our hypothesis. Between 48 and 72 hours, the cotyledons began to appear and continue germinating, which is what we expected after reading the Wisconsin Fast Growing plants manual.

At 90 hours, we found that the control group was growing the most. In Table 7, we conducted an analysis of variance test on the germination progress at 95 hours, and we found an f-ratio value of 16.32413 and a p-value less than 0.00001 which is significant at

the significance level of 0.05. Looking at Table 3, the highest mean was 15.4mm, which is the control group, and the lowest mean was 6 mm for 30 mL. This supports our hypothesis since the 30 mL group at 95 hours has grown the least. We can also see this in Graph 1, where the control group has consistent growth, whereas the hydrogen peroxide seeds stagger a bit. Also, the group exposed to 30 mL hydrogen peroxide concentration stays consistently below all other groups growth-wise.

Looking at Figure 1, we can also visually determine how significantly different the means of growth were for each group by looking at the error bars. The error bars on the graphs display the confidence intervals, or the intervals in which the means could lie in. If the error bars for each time interval overlap, then the means are not significantly different. At 70 hours, the control group and the 15 mL group were overlapping, meaning their means were not significantly different, and their growth rates were similar. However, the 5 mL group and 30 mL group error bars were not overlapping with any other group. At 70 hours, the 5 mL concentration group grew the most, and the 30 mL concentration group grew the least.

Continuing to look at Figure 1, at 95 hours, we see that both the 5 mL and 15 mL groups overlapped with the control group. This means that both the 5 mL and 15 mL grew around the same amount as the control group. At 95 hours, we cannot determine which group grew the most, as these three groups were not significantly different from each other. However, the 30 mL group was significantly different from all the other groups and had the least amount of growth. This means that the 30 mL group, at 95 hours, still grew the least. Thus, the 30 mL group consistently had the least amount of growth.

Further research needs to be done on lower concentrations of hydrogen peroxide to determine what concentrations have a harmful effect on seed growth. 30 mL has been proven to stunt the growth of Wisconsin Fast Growing plants; however, it is still unclear if lower concentrations of hydrogen peroxide exposure have the same effect as the control group. As we stated before, looking at graph 1, at 70 hours, 5 mL concentration group grew faster than the control group, and the 15 mL group grew similarly to the control group. At 95 hours, both 5 mL and 15 mL concentrations grew in the same range as the control group. This indicates that lower concentrations of hydrogen peroxide do not affect seed growth. This leads us to believe that concentrations of hydrogen peroxide may need to be regulated in pesticides, but not diminished completely.

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WATER QUALITY/SPECIES DIVERSITY ASSESMENT OF MUDDY RUN PRIOR TO AND POST SUBMERSION UNDER HUNTINGDON, PENNSYLVANIA

Isaac Carachilo, Noah Stroup, and Raphael Parisi

ABSTRACT

Studies have shown that the pollution of water bodies has a detrimental effect on the diversity of species present in such ecosystems. Muddy Run, a small tributary in Huntingdon, Pennsylvania, is used as an emergency sewage overflow which carries excessive amounts of water from large rain events in Huntingdon to the Juniata River. Our research group completed a water quality survey of this tributary prior to its submersion under the town of Huntingdon and right before entering the Juniata River. Water quality parameters, such as pH, conductivity, temperature (C), salinity, and total dissolved solids (TDS) were measured to determine the water quality of our two sample sites on Muddy Run. In addition, core sediment samples were taken at each of our sites with the goal of comparing the diversity and richness of found organisms. It is believed that the introduction of sewage to this stream environment when submerged under Huntingdon should reduce the abundance of species living in the stream. Additionally, nitrate and nitrite levels of collected water samples at each site were measured in the laboratory to gather evidence of sewage present in this aquatic system.

Keywords: *pH, conductivity, temperature, salinity, total dissolved solids, macroinvertebrates, nitrate, nitrite*

INTRODUCTION

Stream quality plays a vital role in affecting a wide variety of organisms and environments both in rural and urban communities. Healthy stream environments are important in regulating watershed landscapes and entire ecosystems, with slight alterations having the ability to drastically change terrestrial and aquatic communities as a result (National Park Service, 2022). All of life on Earth depends on healthy water sources, and the varying ways in which stream environments and their adjacent land are affected naturally or unnaturally, usually due to human cause, can influence a stream's cleanliness, biodiversity, species richness, and so on (U. S. Geological Survey, 2005). When assessing the quality of stream environments, a multitude of physical, chemical, and biological parameters can be measured, allowing for change to be tracked across a large aquatic landscape overtime. (National Park Service, 2022). Biological conditions used to assess the health of aquatic communities and overall water quality can include the fish, plants, and macroinvertebrates present in stream communities. Certain species are more tolerant to negative influences within their environment, while others are more susceptible to

such change. This difference among species means that the presence of particular organisms allows insight into the overall health of particular waterbodies. For example, macroinvertebrates like stoneflies, mayflies, and caddisflies are indicator species of healthy aquatic environments, for these species are susceptible to changes in stream physiochemical parameters and pollution (United States Environmental Protection Agency, 2012). Furthermore, brook trout are similar to these macroinvertebrates, for they are also indicator species which live in clean aquatic environments with a specific set of physiochemical parameters needing to be present. Overall, the presence of particular species helps indicate the health of aquatic environments before physiochemical measurements even need to be conducted. In addition to biotic parameters, chemical parameters are also used to highlight stream quality. Such physiochemical parameters include a stream's pH, total dissolved solids (TDS), dissolved oxygen, salinity, conductivity, and temperature (U. S. Geological Survey, 2005). Lastly, physical conditions need to be considered in regard to stream quality as well. Adequate forest cover allows for streams to remain naturally cool, in addition to providing the ability for terrestrial food sources to enter stream environments. Stream bed sediment composition can allow insight to a stream's ability to house specific species, with rock, gravel, and sand stream beds usually being positive stream quality indicators (United States Environmental Protection Agency, 2021). On the other hand, mud and silt stream beds can be indicators of large high-water events and unsuitable living habitats. Other physical conditions to remain aware of when investigating stream quality include stormwater discharge, land use/geographic location, wastewater discharge, surrounding soil type, and so on (Lintern, et al. 2017). Overall, through the use of assessing biological, chemical, and physical indicators, a stream's water quality can be assessed and tracked across a large landscape overtime. Our research group proposed to assess such conditions with the goal of investigating water quality and species diversity/richness of Muddy Run in Huntingdon, Pennsylvania.

Muddy Run is a small stream located in Huntingdon, Pennsylvania. Being a tributary to the Juniata River, and running through an urbanized location, Muddy Run is highly susceptible to a multitude of different contaminants which threaten to result in the stream's degradation. Muddy Run's headwaters are located parallel to the Salvation Army in Huntingdon, Pennsylvania (Figure 1). Flowing from its headwaters, Muddy Run travels past Juniata College's East Apartments with very little to no riparian buffer present along this specific stretch. Furthermore, Muddy Run then runs parallel to George Waiver Park and Weis Market in Huntingdon. This area, like Juniata College, possesses very little to no riparian buffer due to human impact. Some sections of stream are directly exposed to cement parking lots in this area. Muddy Run then flows under the town of Huntingdon where it emerges to its confluence with the Juniata River in Portstown Park in Huntingdon, Pennsylvania (Figure 1). Overall, when looking at Muddy Run geographically, it is apparent that water quality concerns are present. From bank erosion to sewage contamination, Muddy Run expresses many textbook characteristics of an unhealthy tributary. However, with this being the case from broad observations, an in-depth analysis of Muddy Run would allow even more insight into the concerns present surrounding this stream. With this in mind, our research group proposed to conduct such an analysis into Muddy Run to assess the health of two sample sites. These sites would be located prior to and post submersion under the town of Huntingdon, with water quality parameters (physical, chemical, and biological) measured to assess water quality throughout a broad area.

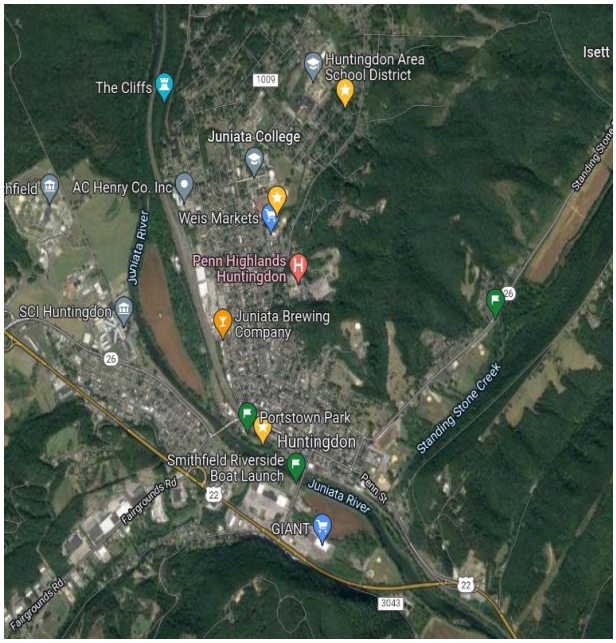


Figure 1. This image shows a map of Huntingdon, Muddy Run's headwaters, and our two sample sites. The headwaters and two sample locations are represented by yellow stars on the map. The yellow star most north is the headwaters of Muddy Run located next to the Salvation Army. The middle most star is our first sample site located at George Waiver Park. This site is located before Muddy Run's submersion under Huntingdon. Our last sample site is represented by the south most star. This site is located at Portstown Park and is after Muddy Run's submersion under Huntingdon.

When conducting this project on Muddy Run, our research group had three main objectives that we wanted to accomplish. First, we had the goal of collecting water samples to measure physiochemical parameters using a PCTA 50. These parameters included pH, conductivity, salinity, temperature, and total dissolved solids (TDS). Additionally, a total of ten core samples from the stream bed (five samples prior to submersion and five post submersion) from our two Muddy Run sites would be collected. Secondly, through the use of collecting core samples, we sought to assess the differences between species diversity and richness between both sites by counting the number of species found in addition to the number of individuals of each species collected to determine the overall habitat health at our sampled locations. Lastly, our group ran analysis to find statistical significance among our collected data to determine the overall water quality and species diversity/richness of assessed locations at Muddy Run.

Overall, this project had the purpose to test the hypothesis that our findings would indicate a decrease in water quality and species diversity/richness at Muddy Run post submersion under the town of Huntingdon. This post submersion location is indicated as "site #2" and "outlet" throughout this report. In addition to this, it was hypothesize that our data would indicate better water quality and an increase in species diversity/richness due to being located above Muddy Run's submersion site. This location will be indicated as "site #1" and "inlet" throughout this report. A large majority of Muddy Run is submerged under the town of Huntingdon, in which it should experience a decrease in water quality and species abundance/diversity due to human contamination events, such as sewage and chemical runoff. Our null hypothesis is that the submersion of Muddy Run will have no effect on its water quality and species diversity/richness.

METHODS

Our research group assessed Muddy Run's water quality and species diversity/richness on Wednesday, April 6, 2022. Two sites were assessed, one being at George Waiver Park (site #1) and the other at Portstown Park in Huntingdon (site #2). At each sample location, water quality parameters were measured using a PCTS 50. The water quality parameters measured included pH, conductivity, total dissolved solids (TDS), salinity, and temperature (C). This process was completed first at both sites, with one student using the PCTS 50 to obtain physiochemical measurements while another recorded data. Afterwards, species sampling occurred through the use of collecting core samples of the stream bed. At both locations, five core samples (ten in total) of the stream bed were taken at random with the goal to obtain varying species. This process was accomplished through the use of a core sampler and plastic collection containers. Along with core samples, five water samples (ten in all) were taken at each sample site for laboratory analysis. After completion of these steps at both sampling locations, Muddy Run water and core

sediment samples were transported to the laboratory and stored in a fridge prior to further assessment.

In the lab, core sediment samples were assessed for collected species. Assessing the species present in each sample was accomplished by shifting through each individual core sample per site. Found organisms, whether being macroinvertebrates or not, were grouped by their lowest determined taxonomic level and counted. Furthermore, each of Muddy Run's two sites had their five water samples' nitrite and nitrate concentrations measured in order to assess the presence of sewage contamination prior to and post submersion under Huntingdon. This was done through the use of an API Freshwater Aquarium Master Test Kit. Lastly, statistical analysis was conducted to calculate the species diversity and richness for both sites. In addition, graphical analysis was completed to further evaluate the trends observed while assessing collected water quality parameter data.

Figure 2. Muddy Run Pre-Submersion Site (Site #1) at George Weaver Park. Left: upstream view. Right: downstream view.

Figure 3. Muddy Run Post-Submersion Site (Site #1) at Portstown Park. Left: upstream view. Right: downstream view.

Figure 4. Sediment Core Sampling of macroinvertebrates (left) and water chemistry testing for nitrates and nitrites (right).

RESULTS

Upon analyzing our results, it is clear that there is a difference in the diversity of species between the pre- and post- submersion sites of Muddy Run under Huntingdon, Pennsylvania. Additionally, we observed differences in water quality measurements between the two sampling locations (Table 1). We noticed that the pH at the inlet was higher than the pH

at the outlet. At the inlet, the pH was 8.43 while, at the outlet, it was 7.92. Salinity was also different between both sites. The salinity, measured in parts-per-thousand, at the inlet was 0.1, while at the outlet, it was 0.2. Continuing, the total dissolved solids (TDS) at the inlet was measured to be 225 and at the outlet to be 278. Temperature was also slightly different. The temperature at the inlet was 9.1°C while it was 8.9°C at the outset. Our last water quality test was conductivity. The conductivity at the inlet was measured to be 327µS/cm and the outlet being 378µS/cm (Figure 2).

Furthermore, our research group measured nitrate and nitrite levels of water samples collected at our two samples sites. Nitrate and nitrite levels are important indicators of stream quality. High nitrate and nitrite levels are indicators of fertilizer runoff and sewage contamination in aquatic stream habitats (Summers, 2021). With this being the case, the Environmental Protection Agency (EPA) has set standards for nitrate and nitrite in water. The standard for nitrate is 10 milligrams (measured as nitrogen) per liter of drinking water (mg/L) (Department of Health, 2021). Additionally, water with levels of nitrate at or below 10 mg/L is considered safe as well (Department of Health, 2021). The standard for nitrite is defined as 1.0 mg/L (Water Quality Association, 2013). Overall, our measured nitrate and nitrite values all were below or at the EPA standard (Figure 3 and 4). These findings would be an indication of little to no sewage contamination during our field work session.

In addition to the water chemistry studied, we also assessed the species abundance, richness, and diversity in both the inlet and outlet sites of Muddy Run. Upon analyzing the species that we found in the five samples we took of each site, we observed six species at the inlet location and found three species at the outlet location (Table 2). At our Muddy Run inlet site, we found three aquatic worms (Class: Oligochaeta), two Asian Clams (*Corbicula fluminea*), and one flatworm (Class: Turbellaria). At our Muddy Run outlet site, we found three aquatic worms and no other species. In order to analyze these results, we performed a t-test since we had only two sampling locations. Our t-test resulted in a t-value of 0.85. It also gave a p-value of 0.42 (Table 2). A photo and the name of each species found are present below. Additionally, we ran Simpson's Diversity Index to calculate the diversity at both sites. Our Muddy Run inlet site had a diversity index of 73.33% and Muddy Run's outlet has a diversity index of 0% (Table 3).

