Measuring and Finding the Effects of Water Temperature on Macroinvertebrates in Streams Around the Cobb Area

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Abstract

This study aimed to answer the question: are colder or warmer streams healthier? The question was answered by measuring 30 streams for water temperature and collecting macroinvertebrates from each stream. Depending on what kind of macroinvertebrates were found, the stream either has a water quality rating of poor, fair, good, or excellent. This study's hypothesis is: if different stream locations around Cobb are measured for water temperature and type/number of macroinvertebrates, then the steam locations with warmer water temperatures will have a smaller quantity of macroinvertebrates and less macroinvertebrates that indicate healthy stream conditions. To answer this question, a thermometer was placed in each stream. Then, the stream was determined to be either muddy or rocky bottomed. Scoops from each stream (exactly how the scoops were obtained differed depending on the type of stream) were collected and macroinvertebrates were sorted out, identified, and documented. The streams' water quality ratings were calculated, and 22 out of 30 streams ended up having poor water quality. There ended being no correlation between water temperature and stream health. Therefore, the hypothesis was not supported.

Introduction

This study aimed to discover the health of streams around the Cobb area by measuring the streams' temperatures and levels of macroinvertebrates.

The methods used to gather the data were based on Georgia's Adopt-A-Stream program. This study measured the water temperature and levels of macroinvertebrates in the streams because those factors can be used to determine the amount of dissolved oxygen in the water. Dissolved oxygen is the O_2 molecules in the water, not the oxygen in H_2O (Mesner, 2010). A common misconception is that dissolved oxygen is the bubbles you see in water (Mesner, 2010).

That is false, because dissolved oxygen is microscopic (Mesner, 2010). All aquatic animals need dissolved oxygen to breathe (Mesner, 2010). Low levels of dissolved oxygen occur most often in the bottom of the body of water, and since macroinvertebrates tend to live at the bottom of streams and cannot migrate or adapt very quickly, they will die if dissolved oxygen levels get too low (Staff, 2015). This is why macroinvertebrates are used to find the health of the stream.

This “danger level” is different for each species of macroinvertebrate. Georgia Adopt-A-Stream guidelines group macroinvertebrates into three different categories: sensitive, somewhat sensitive, and tolerant (Staff, 2015). Organisms in the sensitive category require high levels of dissolved oxygen, somewhat sensitive organisms require moderate levels of dissolved oxygen, and for tolerant organisms, low levels of dissolved oxygen are adequate (Staff, 2015). Some examples of sensitive organisms are stonefly nymphs, mayfly nymphs, and gilled snails (Macroinvertebrate, n.d.). Common net spinning caddisflies, crane flies, and scud are somewhat sensitive organisms (Macroinvertebrate, n.d.). Some tolerant organisms are midge fly larvae, black fly larvae, and lunged snails (Macroinvertebrate, n.d.). The Georgia Adopt-a-Stream program measures stream health by multiplying the number of identified taxa groups by either 3 -- if the organism is in the sensitive group; 2 – if the organism is in the somewhat sensitive group; or 1 – if it’s in the tolerant group (Macroinvertebrate, n.d.). Adding those numbers together results in a number showing water quality, with Excellent being greater than 22; Good being from 17 to 22; Fair being from 11 to 16; and Poor being less than 11 (Macroinvertebrate, n.d.). However, the program also states that “Good water quality is indicated by a variety of different kinds of taxa/organisms, with no one kind making up a majority of the sample” (Macroinvertebrate, n.d.).

Besides macroinvertebrates, the amount of dissolved oxygen can also be measured by the water temperature. Cold water holds more dissolved oxygen than warm water (Frequently, n.d.). This occurs because cold molecules have less energy and are tighter packed than warm molecules (Frequently, n.d.). The larger gaps between warm water molecules means oxygen can escape back into the air (Frequently, n.d.). Georgia state standards require stream temperatures to be less than 32.2 degrees Celsius (Staff, 2015). Temperature is the cheapest and easiest way to measure dissolved oxygen, so that is why this study is comparing macroinvertebrates to temperature. So, temperature can show how much dissolved oxygen is present, which can in turn show how many macroinvertebrates are living in a certain stream. Dissolved oxygen shows how healthy a stream is. To sum it up, the temperature influences the dissolved oxygen levels, and the dissolved oxygen levels influence the macroinvertebrates. Water temperature is the independent variable and the type/number of macroinvertebrates is the dependent variable.

