A survey of the aquatic insects of Dominica

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Abstract

In this study, aquatic insects were collected using seven different techniques in eight different locations around the island of Dominica, West Indies. Both adult and larval forms of insects were collected and identified to order and family. Collecting methods, results and interpretations are presented in this paper.

Keywords: Dominica, West Indies, immature**,** naiad, aquatic

Introduction

Aquatic insects are extremely important in ecological systems for many reasons. Aquatic insects are the primary bio-indicators in bodies of water such as freshwater creeks, streams and rivers. Bio-monitoring pertains to the use of insects and/or their responses to stimuli in their aquatic habitat to determine the quality of that environment (Merritt 2008). The presence or absence of certain families of aquatic insects can indicate whether or not a particular body of water is healthy or polluted. Studying life cycles of aquatic insects and their relationships with other organisms and their own environment can give insight into many different areas of ecology, including population dynamics, competition and predator-prey interactions (Merritt 2008). Another interesting area pertaining to the use of aquatic insects resides in the fly angling community. Anglers are more enthusiastic now than ever before to learn about aquatic insects and how they can be imitated for fish food and cohabitate with their catches (Merritt 2008). More research has recently been applied to understanding and identifying the different biology and life-cycles of common pests, such as mosquitoes, black flies and horse flies. The larvae of these insects develop in the water, making locations with lotic, or stagnant, bodies of water primary targets for human pests to develop. Understanding the basic development and biology of these animals results in more efficient management strategies that can be implemented in order to reduce the pest population in areas of human residence. The goal of this particular study was to expand upon what was found during both the pool and riffle study from 2004 by Ali Duffel, Emily Donahoe, Justin Girdler, and Jeremy Rice and the aquatic insect survey from 2008 by Brendan Morris, Kristen Rodriguez and Stephen Powell (http://dominica.tamu.edu/). In both the Duffel and Morris studies, the only water source sampled was the Checkhall River, located on the ATREC field station. The sampling methods used were a seine, a malaise trap and hand collecting with an aquatic net. The Morris et al. study focused primarily on adult insects that emerged from the water and were caught around the water periphery. The primary goal of this study was to survey both larval and adult forms of aquatic insects in several different locations around Dominica. Samples were taken from the Checkhall River, Bee Pond, Middleham Falls, Cabrits National Park, Emerald Pool, Clark River, and Blenheim River. The various collecting methods implemented during this study included hand collecting with aquatic nets, pan traps and light collecting.

Materials and Methods

The study was conducted on the island of Dominica, West Indies, from May 22 to June 2, 2009. Much of the survey took place at the Archbold Tropical Research and Education Center (ATREC), Springfield (15°20'33.9"N 61°22'41.4"W). Several collecting methods were used including pan-traps, light sheets with black and mercury vapor lights, beat sheets, malaise traps, hand collecting/sifting in various bodies of water, aerial netting and sweeping.

In a period of four separate days, ranging from May 22 to May 27, 2009, specimens were collected at Bee House Pond (15°20'52"N 61°22'04"W) using both small fish nets and a large BioQuip® aquatic net. The large aquatic net was used to collect aquatic insects from a distance on the bank while small fish nets were used to collect specimens in the aquatic plant *Hydrilla verticillata* while in the water. A 15'' diameter BioQuip® aerial net was also used to collect flying insects around the pond. Specimens collected in the water were placed in vials of ethanol (C_2H_6O) and flying insects were placed inside Glassine envelopes and later placed in jars containing ammonium carbonate (NH_2COONH_4).

Another collection on May 23, 2009 occurred at Middleham Falls (15°34887'N 61°33896'W) using pan traps. The yellow, plastic pan traps were set along both sides of the river and each bowl was filled with a mixture of water and surfactant. The insects are attracted to the yellow color and the surfactant reduces the surface tension of the solution resulting in the insects drowning upon contact. The pan traps were left out for 2 ½ to 3 hours, and then filtered with a micro-mesh fish net. Collected specimens were placed in a vial of ethanol (C_2H_6O).

On May 24, 2009 the Checkhall River, located on the ATREC station (15°20.749'N 61°22.147'W), was sampled by hand with aquatic nets. Specimens were collected by placing the aquatic net at the base of a small riffle as well as on the other side of a narrow crevice into which the water flowed downstream. Rocks upstream were manually overturned and the gravel and sand were disturbed by continuous feet-shuffling. After approximately 1 to 2 minutes, the net was removed from the water where the contents and placed into a large white plastic tray. The contents were then sifted by hand and specimens were picked up using BioQuip® forceps and placed in a vial containing ethanol (C_2H_6O).