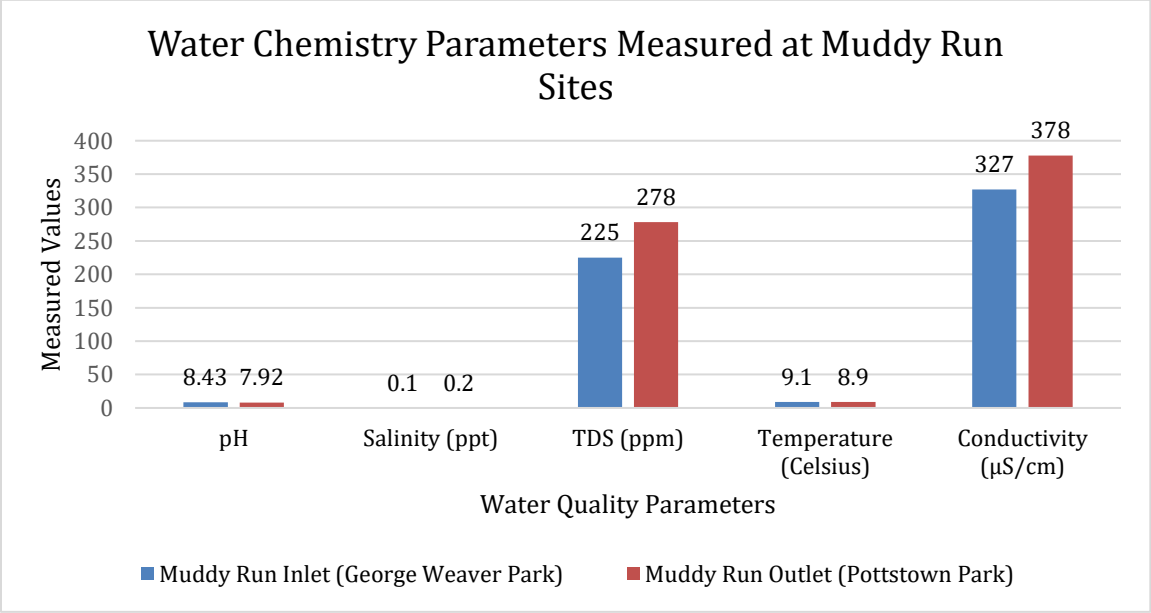


Figure 5. Muddy Run site differences in assessed stream physiochemical parameters

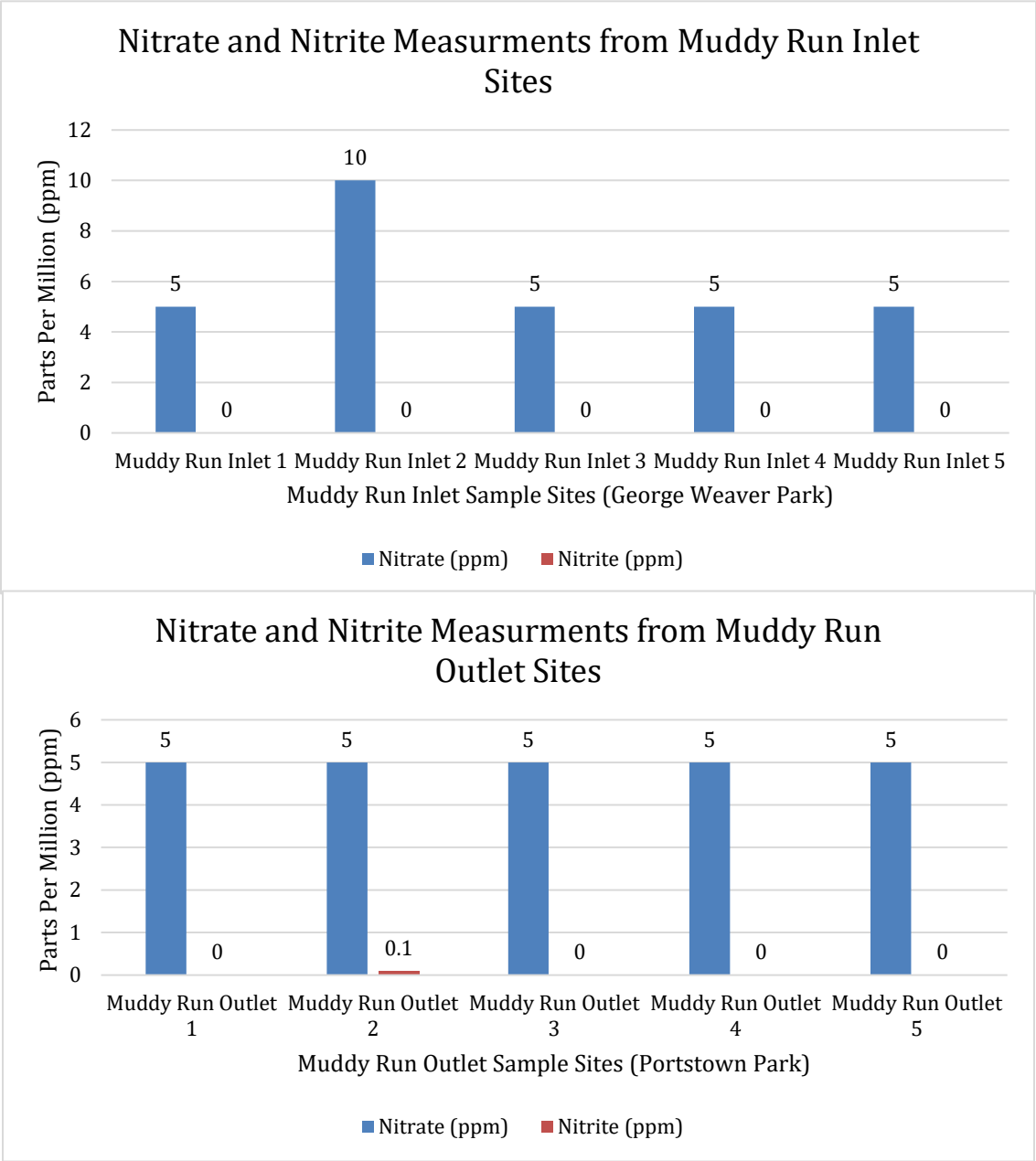
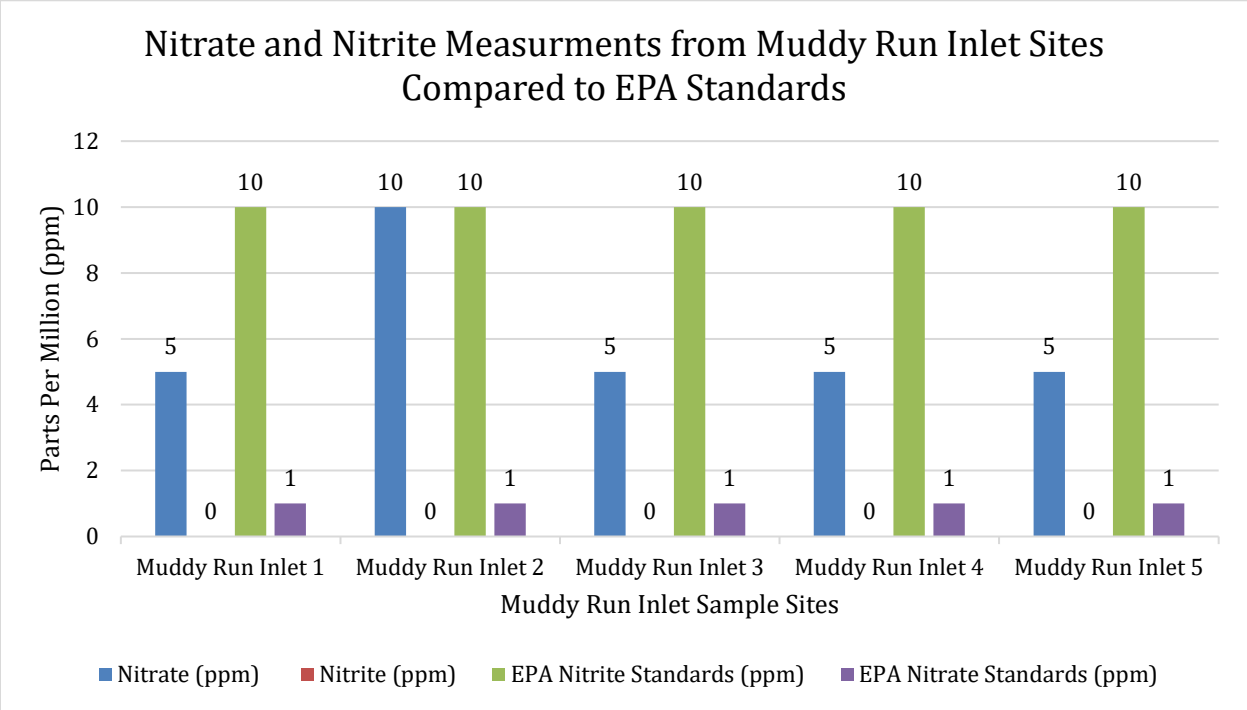


Figure 6. Nitrate and nitrite levels measured at Muddy Run prior to (top graph) and after submersion under Huntingdon (bottom graph). Five water samples were collected at random at each of our sites, thus why there are five measurements per site.



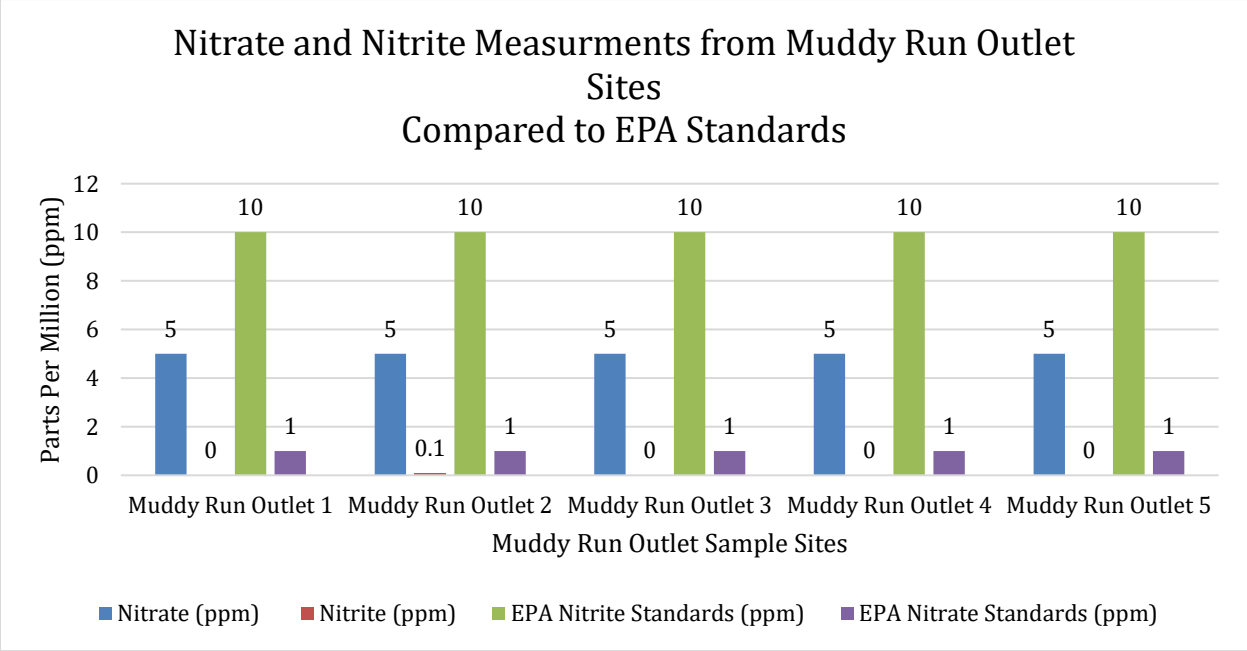


Figure 7. Nitrate and nitrite values found at our Muddy Run sites with EPA standards. All measured values were below the EPA standards for nitrate and nitrite levels in this stream with exception to our second water sample at the Muddy Run inlet site (George Waiver Park).

Table 2. Collected species from both Muddy Run sites. T and P values for our collected species are indicated.

Muddy Run Inlet (Pre-Submersion)			
Organisms	**Aquatic Worm (Class: Oligochaeta)**	**Flatworm (Class: Turbellaria)**	**Asian Clams (*Corbicula fluminea*)**
Abundance	**3**	**1**	**2**
Muddy Run Outlet (Post-Submersion)			
Organisms	**Aquatic Worm (Class: Oligochaeta)**	**Flatworm (Class: Turbellaria)**	**Asian Clams (*Corbicula fluminea*)**
Abundance	**3**	**0**	**0**

t-value	0.84853
p-value	0.420806

Table 3. Species richness and diversity index calculated for both of our Muddy Run sites.

Muddy Run Inlet (Pre-Submersion)					
Species:	**Number or Members in Species**	**n(n-1)**	**N(N-1)**	**Diversity Index**	**Species Richness**
Oligochaete worm (Class: Oligochaeta)	**3**	**6**			
Asian clams (Corbicula fluminea)	**2**	**2**			
Flatworm (Class: Turbellaria)	**1**	**0**			
Sum	**6**	**8**	**30**	**0.7333**	**3**

Muddy Run Outlet (Post-Submersion)					
Species:	**Number or Members in Species**	**n(n-1)**	**N(N-1)**	**Diversity Index**	**Species Richness**
Oligochaete worm (Class: Oligochaeta)	**3**	**6**			
Flatworm (Class: Turbellaria)	**0**	**0**			
Asian clams (Corbicula fluminea)	**0**	**0**			
Sum	**3**	**6**	**6**	**0.00**	**1**

Figure 8. Macroinvertebrates collected at Muddy Run (left to right: flatworm, oligochaete worm, and Asiatic clams.

DISCUSSION

When examining a stream, it is important to keep in mind that external factors have the possibility to negatively affect stream quality. For example, in our study, we hypothesized that there would be a difference in the number of species found, in addition to their abundances, at two separate sites on Muddy Run due to the potential for sewage and other contaminants being introduced to this tributary after submersion under the town of Huntington. Overall, we found that our data supported our hypothesis regarding a difference in species abundance being observed prior to and after Muddy Run's submersion under Huntingdon. Our data shows that physicochemical parameters decline as you travel from George Waiver Park to Portstown Park. To begin, our measured difference between pH values of the inlet and outlet sites was 0.51, with the inlet site having the higher pH value. In continuation, salinity was also different between the two sites, with the salinity at the inlet being lower than that of the outlet. While this may be significant, the simple fact that the outlet is much closer to the Juniata River and that these bodies of

water mix could be a reason for this difference. However, for the purposes of this study, we believe that this may illustrate an actual degradation in water quality. Two other water quality parameters that we believe show true degradation in water quality is total dissolved solids (TDS) and conductivity. The value for TDS was much lower at the inlet than at the outlet, as was the case for conductivity. Both of these results were consistent with what we hypothesized would be the case. The only parameter that we believe does not demonstrate a large change in water quality between the two sites is temperature. The difference between the sites was 0.2°C. With this being such a small difference, we cannot definitively say that the change in temperature, in this specific case, would be significant enough to alter the diversity of species that could live there. Overall, we believe that this difference in temperature could be attributed to user error.