This study is unique in that it is local to the Cobb area. This study is probably most similar to “Assessing small streams in the upper Ocmulgee watershed using the Georgia adopt-a-stream macroinvertebrate monitoring protocols” by Anne Stahley and Christopher H. Kodani. In their study, they followed Georgia’s Adopt-a-Stream guidelines as well (Stahley, 2011). However, they measured streams in the Ocmulgee area, instead of the Cobb and Chattahoochee area. They stated, “Our data showed no clear relationship between average water quality score and average water temperature at each site” (Stahley, 2011). Their conclusions do not support this study’s hypothesis. A less related study is “Relationships between wetland macroinvertebrates and waterfowl along an agricultural gradient in the Boreal Transition Zone of western Canada” by Silver, Thompson, Wong, and Bayley. In their observational experiment, they observed changes in macroinvertebrates (caused by agricultural encroachment) to see if the changes affected the waterfowl community (Silver, 2012). Silver's experiment is like this study, the Cobb Stream Study, in that two variables are being observed. However, Silver is investigating macroinvertebrates and waterfowl, while this study observed temperature and macroinvertebrates. Also, their experiment took place in Canada, while this study was in Cobb County, GA (Silver, 2012). They found scud, flies, backswimmers, and water boatmen (Silver, 2012). Like Silver's study, this experiment expected to find scud and flies, but did not expect to find backswimmers and water boatmen.

This stream study will benefit the immediate society in that it will hopefully locate streams that are more polluted and influence citizens to clean these streams. Healthy streams are important because some humans rely on water from these streams. Also, the macroinvertebrates are food for animals like fish, which in turn are food for birds, and so on. Healthy streams support the food chain. However, some streams always have poor water quality, because they were designed to be that way, like streams that lead into runoff ponds. It is fine if these streams have poor water quality. Since this study depends on the local area, this experiment will not influence the larger scientific community.

Based on prior studies and research, this study's hypothesis is: if different stream locations around Cobb are measured for water temperature and type/number of macroinvertebrates, then the steam locations with warmer water temperatures will have a smaller quantity of macroinvertebrates and less macroinvertebrates that indicate healthy stream conditions. This is the hypothesis because it's proven that warmer water holds less dissolved oxygen.

Methods

This experiment involves 30 stream locations, so the following procedure is repeated at each location.

First, the water temperature is measured. A large alcohol thermometer is placed in the water and left until the red line stops moving, which is usually around 8 to 10 minutes. The temperature is recorded in Celsius. Then, the stream is determined to be either a rocky or muddy bottom stream. Rocky bottom streams have larger rocks or gravel on their bottoms and have faster-moving water, while muddy bottom streams have silt, sand, or small rocks and have slower-moving water. Following actions differ depending on the type of stream.

If the stream is rocky bottomed, then riffles and leaf packs are scooped from. Riffles are areas where underlying rocks disturb the water. An approximately 1-foot by 1-foot net is placed downstream of this riffle. Then, the ground directly in front of the net is kicked at and disturbed. This continues until a 1-foot by 1-foot area in front of the net has been disturbed and washed into the net. The net's contents are then dumped into a white bucket. Two scoops from riffles are obtained. After that, three netfuls of leaf packs are scooped. Leaf packs are underwater clusters of decaying leaves. Three 1-foot by 1-foot scoops are made and placed in another bucket. The buckets are then searched. Two plastic spoons are used to dig through the debris and to scoop up any found organisms. Found organisms are then placed in stream water-filled ice cube trays. Each bucket is searched for 10 minutes.

If the stream is muddy bottomed, then vegetated margins, areas of woody debris, and areas of substrate are scooped from. Four scoops from vegetated margins are obtained. Vegetated margins are areas along the bank of the stream, usually consisting of overhanging bank vegetation, plants living along the shoreline, and submerged root mats. Each scoop covers an approximately 1-foot by 1-foot area and is placed into a bucket. Next, three scoops from areas of woody debris are taken. Areas of woody debris include dead or living trees, roots, limbs, sticks, leaf packs, cypress knees, and other submerged organic matter. The net is used to scrape the side of the woody debris until a 1 square foot area has been scraped into the net. These scoops are then placed into another bucket. Finally, two scoops of substrate are taken. Substrate is the sediment on the bottom of streams. Two scoops are taken from the coarsest areas. The scoops cover an approximately 1-foot by 1-foot area, and are placed into a bucket. Each bucket is then searched for 10 minutes using the same process as outlined above.