Collection of specimens through the use of pan traps on the Checkhall River (15°20.749'N 61°22.147'W) occurred from May 27 to May 28, 2009. The yellow pan-traps were placed downstream on each side of the river and on flat rocks that lay exposed in the middle of the river. The traps were filled almost completely with the water and surfactant mixture and left for twenty-four hours. The pan-traps were checked the next day and insects were filtered through the micro-mesh fish net and placed in a vial of ethanol (C_2H_6O).

Specimens were also collected on the night of May 28, 2009 by a Mercury Vapor light. Flying insects landing upon the light sheet were then collected by hand and placed in a vial of ethanol (C_2H_6O).

Another collection day occurred on May 30, 2009 at the Emerald Pool Stream in Morne Trois Pitons National Park, in the St. David Parish (15°23.739'N 61°18.624'W). The group was unable to establish an elevation. The aquatic net was used to catch disturbed material containing adult and larval forms of insects that were washed downstream. Specimens were collected by hand and placed into a vial of ethanol. It should be noted that a very small amount of insect fauna was collected here.

The fifth collection took place on June 1, 2009 at the Clark River in the St. David Parish (15°35173'N 61°31662W). The elevation was 914.4 m – 1066.8 m. The downstream debris method was implemented with the use of the large aquatic net and samples were then sifted in a white tray and specimens were placed in vials of ethanol (C_2H_6O). An abundance of unidentified larvae were collected here. The larvae are available for further analysis.

The final collection occurred on June 2, 2009 at Blenheim River, Parish of St. Andrew (15°35'31N 61°23'26W). The elevation was 6.4008 m. A small aquatic net was used to collect aquatic insects from the environment surrounding the plant *Hydrilla verticillata*. Specimens collected in the water were placed in vials of ethanol (C_2H_6O). Note that only a few specimens resulted from this collection site.

All collected specimens were identified, counted and placed into vials of ethanol (C_2H_6O). Labels included in the vials indicate the location and date of each collection. Identifications were made using Chu and Cutkomp (1992), Merritt, Cummins and Berg (2008) and Triplehorn and Johnson (2005). Voucher specimens of all material collected in this study have been deposited in the insect collection, Archbold Tropical Research and Education Centre, Springfield, Dominica.

Results

The following orders and families were collected in this survey:

- Ephemeroptera: Baetidae, Caenidae
- Lepidoptera: Crambidae, Pieridae
- Hemiptera: Gerridae, Veliidae, Naucoridae
- Odonata: Coenagrionidae, Libellulidae
- Coleoptera: Curculionidae, Elmidae, Staphylinidae
- Diptera: Simuliidae, Cecidomyiidae, Chironomidae, Calliphoridae, Sarcophagidae, Muscidae, Stratiomyidae
- Trichoptera: Hydropsychidae
- Hymenoptera: Pompilidae

The following is a key to the collection locations:

A	Bee Pond
B	Checkhall River (by Hand)
C	Middleham Falls

D	Cabrits National Forest
E	Emerald Pool
F	Clark River (Trail to Boeri Lake)
G	Checkhall River (Pan Trap)
H	Bleinheim River

Table 1

Dominica Aquatic Insect Survey

Collected May 21, 2009 through June 2, 2009

Taxonomic Classification		Method			Locations							
Order	Family	MV Light	Pan Trap	Hand Collect	A	B	C	D	E	F	G	H
Ephemeroptera	Baetidae (immature)			20	12				1			7
	Baetidae (adult)	42			42							
Lepidoptera	Crambidae (immature)			10	9	1						
	Pieridae (adult)		1								1	
Hemiptera	Gerridae (adult)			10	3	2			2			3
	Naucoridae (adult)			9	9							
	Veliidae (immature)			22	21					1		
	Veliidae (adult)		2	24			2		15			9
Odonata	Coenagrionidae (adult)			32	10	20	1		1			
	Coenagrionidae (immmature)			5	5							
	Libellulidae (adult)			19	9			3		7		
	Caenidae (immature)			1					1			
Coleoptera	Curculionidae			1	1							
	Elmidae			19		8			1	10		
	Staphylinidae			100+		100+						
Diptera	Simuliidae		4			4						
	Cecidiomyiidae		7				7					
	Chironomidae			1		1						
	Calliphoridae (adult)		4								4	
	Sarcophagidae (adult)		15								15	
	Muscidae (adult)		27								27	
	Stratiomyidae (adult)		14								14	
	Pompilidae (adult)		6								6	
	Tipulidae (adult)		4								4	
Trichoptera	Hydropsychidae			31		9			2	20		
UNKOWN	Unknown (larvae)		100+								100+	
TOTAL		42	84	204	121	45	10	3	23	38	71	19