In addition to water chemistry, we also examined the diversity of species of the inlet and outlet sampling locations. In this study, we found three species at the inlet site, while we only found one species at the outlet site. At our inlet site (Goege Waiver Park), we found three oligochaete worms (Class: Oligochaeta), two Asian Clams (*Corbicula fluminea*), and one flatworm (Class: Turbellaria). At our Muddy Run outlet site, we found three aquatic worms and no other species. Again, these findings were consistent with what we hypothesized, that being that Muddy Run would experience degradation in water quality and species richness/diversity after its time flowing under Huntingdon. These findings were also indicated by the Simpson's Diversity Index. In addition, a t-test was performed on these results. We received a t-value of 0.85. This indicates that there is a large difference in the mean number of species found at each of the sites. In short, this means that the inlet has a relatively large diversity of species compared to the outlet site. We also received a p-value of 0.42 from the t-test. This result suggests that there is a 42% chance that the results from this study occurred randomly. Although this was an unexpected result, we believe that this may be due to the relatively low number of samples that we took from each of the sites. We believe that if we were to have taken more samples and possibly collected more species, we would have received more data that would have helped to strengthen our statistics and yield a more favorable result. However, the time constraints and the weather under which this study was completed forced us to adjust and complete this study with a lower number of samples.

Lastly, nitrate and nitrite measurements do not show any evidence of sewage contamination at the time of our field sampling. There is evidence that sewage contamination is present after Muddy Run's submersion under Huntingdon. During high water events, sewage will enter this tributary and then travel into the Juniata River. During the course of our study, our measured Nitrate and Nitrite values were all under EPA aquatic limits, meaning that sewage contaminated were not picked up during the course of our study. The only questionable measurement recorded was found at Muddy Run inlet #2 (Figure 4). Our measured nitrate value was the same as its EPA standard. We believe that the reason for this was due to how we measured nitrate and nitrite values. Using an API Freshwater Aquarium Master Test Kit, we found consistent values when measuring these parameters. User error is one reason for why this nitrate value is so high, for this tool requires interpretation to find values. Overall, the nitrate and nitrite values do not show any differences between our two Muddy Run sites, or any sewage contamination in this particular case.

In conclusion, our data shows that our hypothesis was correct, that species diversity/richness and water chemistry parameters of Muddy Run were healthier before submersion under Huntingdon and worse after submersion. This is shown by the number of species found at each site, their abundance, and the change seen between each site. Physiochemical parameters also indicate a healthier environment prior to submersion in comparison to post submersion under Huntington. Lastly, even though our nitrate and nitrite values do not indicate sewage contamination, historic observations and past studies does show that sewage infiltration into Muddy Run is an ever-present issue effecting stream quality and species abundances in this tributary.

ACKNOWLEDGEMENTS

We would like to thank Dr. Douglas Glazier for taking the time to help develop our research project in addition to assisting in the identification of aquatic species found at our sample sites. Additionally, we

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MACROINVERTEBRATE ASSEMBLAGES IN STREAMS WITH VERSUS WITHOUT WILD TROUT POPULATIONS

Beck Chickillo, Blake Hoover, Clay Spencer, Braden Whisler, Jack Dovidio and Evan Mock

ABSTRACT

We compared the taxic diversity of macroinvertebrate assemblages in streams with and without wild trout populations. We hypothesized that streams containing wild trout would have the highest diversity of macroinvertebrate assemblages because these streams should have more food available and higher oxygen levels in comparison to the other sampled streams. We found no relationship between macroinvertebrate diversity and the presence of trout in all four streams in Huntingdon County, Pennsylvania. There were no significant differences between macroinvertebrate richness in streams containing wild trout versus streams without wild trout.

Keywords: Salmo trutta*, two sample t-test, Plecoptera, Trichoptera, Ephemeroptera*

INTRODUCTION

Macroinvertebrate diversity is a strong indicator of the quality of a stream (Hawkes 1979). Also, trout are a niche species and typically only exist in streams containing a specific set of environmental parameters. These include a consistent source of cold and oxygenated water, an abundant food source, sufficient shelter such as large boulders, woody debris, undercut banks, and viable spawning gravel to support natural reproduction. The purpose of our research is to determine if there is a significant difference in taxic diversity of macroinvertebrates in streams with versus without wild trout. We did this by collecting macroinvertebrates in various habitat types in two streams that are known to have wild trout present and two streams that do not contain wild trout. Macroinvertebrates are a primary food source for many stream fish species, including wild trout. Therefore, macroinvertebrate diversity should be higher in streams that contain wild trout. Our hypothesis was that streams containing wild trout would have a higher diversity of macroinvertebrates than those that do not contain wild trout.

Both Crooked Creek and Little Juniata River are tributaries to the Juniata River and are classified by the Pennsylvania Fish and Boat Commission as a Naturally Reproducing Coldwater Fisheries for wild Brown Trout. The Pennsylvania Fish and Boat Commission's trout water classification for wild trout waters (Natural Reproduction) is noted as, "Stream sections supporting naturally reproducing populations of trout. A wild trout stream section is a biological designation. These streams may also be stocked with hatchery trout by the Commission." Given that Crooked Creek and Little Juniata River have sufficient biological attributes to support wild populations of trout, we can expect an abundance of different macroinvertebrate assemblages given they are a primary food source.

Brown Trout (*Salmo trutta*) are the main species present in the streams that we conducted our studies at and are known to be sensitive fish. Brown Trout feed on a variety of organisms throughout their life cycle which includes small crustaceans, macroinvertebrates, mice and even other fish. When the brown trout are juvenile, they are more likely to feed on the small crustaceans and macroinvertebrates. As the trout begin to mature and grow larger in size,

they begin to feed on bigger organisms such as crayfish and small fish. Although there are some slight differences in feeding habits at different stages in their life, it remains constant that trout will feed on macroinvertebrates. Trout will feed on macroinvertebrates at different times including while they are emerging, hatching, flying or even drifting in the stream. The most common macroinvertebrate that is preyed on by the Brown Trout are Stoneflies (*Plecoptera*), Caddis Fly (*Trichoptera*), and the Mayfly (*Ephemeroptera*).

Macroinvertebrates are natural indicators of a stream's health, and their lack of abundance may be indicative of habitat degradation that goes undetected by traditional water quality assessments (Resh 1984). In addition, macroinvertebrates are sedimentary in nature and each species has its own environmental preferences (Waters 1995). The objective of this study was to determine if there was any significant statistical difference in macroinvertebrate assemblages within streams that contained trout and others that did not.

FIELD SITES

Field sites were located in Huntingdon County, Pennsylvania and consisted of four different streams. The studied streams were Crooked Creek, Little Juniata River, Muddy Run Creek, and Standing Stone Creek. Sampling locations consisted of areas within each stream that were characteristic of riffles, pools and tailouts. Each sampling location consisted of a rocky and sediment filled creek floor and also contained plants and wooded debris. Plants and wooded areas covered the banks of these study sites providing cover and protection for the inhabitants of the water. Crooked Creek and Little Juniata River were both known to have high amounts of wild trout present while Muddy Run Creek and Standing Stone Creek had little or no wild trout present.

Figure 1. Ground-level photograph of Little Juniata River. Samples were collected at three different locations within the river.

Figure 2. Ground-level photograph of Muddy Run Creek. Samples were collected at three different locations within the creek.

Figure 3. Ground-level view photograph of Standing Stone Creek. Samples were collected at three different locations within the creek.

Figure 4. Photograph of Crooked Creek. Samples were collected at three different locations within the creek.

METHODS AND MATERIALS

We collected samples from each stream during April of 2022. All sampling took place in weather conditions of 50-60ºF to limit the number of variables that could affect our study. Each site was divided into three different sections such as riffles, pools and tailouts where macroinvertebrate collection occurred. All macroinvertebrates were collected using the kick-net sampling method while utilizing protocol according to US EPA Standards. (Chapter 7 (Part A)). The kick-net was about three feet wide and three feet tall. At each location within the stream, two people setup the kick-net downstream from the person that would dislodge rocks from the stream bottom. The person above the net would kick aggressively for one minute exactly. After one minute, the kick-net was taken out of the stream and all macroinvertebrates were transferred into plastic containers. The containers were stored in a cool refrigerated environment until the macroinvertebrates were identified.

Identification of the macroinvertebrates was to the lowest taxa possible (genus level) in the lab using dichotomous keys and microscopes. Data were entered into Microsoft Excel so it could be extrapolated using R to determine if there was any significant statistical difference in macroinvertebrate assemblages between streams supporting populations of wild trout and streams that do not. Simpson's Diversity Index (SDI) was calculated for each sample site (pool, riffle and tailout). Since our data are quantitative and predicted by a categorical variable, a two sample T-test was run to determine if the data were significantly different. The T-test was conducted comparing the SDI of two sites with trout versus two sites without trout. If the resulted P-value was less than a value of 0.05, the results were considered to be significantly different.

RESULTS

The macroinvertebrate assemblages varied between streams. An abundance of macroinvertebrates was collected in the Little Juniata River but the smaller streams, Muddy Run and Crooked Creek, had smaller sample sizes. Crooked Creek and Little Juniata River both had high counts of *Ephemeroptera* (Tables 1 and 2). Both Muddy Run and Standing Stone Creek had smaller sample sizes (Tables 3 and 4). Standing Stone Creek had the highest SDI value at 0.744 and the lowest SDI value came from Little Juniata River (Table 5).

Table 1. List of macroinvertebrates collected from Crooked Creek. Data is separated according to each sample site (riffle, pool and tailout).

Crooked Creek Riffle	30
Ephmeroptera Heptageniidae Macaffertium	3
Ephmeroptera Ephemerellidae Ephemerlla	6
Ephmeroptera Baetis	14
Trichoptera Hydrosychidea Cheumatopsyche	4
Trichoptera Calamoceratidea Heteroplectroı	1
Coleoptera Psephenidea Psephenus	1
Diptera Stratiomyidea Odontomyia	1
Crooked Creek Pool	9
Ephmeroptera Heptageniidae Macaffertium	1
Ephmeroptera Ephemerellidae Ephemerlla	3
Ephmeroptera Baetis	2
Ephmeroptera Heptageniidae Epeorus	1
Coleoptera Psephenidea Psephenus	1
Megaloptera Corydalidea Nigronia	1
Crooked Creek Tailout	39
Ephmeroptera Heptageniidae Macaffertium	24
Ephmeroptera Ephemerellidae Ephemerlla	3
Ephmeroptera Baetis	8
Plecoptera Perlodidae Isoperla	3
Trichoptera Calamoceratidea Heteroplectroı	1

Table 2. List of macroinvertebrates collected from Little Juniata River. Data is separated according to each sample site (riffle, pool and tailout).

Little J Riffle	141
Ephmeroptera Ephemerellidae Ephemerlla	44
Ephmeroptera Baetis	33
Ephmeroptera Ephemerellidae Eurylophella	52
Diptera Limnoniidea Antocha	2
Diptera Chironomidea Diamesa	8
Coleoptera Psephenidea Psephenus	2
Little J Pool	30
Ephmeroptera Ephemerellidae Ephemerlla	6
Ephmeroptera Heptageniidae Macaffertium	4
Ephmeroptera Ephemerellidae Eurylophella	19
Trichoptera Calamoceratidea Heteroplectron	1
Little J Tailout	146
Ephmeroptera Ephemerellidae Ephemerlla	55
Ephmeroptera Ephemerellidae Eurylophella	46
Ephmeroptera Heptageniidae Macaffertium	8
Trichoptera Calamoceratidea Heteroplectron	12
Ephmeroptera Baetis	15
Coleoptera Psephenidea Psephenus	7
Plecoptera Perlidea Agnetina	2
Plecoptera Perlidea Neoperla	1

Table 3. List of macroinvertebrates collected from Muddy Run. Data is separated according to each sample site (riffle, pool and tailout).

Muddy Run Riffle	22
Caecidotea	3
Hirundenea medicinalis	1
Gammarus pseudolimnaues	4
Oligochaeta	1
Ephemeroptera Baetidae Heterocloeon	1
Emphemeroptera Ameletidea Ameltus	3
Diptera Chironomidae Orthocladius	9
Muddy Run Pool	16
Caecidotea	10
Hirundenea medicinalis	1
Gammarus pseudolimnaues	2
Platythelminthes	1
Emphemeroptera Ameletidea Ameltus	1
Diptera Chironomidae Orthocladius	1
Muddy Run Tailout	36
Caecidotea	10
Hirundenea medicinalis	9
Platythelminthes	10
Gammarus pseudolimnaues	6
Diptera Ceratopognidae Probezzia	1

Table 4. List of macroinvertebrates collected from Standing Stone Creek. Data is separated according to each sample site (riffle, pool and tailout).

Standing Stone Riffle	27
Ephmeroptera Ephemerellidae Ephemerlla	3
Plecoptera Perlidea Agnetina	8
Plecoptera Perlidea Isoperla	12
Megaloptera Corydalidea Nigronia	2
Diptera Pediciidae Dicanota	1
Coleoptera Psephenidea Psephenus	1
Standing Stone Pool	18
Ephmeroptera Heptageniidae Macaffertium	1
Plecoptera Perlidea Isoperla	8
Coleoptera Psephenidea Psephenus	3
Odonata Coenagronidea Argia	1
Ephmeroptera Ephemerellidae Ephemerlla	5
Standing Stone Tailout	14
Megaloptera Corydalidea Nigronia	3
Plecoptera Perlidea Agnetina	2
Ephmeroptera Heptageniidae Macaffertium	2
Ephmeroptera Ephemeridea Ephemera	6
Trichoptera Hydrosychidea Hydrosyche	1

Table 3. Simpson's Diversity for each stream (means for 3 samples: riffle, pool and tailout) indicated by trout presence.

Stream	Trout_Presence	SDI
Little J	Yes	0.671
Crooked Creek	Yes	0.735
Standing Stone Creek	No	0.744
Muddy Run	No	0.728

The average Simpson's Diversity between Muddy Run and Standing Stone Creek is 0.736. The average SDI in Little Juniata River and Crooked Creek is 0.703 (Figure 6). A two sample T-test on the mean SDI between streams with trout, Crooked Creek and Little Juniata River, and streams without, Standing Stone Creek and Muddy Run, was run to better understand if there is a relationship between the two. After running the T-test we fail to reject the null hypothesis that there is a different average SDI in macroinvertebrate assemblages in streams with and without trout. There is not enough evidence to support the claim (Two Sample T-test: t = 1.0005, d.f. = 1.1245, p = 0.4847).