After all of the buckets have been searched, the macroinvertebrates are identified. Georgia Adopt-A-Stream's macroinvertebrate key is used to identify the organisms. The type and number of each macroinvertebrate is identified, and then they are released back into the stream.

Results

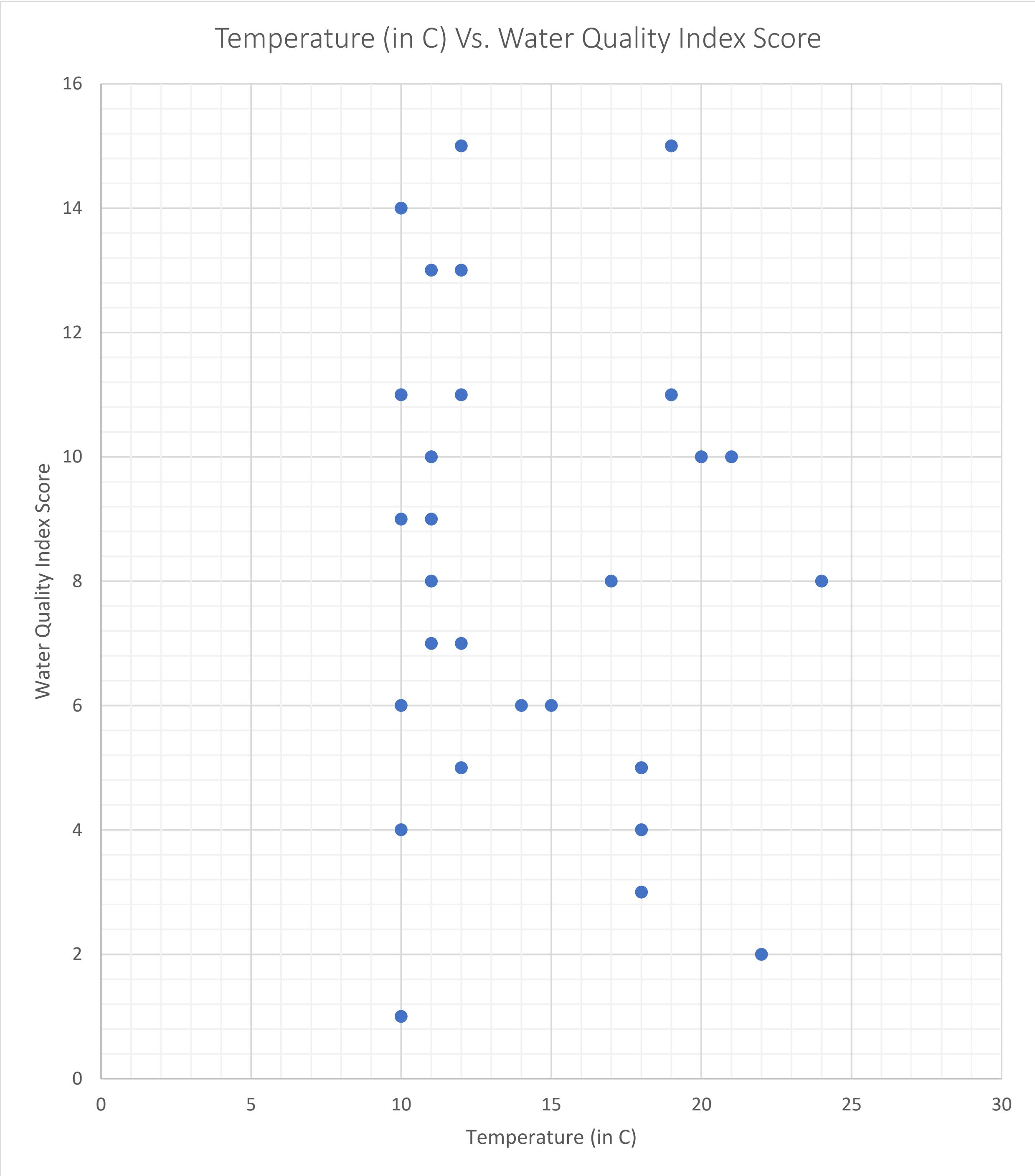

Figure 1. A scatter plot comparing water temperature and the streams' water quality index scores, which is a measure of stream health.

