Annual Variations in Mayfly Populations and Relations to Water Quality in the New River of Ashe County, NC

Benjamin Lee

Field Biology and Ecology Class of 2010 at Summer Ventures in Science and Mathematics at UNC-Charlotte

Michael J. Baranski, Instructor

Katie Bender, Assistant

July 16, 2010

Abstract

Mayfly larva or nymphs belong to the order Ephemeroptera and are a macro-invertebrate that plays an important role in the ecology and upkeep of aquatic ecosystems. An experiment was conducted by the Field Biology and Ecology Summer Ventures Class of 2010 at UNC-Charlotte in the Woods River, commonly known as the New River, in Ashe County, North Carolina, testing the diversity and quantity of macro-invertebrates. Various hypotheses were created, one being that the number of mayfly larvae in the river corresponded with the water quality of the river. During the experiment, a large quantity of diverse specimens was collected from the New River and later identified, grouped, recorded on a data sheet, and compared with other annual experiments. The data collected were then analyzed and interpreted, showing that a correlation between water quality and mayfly populations existed, supporting the hypotheses.

Introduction

Background

Being almost microscopic, mayfly larvae (see Figure 1) and other macro-invertebrates are rarely thought about. However, being so small but still large enough, mayfly larvae are an important food resource for many aquatic species' diets such as small-mouth bass, channel catfish, crayfish and trout. Because of their regularity in fish diet, even fishing lures are mainly designed after them. Though mayflies are a valuable order in the macro-invertebrate group, macro-invertebrates are a very diverse group of species ranging from crustaceans, such as crayfish, to aquatic worms.

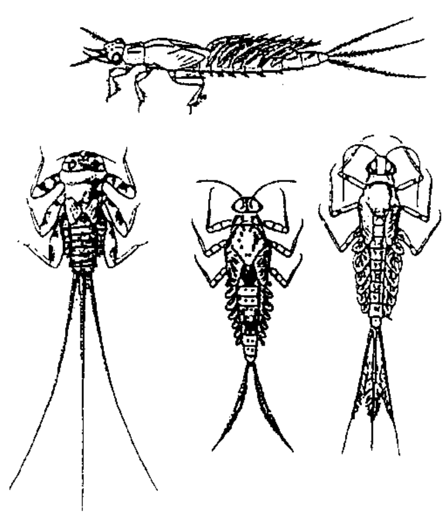

Figure 1: Examples of Mayfly larvae

Rarely seen by the naked eye, macro-invertebrates (see Figure 2) dominate the streams and rivers of the world and though at the bottom of the food chain, they help maintain the healthiness of the aquatic ecosystem by eating bacteria and dead, decaying plants and animals. Overall, the water quality of the ecosystem determines what kind of aquatic species can exist in a body of water (Cleveland, 1998). Because of this role, macro-invertebrates are seen as some of the most important species in an aquatic ecosystem. However, though macro-invertebrates can reduce the amount of pollution in the water, they are still susceptible to it, some species more than others. Some examples would be the mayflies (Order Ephemeroptera), stoneflies (Order Plecoptera) and water pennies (Family Psephenidae), which require a much higher level of dissolved oxygen. An abundance of these taxa is usually a good indicator of high water quality (Cleveland, 1998). A good example of pollution's effect on mayfly populations is seen in Freedman (2010). A famous study involving mayflies was conducted in Lake Erie during the 1950s and early 1960s. Lake Erie was badly polluted at that time, especially by organic debris associated with sewage and algal growths, the decomposition of which consumed most of the oxygen in the waters of deeper parts of the lake.