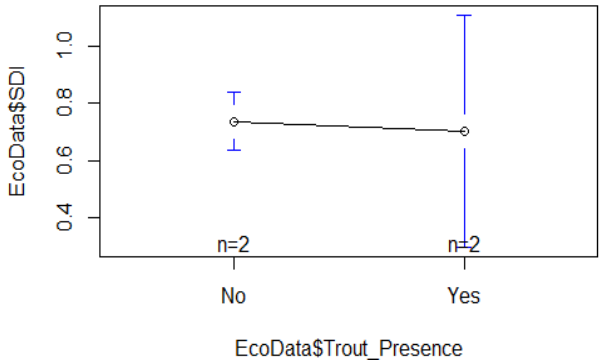

Figure 5. Plot of the average Simpson's Diversity between streams with and without trout. Error bars represent a 95% confidence interval of the true population mean.

```
data:  EcoData$SDI by EcoData$Trout_Presence
t = 1.0005, df = 1.1245, p-value = 0.4847
alternative hypothesis: true difference in means between group No and group Yes is not equal to 0
95 percent confidence interval:
 -0.2908941  0.3568941
sample estimates:
 mean in group No mean in group Yes
            0.736             0.703
```

Figure 6. Two sample T-test results between average Simpson's Diversity of streams with trout and streams without.

DISCUSSION

Through our macroinvertebrate collections from the various streams, we found our hypothesis did not align with our results. Our hypothesis stated that in streams with an abundance of wild trout, there would be a much higher diversity of macroinvertebrates. Through our statistical analysis, we found there to be only a slight difference in how many different macroinvertebrates were found within the streams, but not a large enough amount to be statistically significant. The differences that we found were the number of macroinvertebrates that we collected and what types of species were within each study site.

Within the streams that contained wild trout, there was a relative trend in the number of macroinvertebrates that we collected within each sample. The Little Juniata River, which holds the greatest number of wild trout, had a significantly large number of macroinvertebrates with over 100 specimens collected in two out of the three samples sites in the river. Crooked Creek had over 30 specimens collected within two out of the three samples that were collected. Both Little Juniata River and Crooked Creek had a higher number of macroinvertebrates than either of the two streams that did not sustain wild trout. The abundance of macroinvertebrates could play an important role as to why Muddy Run Creek and Standing Stone Creek do not have naturally occurring trout within them. It is possible there is not enough food in Muddy Run Creek and Standing Stone Creek to support wild trout populations.

Another observation was the similarity in taxic diversity of macroinvertebrates that were collected within each stream. Within the Little Juniata River, we collected a total of 10 different macroinvertebrates which included multiple species of mayflies, crane flies, water pennies, caddisflies, and stoneflies. Crooked Creek also had a total of 10 different macroinvertebrates, which included mayflies, stoneflies, water pennies, caddisflies, and one dragonfly. Standing Stone Creek had 9 species that were collected including dobsonflies, mayflies, stoneflies, dragonflies, and caddisflies. Muddy Run Creek had a total of 10 different species including

amphipods, aquatic worms, leeches, mayflies, and midges. While each of these streams consisted of about 10 different species of macroinvertebrates, some had greater abundances of a particular species.

While there was a relatively high abundance of macroinvertebrates, the species that were present tell us more about what type of water quality the stream has. The macroinvertebrates that were found in the Little Juniata and Crooked Creek signify that there is very good water quality as many of those species are very sensitive to changes in the environment. Standing Stone Creek had some macroinvertebrates that were sensitive to water quality but also some that were able to withstand more polluted water. This provides evidence that the water quality is not as high as the streams that contain wild trout. Muddy Run Creek only had species that could withstand very polluted waters, which signifies that the water quality is not suitable for wild trout.

There were many things that we could have done differently in order to maximize our effectiveness and gather more insight within this study. To minimize any outliers in our data, we could have conducted more samples at different locations of the stream. This could have eliminated any possibility of one section of the stream being exceptionally diverse and abundant or one section being very poor. Also, we could have sampled the same streams multiple days instead of just doing one trial for each stream. To further analyze the stream, we could have collected the chemical data on the day that we tested including conductivity, water temperature, flow rate, etc. and researched how these affected macroinvertebrates and other species within the stream. The last factor that could have been added is sampling more streams as this would give us more data to analyze and see if other streams would fit into our hypothesis.

ACKNOWLEDGEMENTS

We thank Dr. Glazier for his support and advice throughout the development of this study.

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FRUIT PREFERENCE AMONG TERRESTRIAL MACROINVERTEBRATES ON THE CAMPUS OF JUNIATA COLLEGE

Joshua Duggan, Noah Rahn and Madison Kyle

ABSTRACT

Our experiment examined the fruit preference (apple, pear, banana or orange) of terrestrial macroinvertebrates on the Juniata College campus. We hypothesized that the banana option would be preferred, because bananas contain the highest sugar per gram of the fruit options. We tested this hypothesis by setting eight baited traps, two of each fruit option, around the campus of Juniata College in randomly selected locations. After twenty-four hours, we collected the traps and quantified the amount of macroinvertebrates. Afterwards, we ran an ANOVA single-factor test for significance. The results showed no significance among fruit preference of terrestrial macroinvertebrates on the campus of Juniata College.

Keywords: terrestrial macroinvertebrates, fruit preference, random number generator (RNG)

INTRODUCTION

Terrestrial macroinvertebrates are land-dwelling, macroscopic animals that lack a vertebral column, commonly called the backbone. The most prevalent and common terrestrial macroinvertebrate is insects, but this group also includes other arthropods, mollusks, and nematodes (USDA). Feeding habits among such a large and diverse class are quite varied. However, it is fairly well-known that fruit flies are a species that specialize in fruit (Fruit Flies & Food). Lesser known is that many different species of insects specialize in fruit, and previous studies have supported the idea that insects prefer some samples of fruit over other samples. A study published in International Journal of Tropical Insect Science provided data that supported the hypothesis that the melon fruit fly preferred *C. savitus* and *C. pepo* over the other fruit options provided (Farooq 2019). Other studies, such as the separate studies ran by Dworkin and Jones (2009) and Zhang et al. (2019), have delved into which part of the genetic code is responsible for host specialization and feeding preference. There are comprehensive studies of fruit preference, but only on specific species. To see if there was fruit preference among terrestrial macroinvertebrates in general, we decided to test the fruit preference among terrestrial macroinvertebrates, and our sample area was the campus of Juniata College.

METHODS AND MATERIALS

On April 12th, 2022, we set out baited sticky traps contained within wire mesh (Fig. 1) at eight different locations around campus chosen via random selection. Wire mesh was employed to prevent access by vertebrate animals.

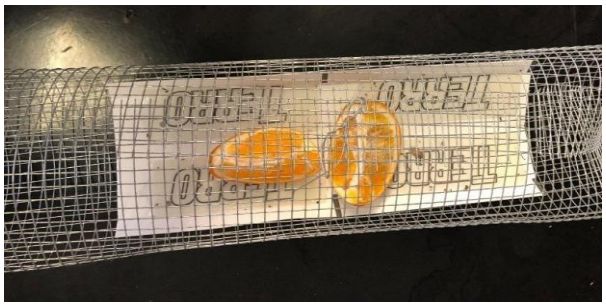

Figure 1: The traps that were used. Contained within the wire mesh is a sticky trap baited with an orange.

To ensure that our locations were random, we divided the Juniata College campus into a grid and used a random number generator (RNG) (Fig. 2). The one tile that was off of the grid was due to human error (to the left of tile six). Juniata College's campus was located in a relatively rural area with neighboring residences and forested areas, which supported our study by creating an environment with high densities of terrestrial macroinvertebrates. Eight sticky traps were set with four different fruit types as bait, including apples, bananas, oranges, or pears.

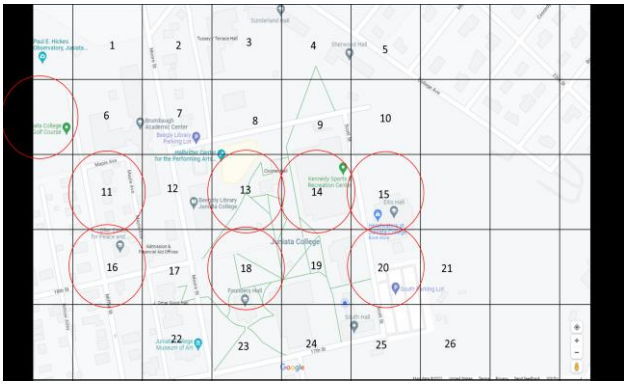

Figure 2. The campus of Juniata College and the locations selected with random number generation.

Twenty-four hours later, we collected the traps and counted the quantity of macroinvertebrates on each trap. The results were documented. The purpose of the study was to indicate which of the four types of fruit that insects and similar organisms (terrestrial macroinvertebrates) preferred (fruit preference), if there was any preference at all.

RESULTS

The data was compiled in a table (Table 1) which displays the quantity of terrestrial macroinvertebrates found at each trap, as well as the section number from the grid in Fig. 1 and the bait type.

Table 1. Quantitative data collected from the baited traps.

Section #	Bait Type	Quantity
13	Pears	24
7	Bananas	102
14	Oranges	42
1	Oranges	73
20	Bananas	8
15	Apples	10
11	Pears	31
18	Apples	12

The terrestrial macroinvertebrates showed no significant preference for any of the four types of fruit (Table 2). The single-factor ANOVA test produced a F value of 0.81665, and since 0.81665 < 1, this supports the null hypothesis instead of the alternative hypothesis. The ANOVA also provided a P-value of 0.548131, and since 0.548131 > 0.05, this supports the null hypothesis.

Table 2. Summary of results from a ANOVA single-factor test.

Anova: Single Factor

SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*
Pear	2	55	27.5	24.5
Banana	2	110	55	4418
Orange	2	115	57.5	480.5
Apple	2	22	11	2

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	3016.5	3	1005.5	0.81665	0.548131	6.591382
Within Groups	4925	4	1231.25			
Total	7941.5	7				

These results support the null hypothesis that there is no significant preference for any of the fruit types tested (apples, pears, oranges, bananas) among terrestrial macroinvertebrates on the campus of Juniata College.

DISCUSSION

Our data analysis shows that there was no significant preference for any of the four types of fruit, which does not support our proposed hypothesis that terrestrial macroinvertebrates would prefer the banana. This means that terrestrial macroinvertebrates did not significantly prefer any one fruit option over the other fruits, which contradicts our proposed hypothesis. We theorized that terrestrial macroinvertebrates would prefer the banana option because of its higher sugar per gram compared to the other fruits. A possible explanation for this result lies in the variability among species and the number of individuals of terrestrial macroinvertebrates present throughout each baiting location. This could be a result of different biomes on an insect-level scale. This could also be, in part, due to the possibility of pesticide usage by the facilities department in close proximity to the buildings across campus. Additionally, our results could have been more reliable (i.e., less variance) and conclusive if we incorporated several more sticky traps to test additional trials with each bait type.

ACKNOWLEDGEMENTS

We would like to extend our thanks to Dr. Douglas Glazier for his support and advice during the project and for supplying us with sticky traps. We also thank Dr. Neil Pelkey, who provided the wire mesh for the cages we constructed to surround the traps.

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EFFECT OF WATER QUALITY ON SALAMANDER DIVERSITY WITHIN LOCAL STREAMS

Marta Cabellos, Dee Dee George, Lauren Hahn, Anthony Mazoff and Elisha Stenger

ABSTRACT

Salamanders prefer very specific water conditions and thus are capable of being biological indicators. For our research we decided to sample Warm Spring and Cold Spring for the species of salamander along with the water quality of the springs. The northern dusky (*Desmognathus fuscus*), northern red (*Pseudrotriton ruber*), and the northern two-lined (*Eurycea bislineata*) were observed at both springs, while the spring salamander (*Gyrinophilus porphyriticus*) was only observed at Warm Spring. More studies should be conducted to understand why the spring salamander seems to prefer Cold Springs.

Keywords: biological indicator, freshwater springs, pH, salamander, water quality

INTRODUCTION

Biological indicators are species, communities, or biological processes that are used to assess the quality of the environment and how it changes over time. Specifically, species used as biological indicators are chosen because they exhibit a measurable response to stress that is reflective of the whole ecosystem. Additionally, using bioindicators can serve as a cost-effective alternative to chemical sampling (Holt and Miller 2010). Amphibians, especially plethodontid salamanders, are seen as prime examples of valuable indicator species because of their dual life histories and permeable skin and eggs. (Siddig 2018). "Their (salamanders) longevity, small territory size, site fidelity, sensitivity to natural and anthropogenic perturbations, tendency to occur in high densities, and low sampling costs mean that counts of plethodontid salamanders provide numerous advantages over counts of other North American forest organisms for indicating environmental change." (Welsh, et. al 2002). Typically, changes in salamander communities can reflect changes in moisture, succession, and trophic disturbances. Central Pennsylvania is home to numerous types of plethodontid salamanders, including the redback, eastern newt, and slimy salamander (Pennsylvania Fish and Boat Commision). Pennsylvania is also home to many natural springs, which, despite the perception of clean, untainted water, have the potential to be polluted and disease-ridden (Boser et. al, 2016) . The presence of salamanders at specific spring locations may coincide with certain qualities of the springs, elucidating their true health. We propose that the species and number of salamanders found to be inhabiting Warm Spring will differ from that of Cold Spring due to variances in pH, temperature, dissolved oxygen, and other water quality factors.

METHODS AND MATERIALS

We took water quality measurements and sampled for salamanders in Warm Spring and Cold Spring. We recorded water temperature, dissolved oxygen, conductivity, and nitrates of the sites. We also surveyed the surrounding area taking note of dominant vegetation and the weather at the time of visit. Water quality was recorded in the afternoon. We would begin our salamander sampling in the evening after sunset where we would walk a total of 60 steps (roughly 60

feet) along the edge of the spring, setting up our transect area. As we followed the bank of the spring, we would sample 3 feet into the water and 3 feet on land. When a salamander was collected, we would photograph to confirm identifications and record the snout vent length before releasing back into the spring. In traveling between locations, waders and materials were disinfected. At a later date, we returned to the photographs and identified them with the help of Dr. John Matter.

SITE LOCATION

Cold Spring is a cool, acidic spring located off of Cold Springs Road. The water was clear, with minimal algae and marsh marigold cover. Vegetation surrounding the stream consisted mostly of grass, with some trees, flowers, and skunk cabbage. Stream flow was moderate, and sediment was made up of gravel, sand, silt, and cobbles. Other observed aquatic life included wood frogs and American toads.

Warm Spring is a warm, alkaline spring located off of Cold Springs Road, about 2 miles away from Cold Spring. The water was clear aside from plant coverage, which consisted of moss, duckweed, and algae. The area surrounding the stream was muddy and saturated, and vegetation consisted of some grass and plentiful skunk cabbage. Water movement was relatively slow and the sediment was made up of gravel, sand, silt, and cobbles. Other aquatic life included various frog, fish, and macroinvertebrate species.