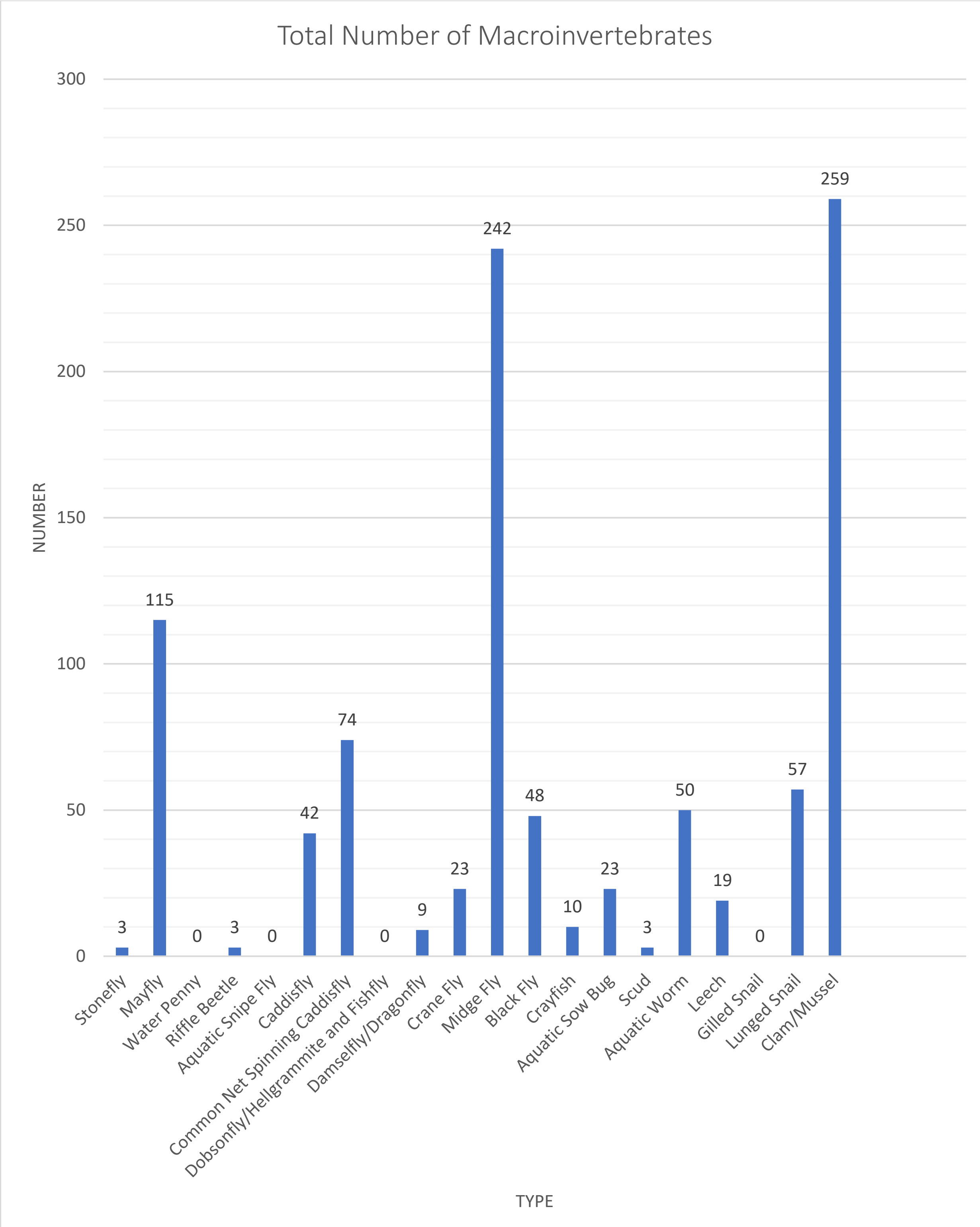

Figure 2. A bar graph showing the total number of macroinvertebrates found across all 30 streams surveyed.