Figure 1:

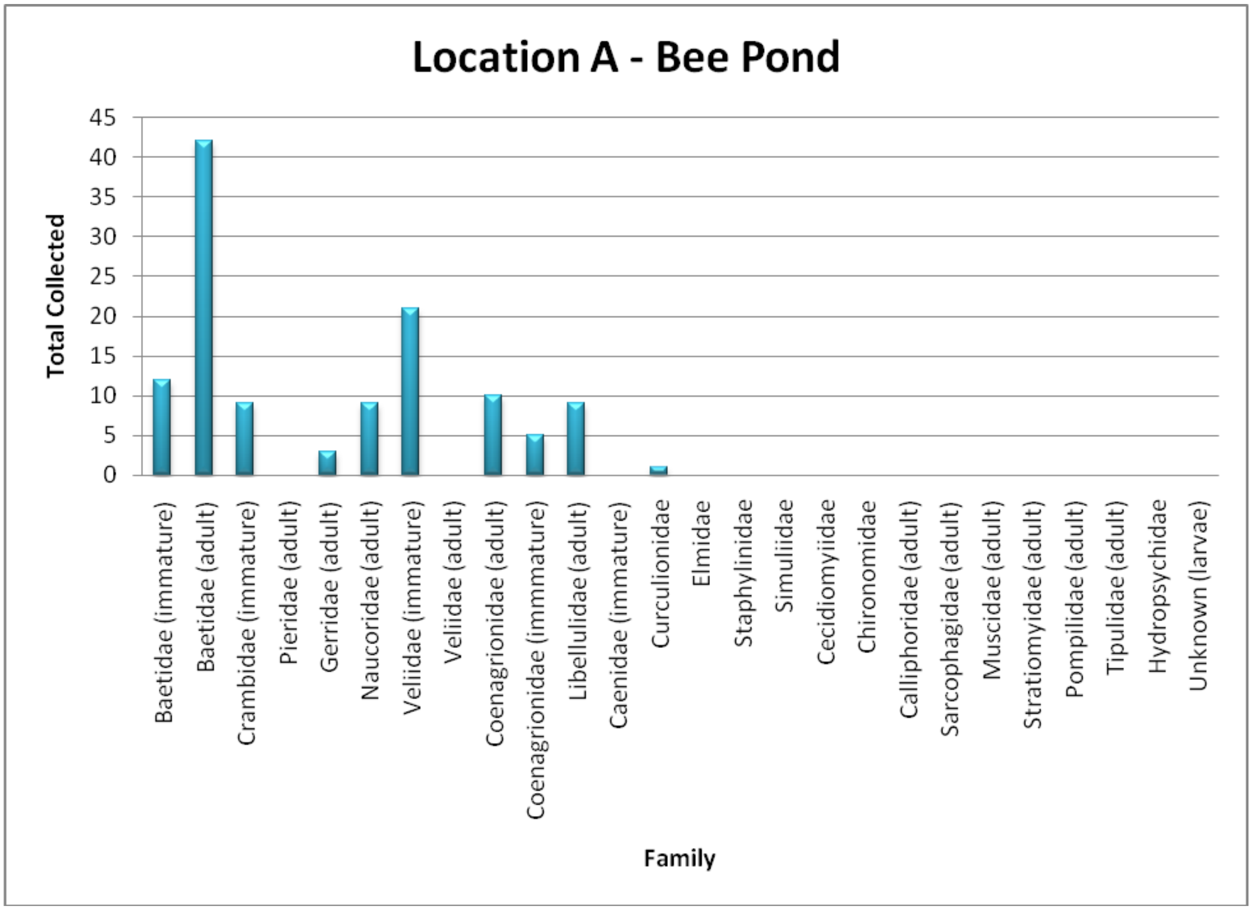


Figure 1 illustrates the total individuals collected in each family during the collection at the Bee Pond in the ATREC Springfield Station. Collection in Bee Pond was one of the most beneficial of all collections during this study in regards to numbers and species diversity found. As mentioned previously, several collection methods were used in Bee Pond. Table 1 shows that the majority of the specimens collected were adults belonging to the family Baetidae. The second biggest taxanomic classification collecte at Bee Pond were immature belonging to the family Veliidae. Bee Pond is a small pond with very little water movement. It is full of an aquatic weed called *Hydrilla verticillata.* There are several other plant species growing around the brim of the pond. Even though there are these other plants growing in the area, the *Hydrilla verticillata* domincates the plant flora.