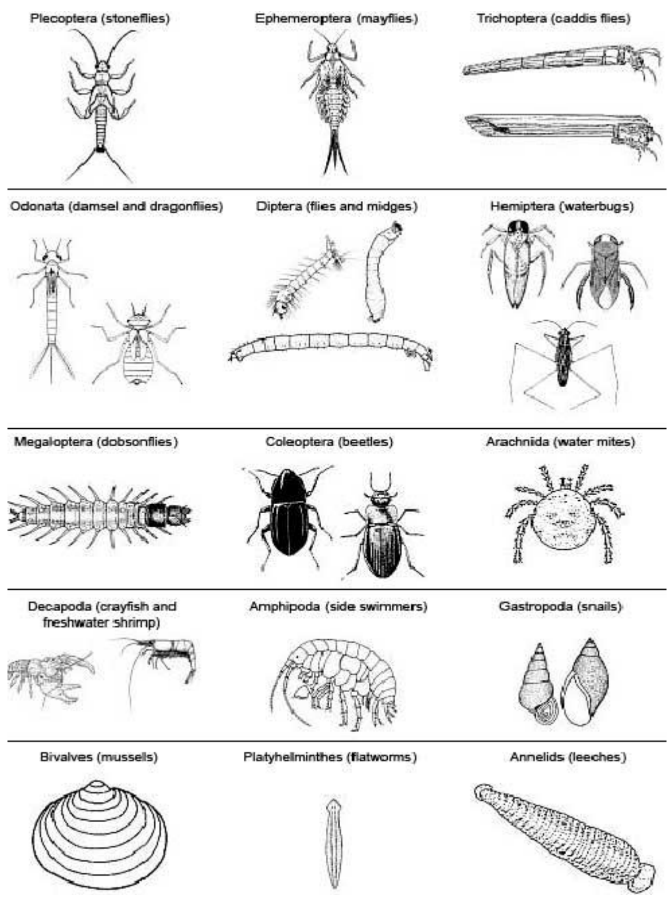

Figure 2: Examples of macro invertebrates found in the New River.

The development of anoxic conditions resulted in mass die-offs of nymphs of the mayflies *Hexagenia rigida* and *H. limbata,* which were previously extremely abundant. The virtual collapse of the populations of mayflies in Lake Erie was widely reported in the popular press, which interpreted the phenomenon as an indication that the great lake was "dead," and had been rendered as such by pollution caused by humans. Today, the waters of Lake Erie are much cleaner, and its populations of mayflies have recovered somewhat (Freedman, 2010).

Mayflies are placed in Group I-Index Value 3 along with stoneflies because of their extreme sensibility to the effects of pollution (Cleveland, 1998). They prefer cool water temperatures (about 55 degrees Fahrenheit or lower), as it dissolves oxygen more easily than warm water because they require a dissolved oxygen level of 6 ppm. They are also highly susceptible to changes in pH level, being able to exist only in almost neutral water; about 6.5-7.5 (Cleveland, 1998).

Research Question/Problem

Though macro invertebrates are numerous, the main focus of this report is on the annual variations of mayfly populations and relations to the water quality in the New River of Ashe County, NC. The Null Hypothesis is that mayfly populations and water quality of the new river are not correlated. The purpose of this study is to examine mayfly populations in relation to water quality in the New River. The experiment was conducted on July 9th, 2010, around 7:00 P.M after heavy showers and during a light sprinkle. The New River, though cloudy from the rain, appeared to be in good condition with no pollution visible at the site. After being collected, the data were compared to past experiments conducted in the same area and conclusions were drawn.

Materials and Methods

The experiment was conducted in cooperation with the staff of the New River State Park in Ashe County, NC and with the Field Biology and Ecology Summer Ventures Class of 2010 at UNC-Charlotte. The data collected will be used in Virginia Save Our Streams efforts, a non-profit, nongovernmental organization that documents pollution in streams with various methods and reports that data to state agencies

At the site, we were instructed to use Virginia SOS methods to extract specimens from the water (Virginia Save Our Streams, n. d.). We chose a riffle in the stream where there was shallow, fast moving water with a depth of 3-12 inches or deeper and created a 1-by-1 meter square perimeter in front of a seine net. The net was tilted back and set perpendicular to the flow of water downstream and held in place. Cobble sized stones were turned over, preferred more by macro invertebrates because they make excellent cover, and other habitat to dislodge the macro-invertebrates into the kick net. To make sure the area was thoroughly sampled; stones were picked up and rubbed underwater to dislodge the specimens

The amount of time allowed for this sampling was about 90 seconds. After time ran out, the net was dislodged by a scooping motion upstream to contain the specimens which were then collected into a bucket with an aerator to keep oxygen flowing, allowing them to live, until we reached our workstation. The specimens were taken off the entire net and with a tray to hold the specimens, forceps and magnifying glasses were used to handle and identify the ones collected which were then tallied on another data sheet. At least 200 specimens were required for an accurate representation of the stream’s macro-invertebrate population.

The way the data were used to determine the ecological condition of the water was through a method called the SOS Multimetric Index method (Virginia Save Our Streams, n. d.) which has been used consistently through all seven years of the data used in this study. The individual specimens collected were all recorded, sorted into groups and used in calculations to help determine the total percentages of each group of macro-invertebrates. This data were compared to the SOS Multimetric Index's final score, 0-6 being poor ecological condition and 7-12 being sustainable or acceptable ecological condition (Virginia Save Our Streams, n. d.). In this study, the data were also put into a chi-square test, a statistical test used to compare observed data and expected data, and the Shannon Diversity Index to examine the diversity of the aquatic life. The data in this report were graphed using Microsoft Excel. Chi-Square analysis was done with the program *Quantitative Analysis in Ecology (*Brower, et. al., 1998).