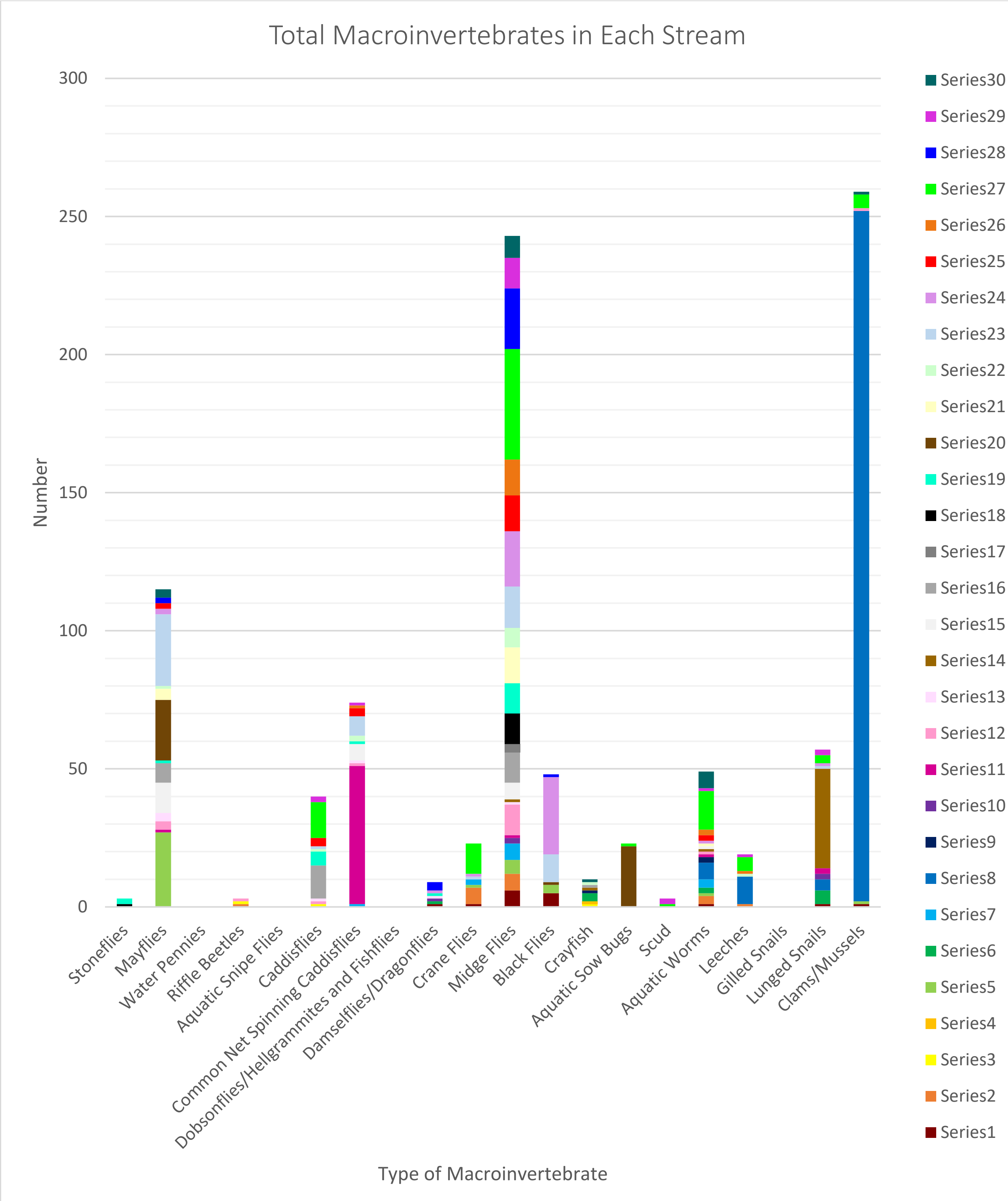

Figure 3. A bar graph showing where each type of macroinvertebrate was found. (Series means stream #)