Figure 2:

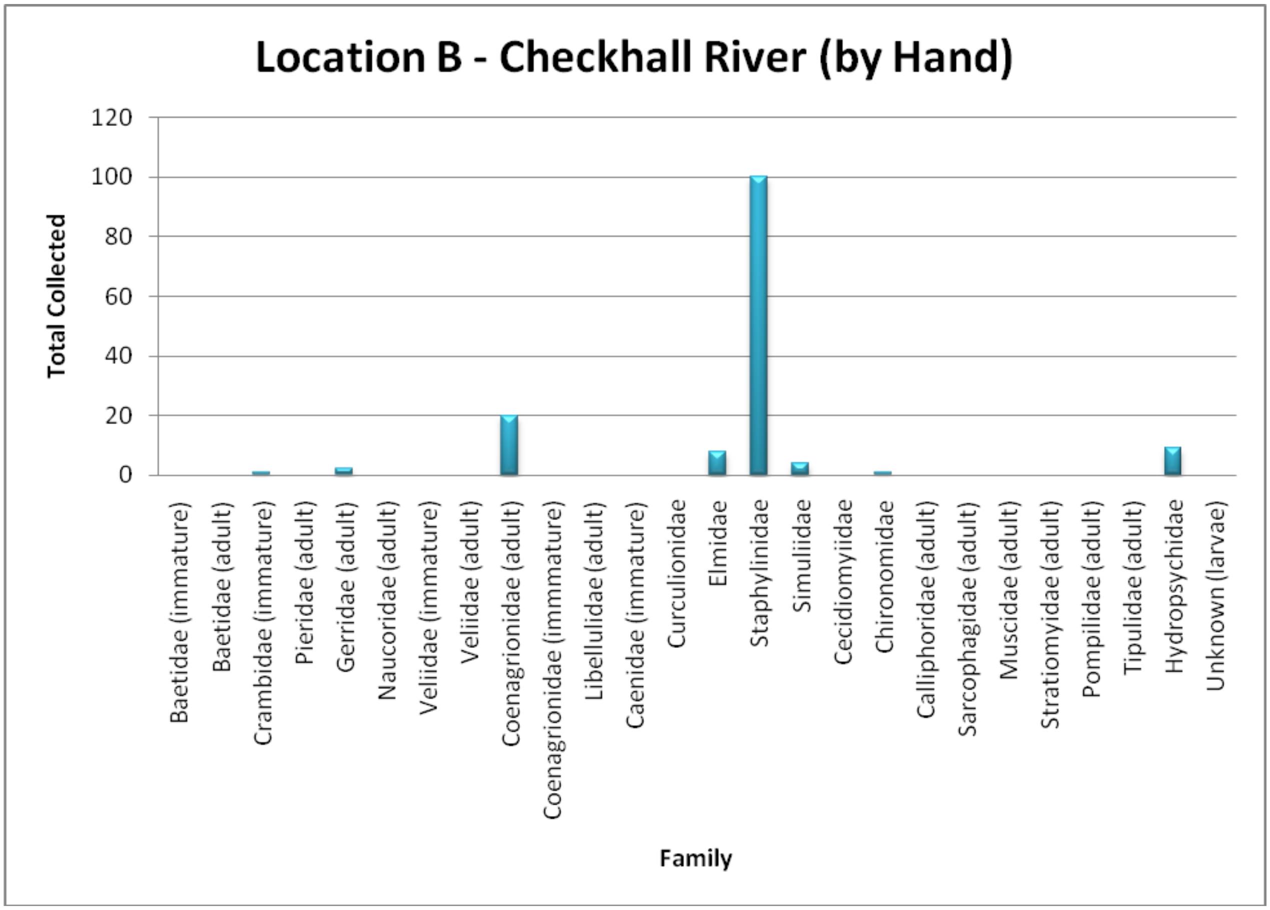


Figure 2 illustrates the total individuals collected in each family during the collection at the Checkhall River, by hand. The Checkhall River was productive in that it provided data in eight different families. The Checkhall River is a lotic flowing stream. It also has some lentic pools where water has pooled behind big rocks. The Gerridae specimens were found in these lentic pools. The group of Staphylinidae, the most abundant family found in this collection period, were found on a rock in the middle of the river. The section of the Checkhall River that was sampled is within the ATREC Springfield boundaries at appproximately 346 meters high in elevation.