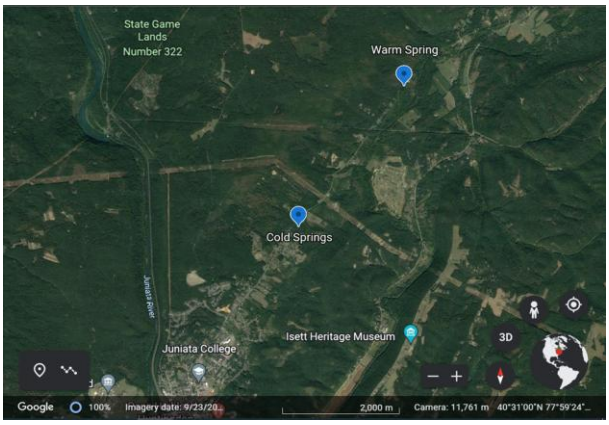

Figure 1. Map of sampling locations, Cold Spring and Warm Spring, in Huntingdon, PA, 16652

RESULTS

Overall, 4 different species of salamanders were observed between both springs. The northern dusky (*Desmognathus fuscus*), northern red (*Pseudrotriton ruber*), and the northern two-lined (*Eurycea bislineata*) were observed at both springs, while the spring salamander (*Gyrinophilus porphyriticus*) was only observed at Cold Spring (Table 1). Snout vent length of the salamanders was also collected and averaged (Figure 1). We used a 2-tailed, paired t-test to determine the significance of amounts of individuals between the cold and warm sampling groups (Table 2). Our calculated p value was 0.263, which means that the difference in the number of individuals between the springs was not significant. The t-Value was 1.54. Our Simpson's Diversity index was 3.3 at Cold Springs and 2.5 at Warm Spring (Table 3). This demonstrated the species abundance and species observed at each spring. Lastly, we recorded water quality at each of the springs (Table 4).

COUNT of Species	*Location*		
Species	Cold	Warm	Grand Total
Northern Dusky	4	22	26
Northern Red	9	15	24
Northern Two-Lined	7	43	50
Spring Salamander	6		6
Grand Total	**26**	**80**	**106**

Table 1. Sum of all individuals observed at both sites.

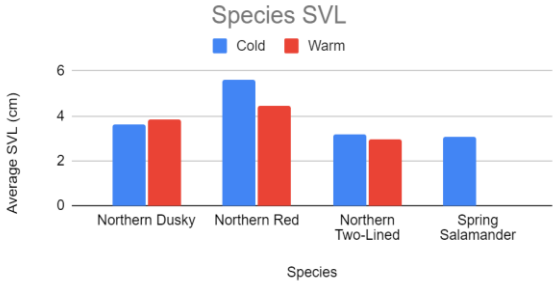

Figure 1. Average snout vent length in centimeters of each species observed at Cold and Warm Springs.

Table 2. Sum of all individuals observed at each site, separated by sample, on which the t-test was performed.

COUNT of Species	*Location*		
Sample	Cold	Warm	Grand Total
1	8	34	42
2	15	10	25
3	3	36	39
Grand Total	**26**	**80**	**106**

Table 3. Simpson's Diversity Index calculated from total abundance and species richness at each location.

Location	Diversity Index
Cold	3.3465
Warm	2.5020

Table 4. Average water quality taken at Cold and Warm Springs.

Site Water Quality	Temperature (C)	Nitrates (ppm)	Conductivity (ppm)	Dissolved Oxygen (ppm)	pH
Cold Springs	10.73	1.67	25.43	7.41	4.32
Warm Springs	16.70	5.00	109.50	5.42	6.84

DISCUSSION

Although more individuals were found in Warm Springs than Cold Springs (Table 1), this difference was not significant (Table 2). As a result, the diversity indexes calculated for each stream did not differ significantly because most species were found at both sites (Table 3). Yet the spring salamander was not found at both sites, and it is likely due to the differences in water quality (Table 4). Looking at water quality of Warm Spring and the number of individuals found there it can be inferred that salamanders prefer a warmer, more basic pH compared to the colder and more acidic water of Cold Spring. Further, the compositions and flow of the springs differ greatly from one another. Warm Spring has an extremely saturated marsh surrounding the spring, a sand and silt bedding with numerous large rocks, and significant amounts of moss, duckweed, and algae covering the water along with a slow flow rate. This gives the salamanders plenty of space and cover from potential predators. In contrast, Cold Spring consists of forest surrounding a fairly solid cobble bedding with intermittent silt and sand bedding, and while there are many large rocks the spring itself has a fast rate of flow with few slow-moving areas, which salamanders prefer. Just looking at the difference in the number of specimens found (with the same amount of time and effort dedicated to each search) indicates that there is the potential of preference regarding water quality in habitat selection, or, benefits of qualities of water and cover that allow them to have more reproductive success. In relation to water quality of the springs, we discovered Spring Salamanders at only Cold Spring. With what we know of salamanders' preferences it would be thought that they would have been found in Warm Spring, but they were not. A possible explanation for this could be the slightly higher dissolved oxygen in Cold Spring, and the considerably lower nitrate concentrations.

A further study that could be conducted to expand our knowledge would be a transplant study of spring salamanders. This would clarify the reason why spring salamanders weren't found there– can they not get there, or is the habitat not suitable? It is possible that either the warmer temperature, differences in vegetation, or higher pH is not conducive to optimal spring salamander habitat. This experiment could be conducted by collecting water from warm springs and maintaining the temperature with a heater. This isolates the pH and temperature component. Further on, individuals could be released to the spring to be collected later. If the habitat is unsuitable at this point, it is probably due to biotic factors like competition and predation.

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We thank Paige Hollibaugh for her assistance in data collection, Dr. Douglas Glazier, Dr. John Matter for his assistance in identifying salamander species, and Dr. Neil Pelkey.

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FORAGING PREFERENCE OF ANIMALS ON CAMPUS AT JUNIATA COLLEGE

Hailey R. Campbell, Jessie R. Freeland, Mel J. Mendez and Bernadette R. Traina

ABSTRACT

Several studies have shown that when animals live in close proximity to humans, they will begin to stray further from their homes. On the campus of Juniata College, this can be seen with squirrels and rabbits. In our study, we wanted to see if animals preferred feeding at ground locations protected from predators by vegetation, compared to ground locations without protection or cover. We had three different locations of food, each varying in distance from dense cover. An ANOVA test was run to test our hypothesis that there would be the most activity at the feeders placed underneath vegetation, and the results provided a p-value of 0.975. This provides us with no significant results because it is higher than the base p-value of 0.05, showing that the location of the feeders relative to vegetation does not influence wildlife foraging habits.

Keywords: visitation, Sciurus carolinensis, Aves, Tamias striatus, *predation*

INTRODUCTION

Sciurus carolinesis (Eastern gray squirrel), *Aves (b*irds), *Tamias striatus* (Eastern chipmunk) and other wild animals are constantly foraging for food when the grounds begin to dry, and the weather starts to get nice. Ground animals tend to search for food around their nests and in areas that are densely covered (Michael Bowers and Bianca Breland 1966). On the campus of Juniata College in Huntingdon, Pennsylvania, the animals have become accustomed to living around humans and have started to stray farther away from their densely covered habitats. The animals in the central part of campus are accustomed to the students and faculty members walking around, while parts of campus that do not see much human activity may have different effects in the selection of trays. In this study, we looked at the foraging habits with respect to ground location of the animals on the campus of Juniata College.

We know that the animals here on campus are used to human activity, but we are unsure of the predation they face. Due to us not watching the trays for the full 24-hour period, predation may have a negative effect on foraging habits. The large scale of animals that could come to the trays is unknown, which leaves us only with the knowledge of how many seeds were eaten.

We hypothesized that feeders placed under bushes and trees with low-hanging branches will receive the most visitation from wildlife. Wildlife tested included native birds of central Pennsylvania, squirrels, rabbits, etc. Our null hypothesis is that each feeder would receive an equal amount of visitation from wildlife, and whether sunflower seeds were put out in the open, under shrubbery, or under large trees would have no effect on where wildlife prefers to feed from. Our reasoning for our hypothesis was that birds and other wildlife would not want to feed without protection from vegetation therefore feeders left in the middle of a field would receive less visitation from wildlife. Large birds would be better able to see *Sciurus carolinesis* and *Tamias striatus* out in the open, so we believed these small animals would prefer

to feed where they are hidden. By testing four different locations within a one-mile radius on the Juniata College Campus, we were able to justify whether our hypothesis or null hypothesis was correct.

FIELD SITE

The data were collected from four separate locations around the Juniata College campus, in Huntingdon, PA: the East Riparian Buffer, between the dorms Sunderland and Sherwood, behind the Brumbaugh Academic Center (BAC), and on the quad by the dorm Cloister.

Figure 1. Arial photograph of the feeder locations placed behind BAC. The red dots are the approximate locations of where the seed trays were placed for each data collection.

Figure 2. Arial photograph beside the Riparian Buffer in front of East housing. One tray was placed at the base of a large tree, one under shrubbery in the riparian buffer, and one was out in the open for each data collection.

Figure 3. Arial photograph of the Sunderland and Sherwood lawns. The red dots denote locations of feeders for each data collection.

Figure 4. Arial photograph of the campus quad in front of Cloister. The red dots denote locations of feeders for each data collection.

METHODS AND MATERIALS

We collected data on which ground locations around the Juniata campus animals (such as squirrels, chipmunks, birds, skunks, etc.) prefer to feed at. We mixed three kinds of sunflower seeds (stripped, black oily, and shelled) and placed them in metal trays. We used three seed types to prevent shell hardness from being a factor that discourages animals from eating from our trays. Before placing the feeders around campus, we weighed the seeds we deposited into each tray using a triple beam mechanical balance scale (note: data collected in Table 4 in the "Results" section below was weighed with a digital scale). The data was collected from the four locations around campus as described in the section "Field Site" above. For each data collection, we placed one tray underneath vegetation, one next to the trunk of a large tree, and

one out in the open to total three trays. We weighed the seeds left in the trays after 24 hours.

The data collection was completed three times for each of the four sites to increase our accuracy and precision. The collected data can be seen in Table 1, Table 2, Table 3, and Table 4 in the "Results" section below. When all the data was collected the differences between the initial and final weights of the seeds were averaged together to perform statistical tests on. Treatment effects were tested using analysis of variance (ANCOVA: SYSTAT 10, SPSS Inc., Chicago, IL).

RESULTS

An ANOVA test was run on our data to look at the variance in our data. A plot of seed mass depletion versus habitat was plotted, which indicated that there was not much of a change between the locations of the trays. The ANOVA test gave us a p-value of 0.975, showing that it is not significant. An analysis of the variance was conducted giving an F-value of 0.026, indicating that there was no significant impact on the habitats. Figure 5. shows that there is not a large change in the average seed masses within the three locations of the trays.

Table 1. Average of findings from three 24-hr long data collections behind BAC.

Behind BAC	Initial weight of seeds	Final weight of seeds	Difference of seed weights
Under Bush	315.9 g	82.3 g	233.6 g
Next to Large Tree	371.6 g	156.2 g	215.4 g
In the Open	364.5 g	136.7 g	227.8 g

Table 2. Average of findings from three 24-hr long data collections at the East Riparian Buffer.

East Riparian Buffer	Initial weight of seeds	Final weight of seeds	Difference of seed weights
Under Bush	229.9 g	150 g	79.9 g
Next to Large Tree	387.7 g	382.5 g	5.2 g
In the Open	396.3 g	393.9 g	2.4g

Table 3. Average of findings from three 24-hr long data collections near Sunderland and Sherwood.

Sunderland and Sherwood	Initial weight of seeds	Final weight of seeds	Difference of seed weights
Under Bush	223.5 g	173.0 g	50.5 g
Next to Large Tree	241.7 g	155.9 g	85.8 g

In the Open	261.2 g	207.1 g	54.1 g

Table 4. Average of findings from three 24-hr long data collections on the Quad in Front of Cloister.

On the Quad in Front of Cloister	Initial weight of seeds	Final weight of seeds	Difference of seed weights
Under Bush	283.5 g	221.1 g	62.4 g
Next to Large Tree	247.4 g	173.1 g	74.3 g
In the Open	319.4 g	250.5 g	68.9 g

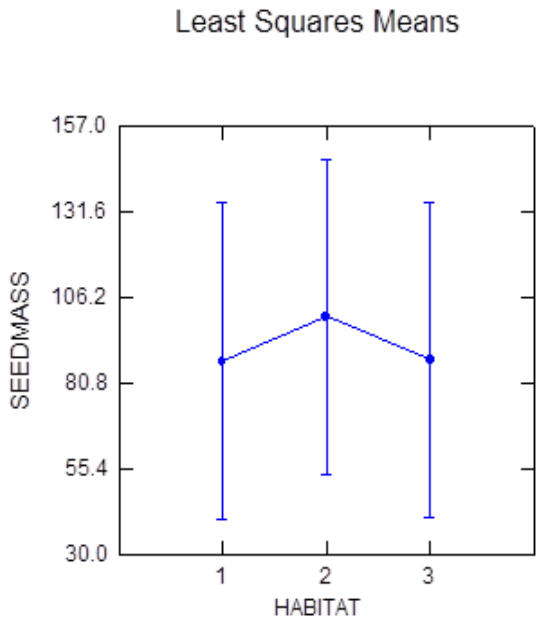

Figure 5. Graph of ANOVA test results – compares variance between the average seed mass differences of the three tray locations. Average seed mass difference (in grams) is the dependent variable, as microhabitat/tray site is the factor of variance.

Table 5. Outlined statistics of the analysis of variance between microhabitats (three tray locations) as detailed in Figure 1. The F-ratio is 0.026, and the p-value is 0.975.

Analysis of Variance Between Microhabitats

Dep Var: SEEDMASS N: 12 Multiple R: 0.075 Squared multiple R: 0.006

Source	Sum-of-Squares	df	Mean-Square	F-ratio	P

HABITAT	446.795	2	223.397	0.026	0.975
Error	78698.527	9	8744.281		

	SMBUSH	SMTREE	SMOPEN
N of cases	4	4	4
Minimum	3.000	26.600	0.700
Maximum	233.600	215.400	227.700
Mean	87.375	100.550	87.850
95% CI Upper	247.777	229.045	243.354
95% CI Lower	-73.027	-27.945	-67.654
Std. Error	50.402	40.376	48.863
Standard Dev	100.804	80.752	97.726

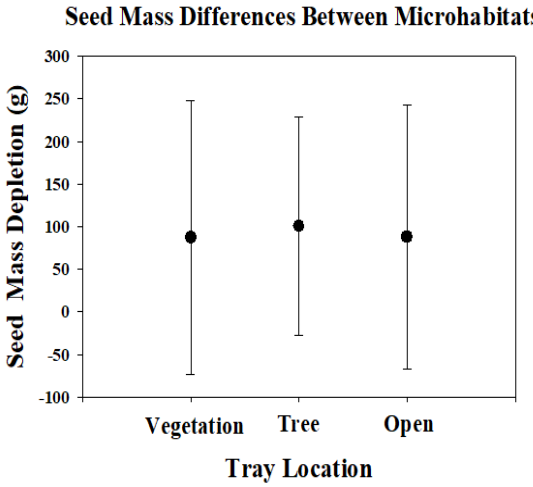

Figure 6. Graph of means of seed mass depletion vs. microhabitat/tray location. Error bars are the 95% confidence intervals for each microhabitat.

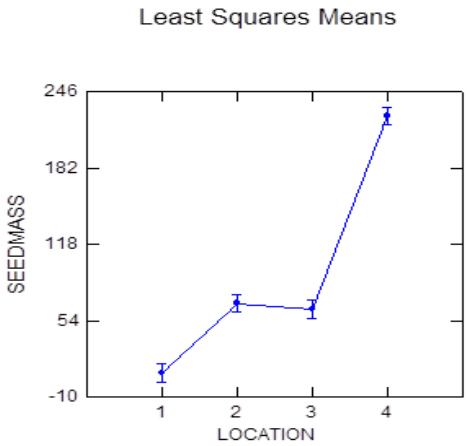

Figure 7. Graph of ANOVA test results – compares variance between average seed mass differences found at each of the four sites. For the X-axis, 1 corresponds to the East Riparian Buffer, 2 corresponds to the Quad in front of the Arch and Cloister, 3 represents the Sundy and Sherwood lawns, and 4 denotes the lawns behind BAC. Average seed mass difference is the dependent variable, as campus site is the factor of variance.