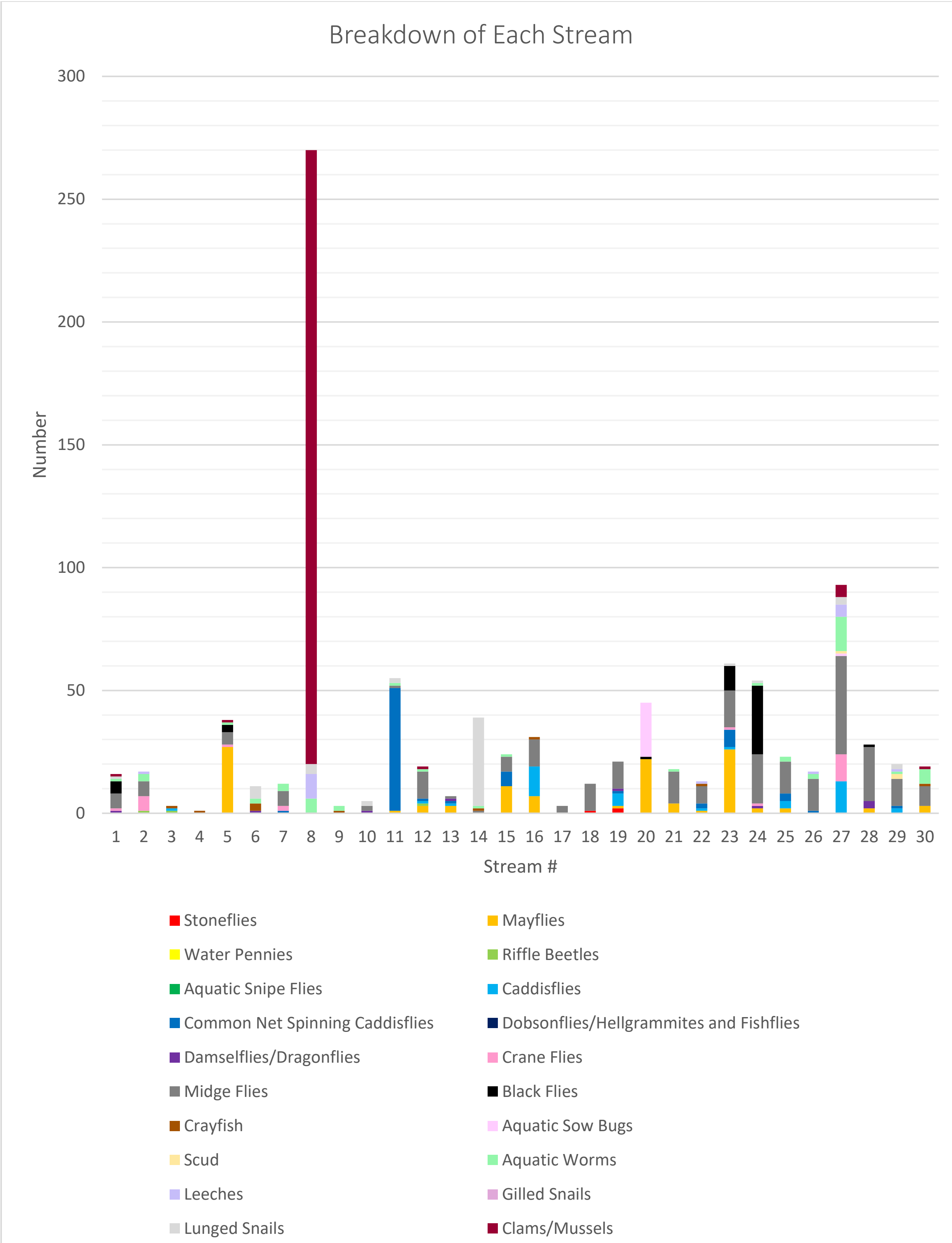

Figure 4. A bar graph showing the amount of macroinvertebrates at each stream.

Table 1

Stream Location and Macroinvertebrate Identification

Stream #	Stoneflies	Mayflies	Water Pennies	Riffle Beetles	Aquatic Snipe Flies	Caddisflies	Common Net Spinning Caddisflies	Dobsonflies/Hellgrammites and Fishflies	Damselflies/Dragonflies	Crane Flies	Midge Flies	Black Flies	Crayfish	Aquatic Sow Bugs	Scud	Aquatic Worms	Leeches	Gilled Snails	Lunged Snails	Clams/Mussels
1									1	1	6	5				1			1	1
2				1						6	6					3	1			
3				1		1							1							
4													1							
5		27								1	5	3				1				1
6									1				3			2			5	
7							1			2	6					3				
8																6	10		4	250
9													1			2				
10									1		2								2	
11		1					50				1					1			2	
12		3		1		1	1				11					1				1
13		3				1	1		1		1									
14											1		1			1			36	
15		11					6				6					1				
16		7				12					11		1							
17											3									
18	1										11									
19	2	1				5	1		1		11									
20		22										1		22						
21		4									13					1				
22		1				1	2				7		1				1			
23		26				1	7			1	15	10							1	
24		2							1	1	20	28				1			1	
25		2				3	3				13					2				
26							1				13					2	1			
27						13				11	40			1	1	14	5		3	5
28		2							3		22	1								
29						2	1				11				2	1	1		2	
30		3									8		1			6				1