Results

In 2010, the total number of specimens sampled from the river was 331 (see Figure 3) with mayflies making up about 26% of those collected. All together, mayflies, stoneflies and most caddis flies made up about 41% of the sample, common net spinners 8.5%, and beetles 22%. There were 25% tolerant specimens and 7% amount non-insects. No lunged snails were identified in 2010's study. The New River had a SOS Multimetric Index of eleven, a rating of excellent in 2010.

In 2003, the SOS Index was two levels lower with a rating of nine, still in the excellent water quality range (see Table 1). The number of specimens sampled totaled 330 with mayflies, stoneflies and most caddisflies making up 35% of that amount. Common net spinners also made up 35% of the specimens and beetles were 12% of that amount. That year had 11% of tolerant specimens and 14% of non-insects. No lunged snails were sampled in 2003.

Table 1: Virginia SOS Samples from the New River

Year	# of Macro Invertebrates	# of Mayflies	Mayflies, et. Al.	SOS Multimetric Index
2010	331	85	136	11
2009	245	29	99	10
2008	222	42	69	11
2006	498	73	227	11
2005	390	86	154	10
2004	756	60	375	11
2003	330	35	117	9

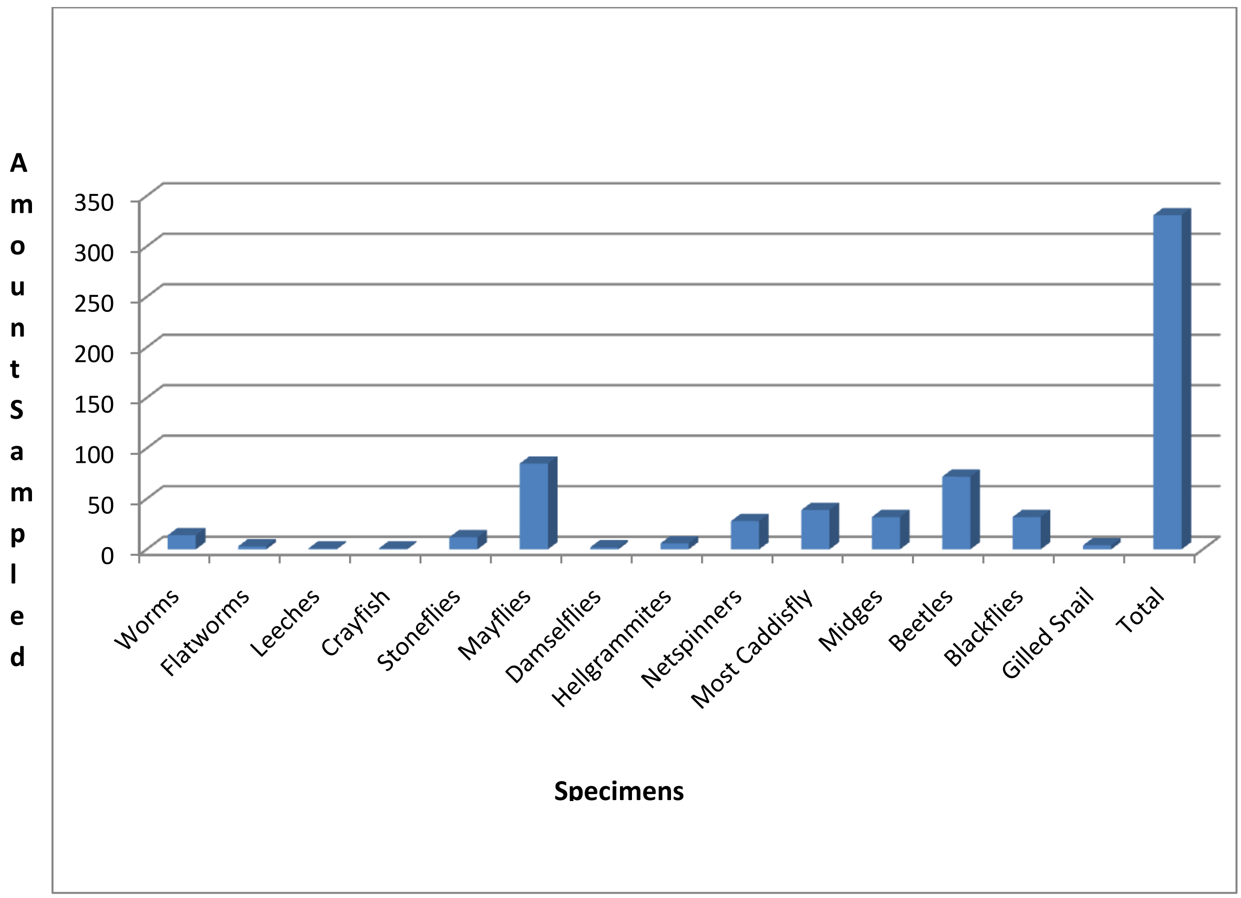

Figure 3: Number of Specimens Sampled in 2010

The specimens sampled in 2009 were similar in regards to species identified but the total amount differed. Only 245 macro invertebrates were sampled with mayflies only making up 11.8% of those sampled. All together, mayflies, stoneflies and most caddisflies made up 40.4% of the total amount. However, the stream still had a SOS Index rating of ten even with the low quantities of mayflies sampled. The stream sample in 2010 was extremely diverse with a Shannon Diversity Index of 2.08 with mayflies dominating the amount of macro-invertebrates (see Table 2).