Table 6. Outlined statistics of the analysis of variance between site locations as detailed in Figure 6. The F-ratio is 146.637, and the p-value is less than 0.001.

Analysis of Variance Between Campus Locations

Dep Var: SEEDMASS N: 12 Multiple R: 0.991 Squared multiple R: 0.982

Source	Sum-of-Squares	df	Mean-Square	F-ratio	P
LOCATION	77731.729	3	25910.576	146.637	0.000
Error	1413.593	8	176.699		

	SM1	SM2	SM3	SM4
N of cases	3	3	3	3
Minimum	0.700	62.400	50.500	215.400
Maximum	26.600	74.300	85.900	233.600
Mean	10.100	68.533	63.500	225.567
95% CI Upper	45.712	83.335	111.897	248.634
95% CI Lower	-25.512	53.732	15.103	202.500
Std. Error	8.277	3.440	11.248	5.361
Standard Dev	14.336	5.958	19.482	9.286

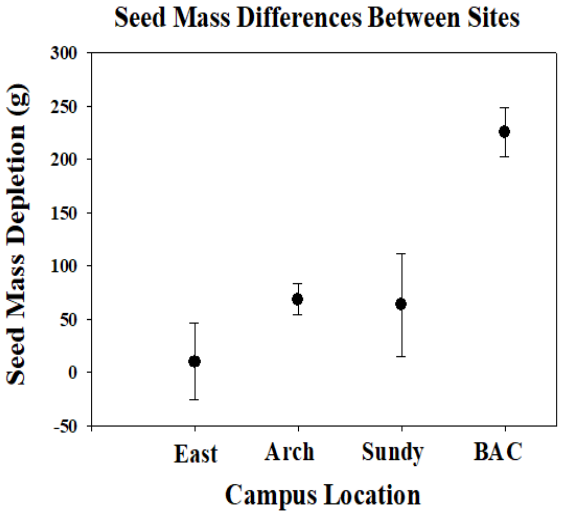

Figure 8. Graph of means of seed depletion mass at each campus site. Error bars are the 95% confidence intervals for each site.

DISCUSSION

Figure 5 displays results of an ANOVA test comparing variance of average seed mass depletion between tray locations, and Table 5 details statistical findings associated with the test. The p-value of the test is 0.975, much higher than the point at which we can consider our test to show significant results (0.05). The F-ratio is 0.026. The F-ratio tells us how much of the data variation is due to the factor of variance (which in this case is microhabitat/tray site) relative to the amount of variance due to the precision of the replicates. The small value of the F-ratio shows our precision between the replicates was poor. In the graph of Seed Mass Differences Between Microhabitats in Figure 6, we see no significant difference between each tray location (underneath vegetation/bushes, next to a large tree, and out in an open field), as shown by the large overlap between the standard error bars on the graph. As a result, we cannot support our hypothesis that the greatest mass of seeds would be lost at the trays underneath vegetation for animals to hide from predators. We support the null hypothesis that there is no significant difference between the three selected ground feeding preferences of animals on campus.

We ran a second ANOVA test to look for variance between average seed mass depletion and campus location, as detailed in Figure 7. Table 6 outlines the statistical findings associated with this test. The p-value is noted as 0.000 because the value is too small to report without scientific notation. Since the p-value is less than 0.05, we found significant difference. Furthermore, the F-ratio is 146.637, meaning most of the data variance is a result of the factor of variance, which in this case is campus site. Both the p-value and F-ratio support the conclusion that there is significant difference of seed depletion masses between the four campus sites. Additionally, the small error bars of 95% confidence intervals for each site in Figure 4 show the good accuracy of the replicates for each data collections. Looking at the graph in Figure 8, it is evident that the seed trays placed behind BAC received the most activity with an average of 225.6 g of seeds lost after each 24-hour data collection. This is likely because

fewer people walk on the lawns there compared to the lawns of the other three sites, creating less of a fear landscape for the animals to forage comfortably. There are also plenty of trees behind BAC, possibly where many of the squirrels on campus live – feeders placed outside their homes would have been convenient for them to feed on. From the graph, we see the East Riparian Buffer hardly had any activity, with an average seed depletion of 10.1 g. Animals likely avoided this area due to its proximity to East Housing, the East parking lot, and occasional dog walkers, all of which would have created noise and/or fear that would have scared animals away from feeding in the area.

Our study shows that animals did not prefer feeding at a certain microhabitat like we hypothesized, but instead preferred feeding at the feeders placed behind BAC. For the future, it would be interesting to research wildlife activity specifically behind BAC, such as the time of day squirrels prefer to forage at, or if squirrels prefer one of the three sunflower seed types we used in our experiment.

ACKNOWLEDGMENTS

We thank Dr. Douglas S. Glazier for his suggestions, assistance, and providing us with all the materials we needed.

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ABUNDANCE AND DIVERSITY OF INSECTS ON THE JUNIATA COLLEGE CAMPUS

Conner Frey, Nikole Koenig, Caroline Letrent, Marie-Claire Ndugu, Nicole Piccioni and Gavin Steward

ABSTRACT

On planet earth, insects make up the largest percentage of organisms in the world. They are the most diverse group of animals with over a million species and counting. With so many species to take into account within Pennsylvania, our study wanted to identify and compare insect species abundance and diversity in three environmental types: tall trees, low shrubs, and a combination of both. Capture attempts at the three environmental types occurred in managed (Juniata College Campus) vs unmanaged (Peace Chapel) locations to see if this had an effect on diversity and abundance. We hypothesized that the combination environment at the unmanaged location would have the largest abundance and diversity. For every specimen collected the location and environment type they were found was recorded and insects were later identified after collection attempts. Once all raw data was collected, we conducted analyses to determine how abundance and diversity differs in our field sites. We found several different outcomes for the insects in our sites. The low brush habitat on campus had the lowest diversity. The most diversity in insects was found in the tall tree and low shrub environment at Juniata College along with the low shrub environment at the Peace Chapel. For abundance, the combination habitat at the Peace Chapel was the least abundant and the most abundance of insects was found to be in the low shrub environment on campus. Our findings do not support our hypothesis, but they were not statistically significant.

Keywords: Simpson's diversity index, abundance, diversity, insects, Chi-Square test

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INTRODUCTION

In Pennsylvania 1,111 species of insects have been identified (Pennsylvania Insects 2017). Species richness is determined by numerous extrinsic factors such as area, habitat and resource diversity, and niche partitioning. In this study, we will be focusing on habitat diversity. With a high richness of insect species, we were interested in testing the abundance and diversity of insects in variable environments. The variable environments investigated will include areas of low shrubs, high trees, and a combination of the two.

In a previous study, abundance and diversity were observed on a college campus in Harrison, NY using the same three environment types. We've expanded our study to include an off-campus location, The Peace Chapel in Huntingdon, PA, as well as the manicured quad sample locations on the campus of Juniata College. The goal of this expansion is to compare how the abundance and diversity differ between human-managed areas compared to an untouched natural location. If we find that we collect a smaller number of species of insects on campus then this demonstrates how natural

locations, such as The Peace Chapel, allow for more species to be successful because the manicured lawns of a campus quad do not provide the correct habitat for a larger diversity of species.

METHODS AND MATERIALS

Field Site

This study was conducted at the campus of Juniata College in Huntingdon, PA as well as The Peace Chapel located in the same town (Latitude: 40° 30' 14.8608". Longitude: -78° 0' 7.308"). Locations on the campus included either side of the library which simulated a short shrub environment and a combination environment as well as behind the Brumbaugh Academic Center which simulated the tall tree environment. The Peace Chapel was selected as the natural environment where short shrubs, tall trees, and a combination environment were present.

Materials

This study utilized three sweep nets of the same size to collect specimens. Small collection jars containing 90% ethanol were used to preserve insect specimens for later counting and identification. Online resources were utilized for insect identification. *Methods* The method for capture utilized sweep nets as well as wood planks. The sweep nets were dragged across each environment type at both Juniata College and Peace Chapel. The sweep net method of capture was performed three times at each collection site once a week for two weeks. The collection attempts occurred on 4/12/22 and 4/26/22. Wood planks were placed at each environment on the ground after the first capture attempt on 4/12/22 and were recovered on 4/26/22. The goal of the planks was to allow insects to hide under them for later capture. Temperature and time of capture attempt for each week were recorded to note any possible variability. After two weeks of collection, insects were identified via online resources and counted. Once all species were identified and counted, abundance was measured, and diversity was calculated using Simpson's diversity index.

Statistical analyses

A chi-Square goodness of fit test and a test for independence were conducted to determine whether the sample represents the whole as well as if diversity and abundance are independent of location and environment type respectively.

RESULTS

Qualitative data regarding the different insect families captured was recorded as well as the quantitative data separating the number of taxa found at each location on each collection day. There were very few repeats of insect family captures and often only one individual captured per insect family with exceptions to the Lampyridae family.

Table 1. Qualitative data showing which insect families were present at each location and environment type.

Environment	Family	JC	PC
High	Tenebrionidae	X	
	Reduviidae		X
	Syrphidae		X
	Ixodidae	X	
	Forficulidae	X	
	Araneidae	X	
	Culicidae	X	

	Chironomidae	X	
	Araneidae	X	
	Lepismatidae		X
	Opiliones		X
	Coreidae		X
Low	Leptothea		X
	Carabidae		X
	Formicidae		X
	Pentatomidae		X
	Agelenidae	X	
	Reduviidae	X	
	Lampyridae	X	
	Pisauridae		X
	Reduviidae		X
Combination	Araneidae	X	
	Rhipiceridae	X	
	Salticidae	X	
	Agelenidae	X	
	Mycetophilidae	X	
	Salticidae	X	
	Elateridae		X
	Theridiidae		X

Table 2. Quantitative data showing the number of insects found (red columns) at each location and environment type on both collection dates.

Dates	Taxa JC High		Taxa PC High		Taxa JC Low		Taxa PC Low		Taxa JC Combo		Taxa PC Combo	
4/12	Tenebrionidae	1	Reduviidae	1	NA	NA	Leptothea	1	Araneidae	1	NA	NA
			Syrphidae	1			Carabidae	1	Rhipiceridae	1		
							Formicidae	1	Salticidae	1		
							Pentatomidae	1	Agelenidae	1		
4/26	Ixodidae	1	Lepismatidae	1	Agelenidae	1	Pisauridae	1	Mycetophilidae	1	Elateridae	1

	Forficulidae	1	Opiliones	1	Reduviidae	1	Reduviidae	1	Salticidae	1	Theridiidae	1
	Araneidae	1	Coreidae	1	Lampyridae	3						
	Culicidae	1										
	Culicidae	1										
	Chironomidae	1										
	Araneidae	1										

To measure diversity of insects at the two testing sites and each of their environments, we utilized Simpson's diversity index and substituted calculating species for families due to identification difficulties. Abundance was calculated by dividing the number of families from one location and environment type by the total number of families at both locations at that same environment type. For example, the number of individuals found in the tall tree environment will be divided by the total number of individuals found at the tall tree environments at both Juniata College and Peace Chapel.

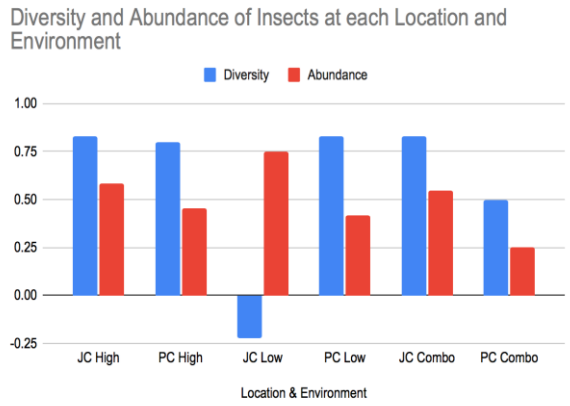

Figure 1. Bar graph demonstrating summary data for abundance and diversity at each location and each environment.

The low brush environment at Juniata College had the lowest diversity, whereas the combination environment at the Peace Chapel was the least abundant (Fig. 1). The most diversity occurred in the tall tree environment at Juniata College, the low shrub environment at the Peace Chapel, and the combination environment at Juniata College. The most abundance was seen in the low shrub environment at Juniata College.

Table 3. Test for independence showing the observed and expected values of each location and environment type.

Observed				
	High	Low	Combo	Total
JC	7	5	6	18
PC	5	6	2	13
Total	12	11	8	31

Expected				
	High	Low	Combo	Total
JC	6.97	6.39	4.65	18
PC	5.03	4.61	3.35	13
Total	12	11	8	31

A Chi-Square test for independence and a goodness-of-fit test was conducted to assess the number of insects captured and their dependency on the environment and location as well as the difference between observed and expected individuals captured respectively. The null hypothesis for the test for independence states the number of individuals captured are independent of location and environment. The alternative hypothesis states that the number of individuals found is dependent on location and environmental type. The test was conducted using two degrees of freedom and an alpha value of 0.05. The critical value was found to be 5.990 and the chi-square value was calculated to be 1.660. The p-value was found to be 0.44. Due to the chi-square value being less than the critical value we could not reject the null hypothesis; since the p-value is greater than our alpha value, the differences were not significant.

Table 4. Goodness-of-fit test showing the observed and expected individuals captured at each location and environment type.

Goodness-of-Fit						
	JC High	JC Low	JC Combo	PC High	PC Low	PC Combo
Observed	7	5	6	5	6	2
Expected	5.17	5.17	5.17	5.17	5.17	5.17

The null hypothesis for the goodness-of-fit test states there is an equal number of individuals found at each location and environment. The alternative hypothesis states that there are an unequal number of individuals found at each location and environment. The test was conducted using 30 degrees of freedom and an alpha value of 0.05. The critical value was found to be 43.77 and the chi-square value was calculated to be 2.862. The p-value was found to be one. Due to the chi-square value being less than the critical value we could not reject the null hypothesis; since, the p-value is greater than our alpha value, no significant differences were found. From both our statistical analyses we cannot make any significant conclusions regarding our project.

DISCUSSION

As mentioned above, our results show that the highest insect diversity was in the tall tree environment at Juniata College, and the most insect abundance was seen in the low vegetation environment at Juniata College. This result of Juniata campus offering more suitable habitat for a variety of bug species, as concluded from our results above, does not support our original hypothesis but these results were found to be statistically insignificant. In terms of our collection method, we originally planned to only collect data from Juniata College. However, due to colder temperatures on our first collection date we had a low success rate. Dr. Glazier suggested we add wood planks at each test site to allow for bugs to hide

underneath it for later capture in addition to the use of sweep nets. We initially picked Peace Chapel as our off-campus testing site for its high density and variety of vegetation. Peace Chapel seemingly offered more suitable habitat for our specimens than on campus since it was more forested, but after merging our data we concluded this theory to be false yet statistically insignificant.