Table 2

Each Stream Location's Water Temperature and Water Quality Index Score

Stream #	Water Temperature (Celsius)	Water Quality Index Score	Water Quality Rating
1	20	10	Poor
2	24	8	Poor
3	17	8	Poor
4	22	2	Poor
5	21	10	Poor
6	14	6	Poor
7	15	6	Poor
8	18	5	Poor
9	18	3	Poor
10	18	4	Poor
11	18	5	Poor
12	19	15	Fair
13	19	11	Fair
14	12	5	Poor
15	12	7	Poor
16	11	9	Poor
17	10	1	Poor
18	10	4	Poor
19	10	14	Fair
20	10	6	Poor
21	12	5	Poor
22	11	13	Fair
23	12	13	Fair
24	12	11	Fair
25	11	10	Poor
26	11	8	Poor
27	12	15	Fair
28	11	7	Poor
29	10	11	Fair
30	10	9	Poor

As seen in Table 2, the streams surveyed had water temperatures ranging from 10 – 24 degrees Celsius. The streams had water quality index scores ranging from 2 – 15. According to Georgia's Adopt-A-Stream guidelines, a water quality index of less than 11 is poor, a rating of 11 – 16 is fair, a rating of 17 – 22 is good, sand a rating of 22+ is excellent. Therefore, the majority of the streams surveyed (22 out of 30) had poor water quality.

Table 1 shows how the data was collected. The type and number of each macroinvertebrate was noted for each stream. This was later used to calculate the streams' water quality index scores. Figure 2 shows how many of each type of macroinvertebrate was observed. The macroinvertebrate that was observed the most was the mussel, however, if one looks at Figure 3, then one can see that almost all the mussels were found at one stream, so they weren't commonly spread out. Figure 3 is similar to Figure 2, but it also shows where each macroinvertebrate was found, so one can pick apart the data more, as in the mussel scenario above.

Figure 4 shows each stream, broken down by macroinvertebrate. This is helpful because it shows Table 1 in an easy to understand format.

Figure 1 is a scatter plot comparing temperature to stream health (via water quality index score). This is an important figure, since this experiment's hypothesis was: the steam locations with warmer water temperatures will have a smaller quantity of macroinvertebrates and less macroinvertebrates that indicate healthy stream conditions. This graph will show if there is a connection between water temperature and stream health, and will either support or not support the hypothesis.

Discussion

This experiment resulted in water temperature and stream health having little to no correlation. When graphed on a scatter plot with temperature on the x-axis and stream health on the y-axis, there was no good line of best fit. This means that there was no correlation between water temperature and stream health. Using macroinvertebrates as a measure of stream health, the healthier streams did not have colder water temperatures.

The scatter plot shows that there is no correlation between temperature and stream health. This study's hypothesis was not supported. Colder water temperatures did not seem to result in healthier streams. This is similar to what Stahley and Kodani found in their experiment, "Assessing small streams in the upper Ocmulgee watershed using the Georgia adopt-a-stream macroinvertebrate monitoring protocols" (Stahley, 2011). They stated, "Our data showed no clear relationship between average water quality score and average water temperature at each site" (Stahley, 2011). This study's results agree with theirs.

This experiment turned out like it did because of several factors. Since the streams were in a mix of environments (neighborhoods vs state parks vs gutter-like drainage streams), some streams may have been inherently healthier, regardless of water temperature. Therefore, the temperature may have made the drainage streams slightly healthier, but they could never be as healthy as the state park streams. Some errors include measuring the streams at different times of day and in different seasons, missing some macroinvertebrates when counting, and putting the thermometer in different places in each stream (in a riffle vs near a bank). Measuring the streams at different times of day and in different seasons could have affected the water temperature. Missing some macroinvertebrates could have affected the stream's water quality rating. Putting the thermometer in different places could have affected the water temperature as well.

If one were to repeat this experiment, it would be better if one measured the streams at the same times each day. Also, it would be better to measure the streams as close together as possible (time-wise), in order to do them all in the season. To further this study, one could take location into account and see if streams in forests are healthier than the streams in neighborhoods. After that study, one could compare only forest streams' water temperatures and health to see if water temperature really did make a difference in stream health.

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