Table 2: Diversity Index of 2010

Species	Amount	Species/total	ln Pi	- (Pi*ln Pi)
Worms	14	0.0423	-3.16	0.13
Flatworms	3	0.0091	-4.70	0.04
Leeches	1	0.0030	-5.80	0.02
Crayfish	1	0.0030	-5.80	0.02
Stoneflies	12	0.0363	-3.32	0.12
Mayflies	85	0.2568	-1.36	0.35
Damselflies	2	0.0060	-5.11	0.02
Hellgrammites	6	0.0181	-4.01	0.07
Net spinners	28	0.0846	-2.47	0.21
Most Caddisflies	39	0.1178	-2.14	0.25
Midges	32	0.2175	-2.34	0.23
Beetles	72	0.0967	-1.53	0.33
Blackflies	32	0.0967	-2.34	0.23
Gilled Snail	4	0.0121	-4.42	0.05
Total	331	1.0000	-48.50	2.08
Diversity Index	2.08			

Compared to the years 2001-2004 (see Table 3), the year 2010 has a below average diversity index. The year 2002 currently had the highest diversity with an Index of 3.01 and 2010 is currently the lowest with a diversity index of 2.08.

Table 3: Diversity index of 2001-2004, 2010

2001	2002	2003	2004	2010
2.46	3.01	2.43	2.77	2.08

Comparatively, the data from 2010 and 2003 were both similar in regards to total specimens and lunged snails collected and sampled with a very minuscule difference of one specimen. The amount of mayflies, stoneflies, and most caddisflies totaled 136 in 2010 and 117 in 2003. No data for the year 2007 were found (see table 1).

The data collected were used in a chi-square test to determine if there was any significant correlation between annual mayfly larvae populace and water quality or if it is all by chance. The data above were put into percentages to allow for easier calculations and entered into a computer program.

Table 3: Chi-Square Test

N	Chi-Square	DF	Probability Level
.118	2.12	6	.05

The critical value was .118 and being less than the chi square value of 2.12 there is significant difference. The data shows that mayfly populations do have a relationship with water quality in the New River. The results show that the Null Hypotheses was rejected and that mayfly populations do have a relationship with water quality.

Discussion

By analyzing the data, it is seen that the water quality has remained constant though all the years sampled with a slight dip in the year 2003. No data was found for the year 2007 and the years 2003-2004, 2008-2010 used a more sophisticated and accurate SOS Multimetric index while the years 2001-2002 used a less sophisticated method, the Biotic Index. With the chi square test results, the presence of mayfly populations in rivers do have a correlation with the water quality of that river. From the earlier study mentioned (see Freedman, 2010), it is seen that various levels of pollution has impacts on mayfly populations from decimating them completely, to only a select few dying off. The abundance of mayfly populations is a good indicator of good water quality.

The years calculated for the diversity index shows that a there is a slight decrease in diversity every year with the exception of 2003. The low diversity index in 2010 could be attributed to the weather conditions encountered at the site, complete cloud cover and light rain showers. The water also seemed to be moving at a high rate of turbidity than normal. Other reasons could include that the riffle chosen just didn’t contain many macro-invertebrates the time of month the experiment was conducted and the theory of climate change causing a rise in temperatures too high to sustain mayfly populations.

Conclusion

From the data analyzed, the results show that the hypothesis is supported. Only slight differences have occurred in the data collected (2003-2006, 2008-2010) but nothing significant enough to be noted. Studies of the macro-invertebrate specimens recorded from the past three years have also shown that the diversity index has remained mainly constant with slight differences but no significant cases.

References

Baranski, M. J. 2010. Field Biology and Ecology Summer Ventures Class at UNC-Charlotte

Cleveland, A. J. 2000, July 27. *Water quality and aquatic macro invertebrates*. Retrieved from http://www.ncsu.edu/sciencejunction/depot/experiments/water/lessons/macro/

Freedman, B. 2010. Mayflies - Ecological and Economic Importance of Mayflies. *Science encyclopedia*. Retrieved (2010, July 14) from http://science.jrank.org/pages/4188/Mayflies-Ecological-economic-importance-mayflies.html

Brower J. et. al., 1998. *Quantitative Analysis in Ecology*