The evidence points to Juniata College campus, especially the tall trees environment, for having the highest diversity, possibly because of different tree species and vegetation at our testing sites. For both Peace Chapel and Juniata College, we did not consider the tree and vegetation species of our sites matching up. Perhaps at Peace Chapel the vegetation at low, high, and combo were simply not as desirable for many bug species, as the taller trees and shrubs at Juniata were. To look further into why the true forest at Peace Chapel had the least instances of diversity and abundance, we could analyze the differences in temperature, or rather temperature triggering bug activity. Bugs like termites, crickets, and mosquitos are more active in warmer temperatures. When we collected at Peace Chapel twice, versus the several instances we collected at Juniata before altering our methods, it was rather cold and even rained during our second collection date. This weather interference of rain and colder temperatures likely obstructed the diversity and abundance of bugs at Peace Chapel.

If we were to reanalyze the diversity and abundance of bug species at both Peace Chapel and Juniata College, we would use consistent vegetation, increase the number of collection dates, collect in warmer temperatures, and assess differences in site elevation. As mentioned previously, something we did not consider was the difference in vegetation at all six of our sites. There was no consistent low, high, or combo vegetation for each category. There were differences in physical height and differences in plants and trees. A second alteration would be to increase collection attempts to allow for more raw data. Another modification would be collecting in warmer temperatures. Temperatures and weather changes have significant effects on what kinds of bugs are active. The capture methods used to collect specimens may not have been conducive so in addition to the sweep nets and planks we could add additional methods of capture. The last modification could be looking at the differences in elevation at all of our sites. Certain bugs may not be found at higher elevations even if it is their preferred habitat. Conducting more collection dates, picking sites with similar or the same vegetation, collecting in warmer temperatures, and assessing elevation differences may help our study have clear significant results of abundance and diversity at Juniata college and Peace Chapel.

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We would like to acknowledge Daniel Demopoulos, Georgie Humphries, and Isabella Wrobel who authored
the original paper that inspired this study, Juniata College for providing the testing sites, and Dr. Glazier of Juniata College for his assistance throughout this assignment.

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BIRD SPECIES RICHNESS COMPARED BETWEEN TWO LOCAL WETLANDS

Grace Gibbs, Lydia Hiller, Payton Miller and Hunter Mona

ABSTRACT

The Old Crow wetlands of Huntingdon County, Pennsylvania are currently faced with the potential construction of a Rutter's gas station at a proximity detrimental to the wildlife found there. Old Crow is known for its bird species richness and plays a significant role in preserving the biodiversity seen in Huntingdon County. This study aims to justify the protection and preservation of the Old Crow wetlands by surveying the bird species diversity found there and comparing these results to a neighboring wetland found at Juniata College. To collect this data, we conducted several surveys of the bird species at each of these locations. By observing the bird species diversity and counts at these locations we hope to show the importance of Old Crow as an area of high species richness. Our results showed a higher individual abundance and species richness at Old Crow wetlands than seen at Juniata. This data proves our hypothesis and shows that the Old Crow wetlands should be preserved as they are an important source of biodiversity.

Key words: species richness, wetlands, birds

INTRODUCTION

In Huntingdon County, Pennsylvania, there are two distinct wetland areas. One is located at Juniata College and the other being Old Crow Wildlife Observation Area. Old Crow was created in 1997 as a PennDOT Advance Wetland Compensation Project, and was originally a wetland, but was tiled for agriculture. PennDOT restored the wetlands, and it is now successful, at one time having the most bird species counted in the state. Recently, the Rutter's gas station chain has planned to construct a location adjacent to and uphill of these wetlands. In our research, we seek to help justify the importance and preservation of these wetlands to Pennsylvania and Huntingdon County's bird species richness. It has been shown that noise pollution can have detrimental effects on bird populations. Most commonly when an area gets too noisy song birds either leave to a quieter area or stay and fare less well [1]. We are observing the species diversity and count of bird species at both the Old Crow Wetlands and the wetlands at nearby Juniata College. We hypothesize that because of the isolation, diversity of vegetation at Old Crow, and presence of multiple larger water sources, we will find a greater diversity of species at Old Crow than at Juniata College, a similar, but much smaller and less isolated, wetlands.

FIELD SITE

The two areas observed are both classified as wetlands. Old Crow is 7.6 acres and located directly off William Penn Highway in Huntingdon Pennsylvania. It is primarily made up of tall grasses with trees scattered about along with small bird houses. Walking paths are present but are not well maintained from our observations. Old Crow contains two large ponds that are home to snapping turtles.

The wetlands located outside of East Houses at Juniata College are 2.6 acres. There is a lot of foot traffic in this area along with lots of disturbance and

pollution due to the movements of the students. These wetlands are primarily composed of tall grasses with two large trees located on the border of the wetlands. Muddy run creek runs along the opposite border of the wetlands.

METHODS AND MATERIALS

Over the course of several days, Old Crow Wetlands and the Juniata College wetlands were studied to determine the exact number of different taxa of birds found in these different environments. The wetlands were similar in overall composition but differed in the amount of foot traffic as well as size. Observations were taken for differing amounts of time, in numerous types of weather and times of day to try to accurately count the number of species present. Binoculars, bird identification books, as well as online resources such as the Cornell Bird Lab as well as YouTube were used to identify species. Statistical analysis of both wetlands was then done to determine the differing species richness as well as statistical significance.

RESULTS

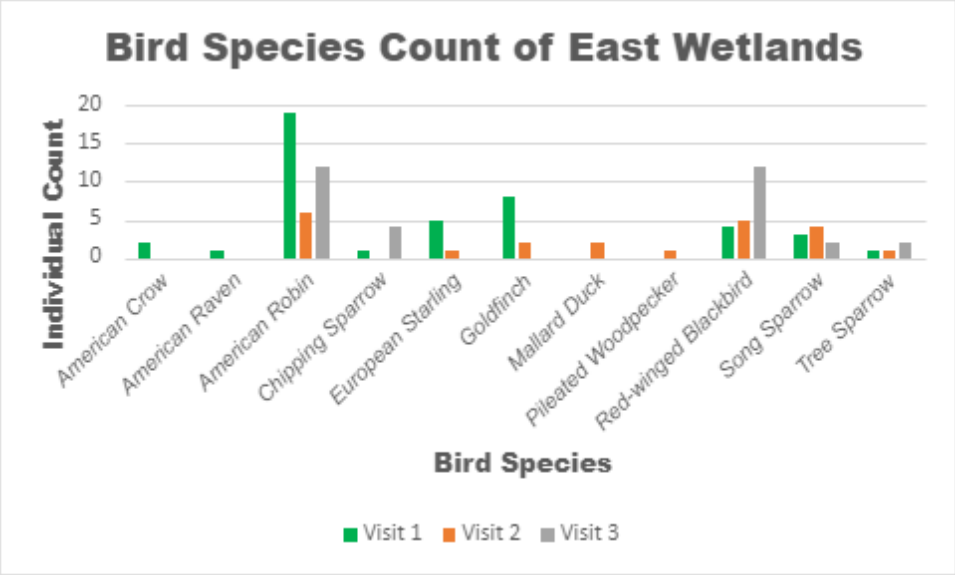

Fig 1. Chart showing count of birds at the east wetlands, arranged by species and visit number

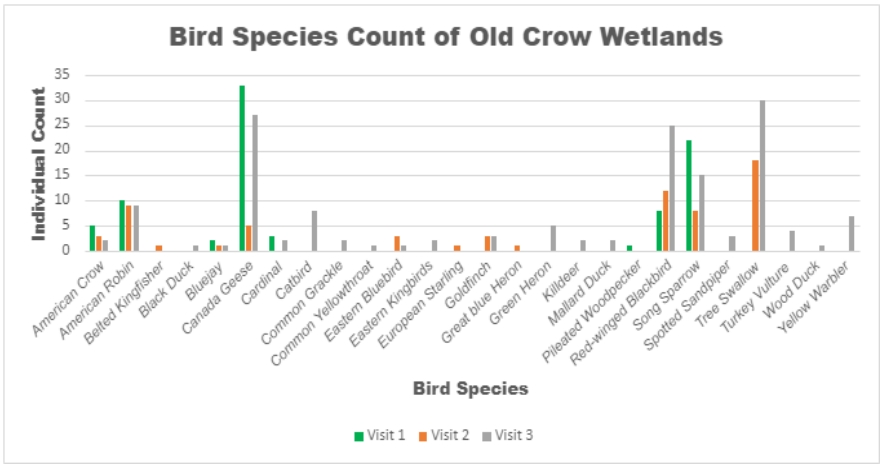

Fig 2. Chart showing count of birds at Old Crow Wetlands, arranged by species and visit number

Location	Species Count	Individual Count
East	11	98
Old Crow	26	302

Fig 3. Table showing location, species count, and Individual count of birds in the study

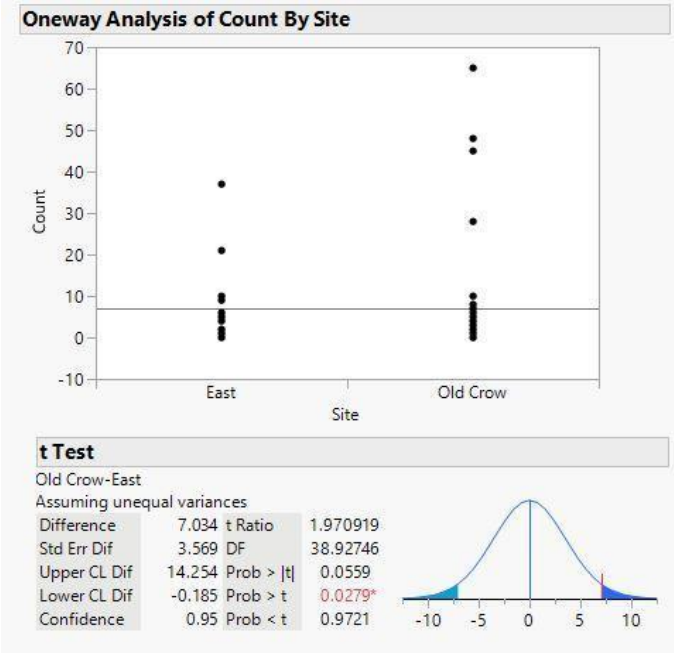

Fig 4. Shows the t-Test comparing individual bird abundance

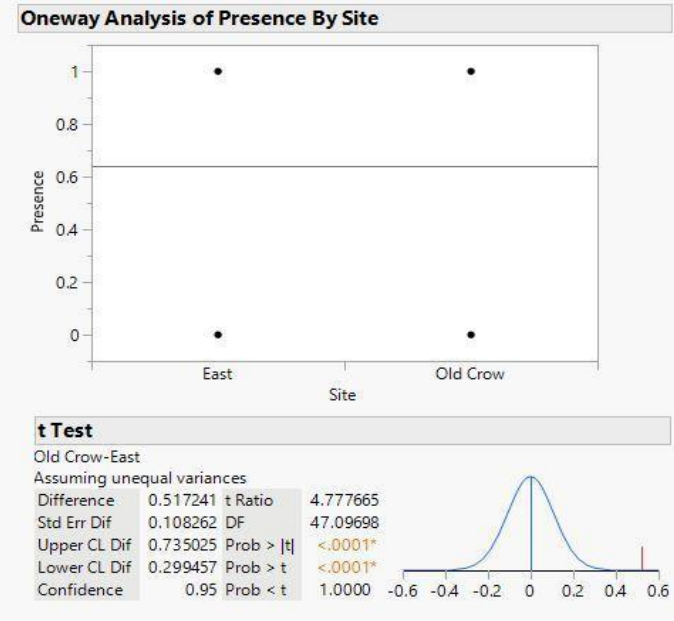

Fig 5. The t-Test showing the relationship between species abundance

DISCUSSION

The t-test values indicated in both our individual (Fig. 4) and species abundance (Fig. 5) tests were statistically significant. This is unsurprising as Old Crow wetlands have over twice the species of birds as Juniata wetlands and showed more than three times as many birds total as shown in Fig 3. Also, to keep in mind when trying to evaluate the environmental importance between the two wetlands, one must consider the species present at each location. Old Crow was home to two different heron species, three different duck species, and two different plover-type birds (Fig. 2). Not included in the results were the other observable benefits of Old Crow's surrounding reeds and grasses, including a nest of six goslings being raised within the preserve. To truly measure the value of Old Crow, we must acknowledge that wetlands are growing increasingly scarce. Between 1992 and 1997, 49% of wetland habitat losses in the eastern United States were attributed to development. From our observations, it is evident that not even similar wetlands habitats in the immediate area can support the species richness and count that is thriving at Old Crow, making it a pertinent part of Huntingdon and Pennsylvania ecosystems. Losing any of the current land at Old Crow or risking increased pollution would be a terrible loss to the local wetland ecosystem and to regional biodiversity as a whole.

ACKNOWLEDGEMENTS

We thank Dr. Douglas S. Glazier for his time and effort into teaching us this semester and preparing us for this project. We would also like to thank the Juniata Ecology Department for allowing us to use their binoculars and other resources in order to identify birds.

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IMPACTS OF RAYSTOWN LAKE ON WATER QUALITY OF THE RAYSTOWN BRANCH OF THE JUNIATA RIVER BASED ON USING MACROINVERTEBRATES AS BIOINDICATORS

Tim DeWalt, Grace Rose, Averie Hess and Brooke Miller

ABSTRACT

This study examined how Raystown Lake impacts the water quality of the Raystown Branch of the Juniata River. To assess the impacts of Raystown Lake, two collection sites were selected. One site was below the dam and the other was located above the dam near Juniata College's Raystown Field Station. Macroinvertebrate sampling as well as the measurement of several physical characteristics of each test site were taken at three different visits. Following the analysis of the results, it was concluded that there are no drastic differences between the Pollution Tolerance Index value or physical indicators of the collection sites above and below the dam. Further investigation of nutrient loads of the water above and below the lake, as well as more precise measurements of water quality indicators could be used in the future for further investigation.

Key words: bioindicators; macroinvertebrates; water Quality

INTRODUCTION

The construction of the second Raystown dam led to the creation of Raystown Lake. It started in October of 1968 and was completed in October 1973. The construction of this dam led to drastic changes to the Juniata River Basin upstream of the dam. The physical environment was altered drastically as the lake filled up. However, the physical environment was not the only thing that changed as the water levels rose. The water quality of the Raystown Branch of the Juniata River was also impacted by the construction of the dam. Dam impoundments have been shown to greatly decrease the quality of water. Some of these negative consequences include warmer temperatures downstream of the dam as well as lower dissolved oxygen levels (Division of Ecological Restoration, n.d.).

Raystown Lake is used heavily for a variety of recreational activities like fishing, boating, and camping. These activities can contribute to anthropogenic pollution of the water within the lake. Other anthropogenic activities that can degrade the water quality include farming on land near the lake or near tributary streams that flow into the Lake. This can result in excess nutrients and sediments being deposited into the lake.

To assess the impacts the lake has on the water quality of the Raystown Branch of the Juniata River, we analyzed macroinvertebrates at two different sites. One site was above the dam and the other was below the dam. Macroinvertebrates were selected as our bioindicator of water quality because they maintain a relatively fixed position in their aquatic environments. Additionally, some macroinvertebrates are very sensitive to stress produced by changes in the pH, temperature, dissolved oxygen, levels of pollution, habitat modifications, or severe natural events while others are more tolerant. Therefore, by assessing the macroinvertebrates present in a body of water, you can determine the quality of water present (Uherek, 2014).

The physical indicators collected at each site include pH, temperature, dissolved oxygen, and conductivity was collected. At each site, collection of macroinvertebrates occurred by kick-net and three samples gathered from each kick-net. This process occurred three times at each of the sites over a three-week period. Once the macroinvertebrate samples were transported to the lab, identification and counting of the macroinvertebrates occurred. An evaluation of the order and number of each order of macroinvertebrate present in the two test sites took place, and the data was used to assess the water quality at the two different sites based on the ecological tolerance of the macroinvertebrates present. This data was compared to our physical indicators recorded from the sites to formulate an assessment on how Raystown Lake impacts the water quality of the Raystown Branch of the Juniata River.

METHODS

There were two collection sites. One was located near the field station and a tributary stream for Raystown Lake, and the other was located below the dam and a distributary stream. At each of the collection sites, multiple samples of physical and biological indicators were taken. Three trips to each site (March 31, April 5, and April 12, 2022) were made and physical indicators like pH, dissolved oxygen (DO), temperature, and conductivity were measured each time.

To sample macroinvertebrates, a kick-net method was used to collect 3 samples for each trip taken to the collection sites. A random number chart was used to select the sampling area. After collection, the macroinvertebrates were taken back to the lab at Juniata College and identified using a dissecting microscope and a macroinvertebrate identification key. All macroinvertebrates were identified to their order and the number present in each sample was recorded. The Pollution Tolerance Index (PTI) was calculated for the two test sites using Biotic Index Calculator found on Stroud Water Research Center's website.

Figure 1. Picture of the distributary stream sampled.

Figure 2. Picture of the tributary stream sampled.

RESULTS

Tables 1 and 3 list the order and the number of macroinvertebrates present at the two collection sites. Tables 2 and 4 contain the water chemistry data for the two sample locations. Table 5 showcases the results using the pollution tolerance index and pollution tolerance rating.

Table 1. Distributary Stream Macroinvertebrate Collection

Order Present	# Present
Ephemeroptera (Mayflies)	21
Plecoptera (Stoneflies)	68
Diptera	11
Trichoptera (Caddisfly)	13
Decapoda (Crayfish)	3
Tricladida (Flatworms)	5
Oligchaeta (Aquatic Earthworm)	7
Megaloptera	1

Table 2. Distributary Stream Physical Indicators Sampled

Sample Number	Temperature (°C)	pH	Conductivity (µS)	Dissolved Oxygen (mg/L)
1	5.7	7.99	2	11.21
2	9.7	6.43	118	9.05
3	13.2	5.83	102	8.46

Table 3. Tributary Stream Macroinvertebrate Collection

Order Present	# Present
Ephemeroptera (Mayflies)	184
Plecoptera (Stoneflies)	28
Diptera	4
Trichoptera (Caddisfly)	37
Decapoda (Crayfish)	1
Oligchaeta (Aquatic Earthworm)	14
Amphipod	49
Hydrophilidae (Water Beetle)	1

Coleoptera (Riffle Beetle/Water Beetle)	41
Isopoda (Sow Bug)	1
Megaloptera (Alderflies/Dobsonflies)	5
Odonata (Dragonflies/Damselflies)	5

Table 4. Tributary Stream Physical Indicators Sampled

Sample Number	Temperature (°C)	pH	Conductivity (µS)	Dissolved Oxygen (DO)
1	9.5	9.15	277	12.3
2	11.4	7.02	201	10.94
3	14.9	7.94	185.8	10.9

Table 5 Pollution Tolerance Index of collection sites

Collection Site	Pollution Tolerance Index (PTI)
Above the dam	20 - Good
Below the dam	20 - Good

DISCUSSION

To assess the water quality of the above and below the dam collection sites, the pollution tolerance index (PTI) of each site was calculated. PTI is a comparison between taxa abundance and tolerance to environmental pollutants and stress. The higher the PTI of a stream the better the water quality. Both the above dam and below dam collection sites had a PTI of 20. The pollution tolerance index rating for both sites was good, since the PTI values fell within the range of 17-22. This rating indicates possible organic pollution present in the water. The expected outcome was the above dam site having a higher PTI than the below the dam collection site; however, the results received did not align with the hypothesis. To develop a better understanding of how Raystown Lake affects the water quality of the Juniata River, more in depth research is needed. Evaluating the nutrient load that the Lake may deposit into the Juniata River, after the dam, is one way to better understand the impacts of the Lake on the Juniata River.

The water quality measurements recorded did not show any drastic difference between the tributary of Raystown lake and the distributary of Raystown lake. Our hypothesis was that the tributary would have better water quality than the outlet of Raystown lake. The conductivity of the two sources indicates no difference in water quality. According to the EPA's website, the typical stream's conductivity varies widely between 50-500 and both average conductivities for the collection sites fell within this range. Compared to each other, the pHs are not drastically different, and the dissolved oxygen levels are also comparable. Note that some of our measurements may be off due to possible calibration errors of the water quality meters. To get more accurate water quality readings a more structured monitoring protocol would need to be implemented to eliminate possible operator error and calibration errors that may have occurred in the study. Assessing the abiotic and biotic data together, there is no discernable difference between the tributary and distributary sampling sites.

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EFFECTS OF HABITAT AND GROWTH FACTOR ON NATURAL MORTALITY RATE IN NORTH AMERICAN FISH SPECIES

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ABSTRACT

Our data were collected by the Virginia Marine Institute of native fish from all over the world. Our hypothesis tests were whether temperature decreases or increases growth rate among fish. There were statistical data taken on preferred water temperatures, Mortality rate, quantitative and qualitative data, family, genus, the specific location they were captured and sex of the species of fish that were captured. According to the statistical data we captured and as well as analyzed multiple sets of confirmed data and graphed according to our hypothesis. In conclusion, we rejected our hypothesis due to the fact that our data analysis such as r-squared and temperature did not correlate with the mortality rate.

Key words: Von Bertalanffy growth parameters, instantaneous natural mortality rate, temperature

INTRODUCTION

In this study, the Virginia Institute of Marine Science had previously done an online database of 230 freshwater fish species on their growth factors and life history characteristics. We tested the relationship between the von Bertalanffy growth factor, average habitat temperature, and the maximum age of the fish stock as the focal point of this study as it pertains to a fish's mortality. We used linear regression analyses to determine the effect of each variable on fish mortality rate.

METHODS AND MATERIALS

We analyzed data from the Virginia Institute of Marine Science (VIMS). VIMS compiled an online database of 230 U.S. fish species that recorded information on growth factors and life history traits. The database identified each species by order, family, genus, species, and common name, and recorded the location, mean annual temperature, and sex of the stock studied when available. The database then included the instantaneous natural mortality rate, von Bertalanffy growth factor, von Bertalanffy asymptotic length, and maximum age of the stock at that location for each species. The data was compiled from a variety of studies and papers published on North American fish species, and each resource was cited along with the species they contributed. The database is routinely updated and maintained by the VIMS. Since we had so much data to work with, we decided to look at the relationships between the three major variables, von Bertalanffy growth factor, average habitat

temperature, and maximum age of the fish stock and their effects on the species' instantaneous natural mortality. We hypothesized that growth factor would have the greatest effect on mortality and the relationship would be positive while temperature and maximum age would have smaller effects on mortality with positive and negative relationships respectively.

Since growth factor is an expression of the bodily growth of a fish species with respect to age, the higher the factor, the faster the fish grows. We thus expected that higher growth factors would result in higher mortality rates since they would likely grow, mature, and reproduce earlier in life. We expected temperature to have a positive effect as well since colder waters are more productive and can lead to longer lived fish with lower mortality rates. In regards to maximum age, the longer the species tends to live, the lower we expect their natural mortality rate to be. To test our hypothesis, we ran linear regressions. We used instantaneous natural mortality as the independent variable and checked the effect that temperature, von Bertalanffy growth factor, and maximum age each had as the dependent factors. We used the calculated p and R^2 values to determine significance and relative amount of variance explained by each regression. We plotted the residuals scatter graphs, showing the results fitted around the least squares (best fit) lines.

RESULTS

Temperature (°C) had a significant ($p=0.002$), but minor ($R^2= 0.041$) effect on mortality ($year^{-1}$). The 95% confidence intervals did not include the horizontal, meaning we rejected the null hypothesis. However, this correlation only explains about 4.1 % of the variation. von Bertalanffy growth factor also had a significant ($p<0.001$) effect on mortality, and accounted for significantly more of the variation ($R^2=0.46$). The relationship between maximum age of stock (years) and mortality was clearly nonlinear, though it was significant ($p<0.001$, $R^2=0.161$). To fit this better to a linear regression, we took the log of maximum age and replotted it against mortality and re-ran the regression. This resulted in a much more correlated relationship ($p<0.001$, $R^2=0.569$). Though all three, temperature, growth factor, and maximum age, had significant effects on the instantaneous natural mortality of each fish species, growth factor and maximum age had the highest correlation. Of these, the maximum age of the fish stock had the greatest effect, explaining about 57% of the variance

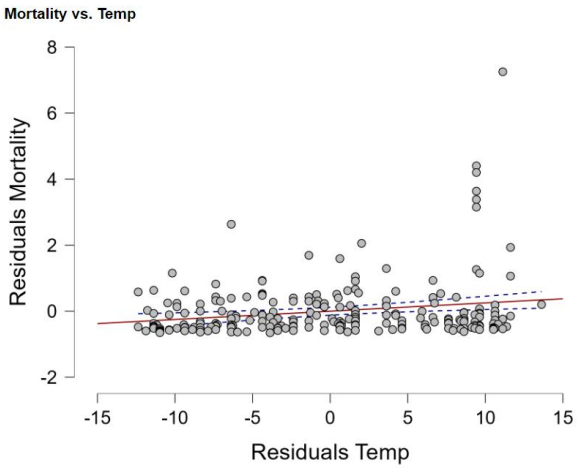

Figure 1. Linear regression of instantaneous natural mortality against average habitat temperature.

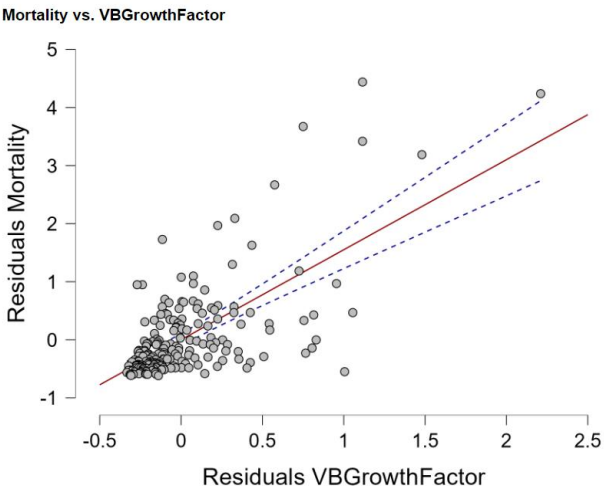

Figure 2. Linear regression of instantaneous natural mortality against von Bertalanffy growth factor.

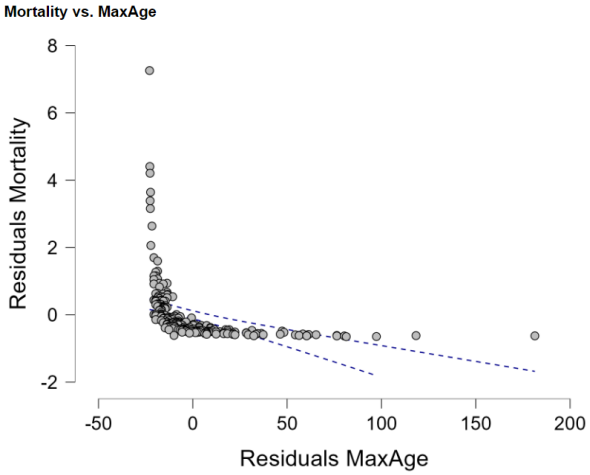

Figure 3. Linear regression of instantaneous natural mortality against maximum age of the fish stock.

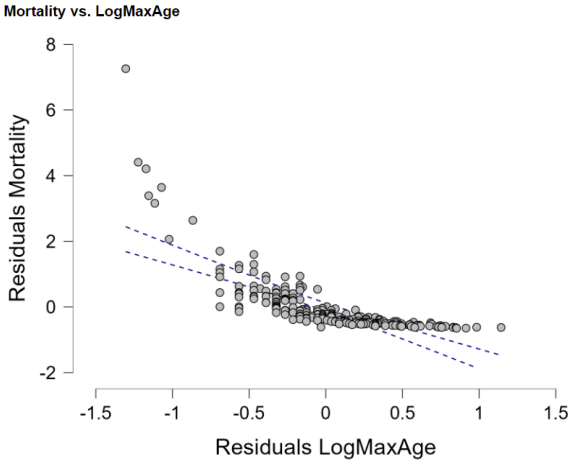

Figure 4. Linear regression of instantaneous natural mortality against logarithm of maximum age.

DISCUSSION

Instantaneous natural mortality is an expression of the likelihood of death of any individual in a population over a very short time period. This value differs across the species in the database, and we wanted to see if these variances were due to any of the other factors recorded in the data. von Bertalanffy growth factor, average habitat temperature, and maximum age of the fish stock all had significant effects on mortality rate. As we expected, temperature and growth factors had positive relationships with mortality. This indicates that warmer habitats tend to host fish species with higher mortality rates. This may be due to colder water being more nutrient rich and tending to support more long lived and slower growing species. However, this relationship was minor and only explained a small portion of the variance. von Bertalanffy growth factor is an expression of the rates of growth over a fish's lifespan. The larger the growth factor, the faster the fish grows. Thus, we hypothesized that higher growth factors, thus faster growing fish, would have higher mortality rates. This

relationship was significant and did explain more of the variance (46%) more than temperature did. We originally thought that this would be the biggest impact on mortality. However, it turned out that the maximum age of the fish stock had the greatest effect, explaining about 57% of the variation in mortality rates. When originally plotted, this relationship was clearly nonlinear, and so it was re-run as the logarithm of the maximum age. This resulted in a much more linear relationship with a higher degree of correlation. This indicates that the older the fish stock could get, the lower their natural mortality rates. Though we had expected this relationship, we were surprised to see that it had a greater correlation than the growth factor. Our results indicate that temperature, von Bertalanffy growth factor, and maximum age reported in the fish population have significant effects on the natural mortality rate, with maximum age having the highest effect. Species with higher habitat temperatures, higher growth factors, and lower maximum ages have higher instantaneous natural mortality rates. Growth factor and maximum age may be able to be used as predictors or indicators of natural mortality rates. This would allow us to use other life history traits of fish species to understand their risk of death. This does align with other publications that have found correlations between von Bertalanffy growth factor and natural mortality (Zhang and Megrey 2009). These parameters and relationships may be useful in conservation efforts and understanding population response to disasters. By understanding how growth rates and maximum age affect mortality rates, we can get a better understanding of populations, their age structure, and how and why they grow, reproduce, and die.

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