Figure 3:

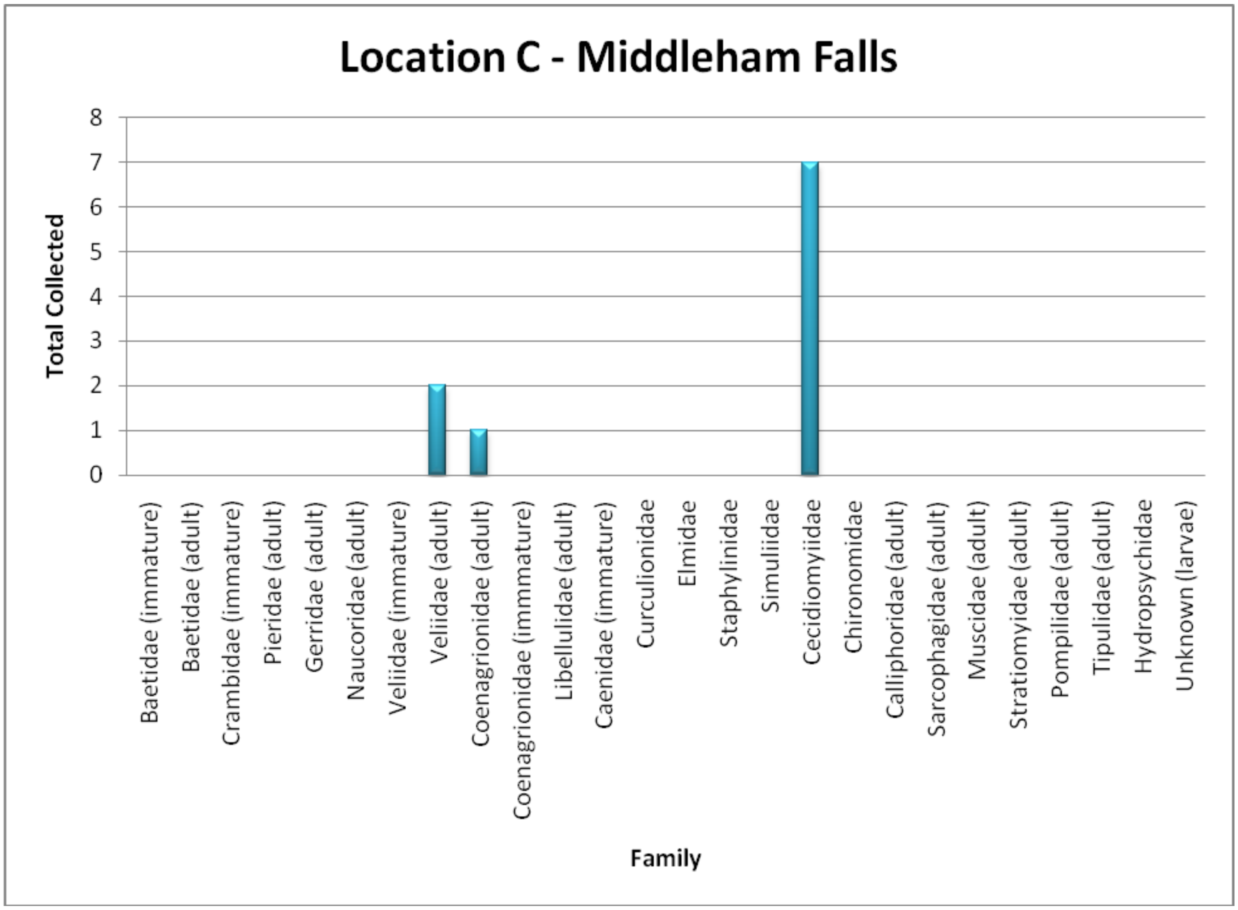


Figure 3 illustrates the total individuals collected in each family by the trail to Middleham Falls. The rivers sampled in Middleham Falls only produced data for three families. The highest number of specimens collected were Cecidiomyiidae. Middleham Falls is approximately 650 meters high in elevation. Middleham is montane rainforest. A combination of Middleham being montane rainforest and its relatively high elevation could explain why there was not much species diversity observed.

Figure 4:

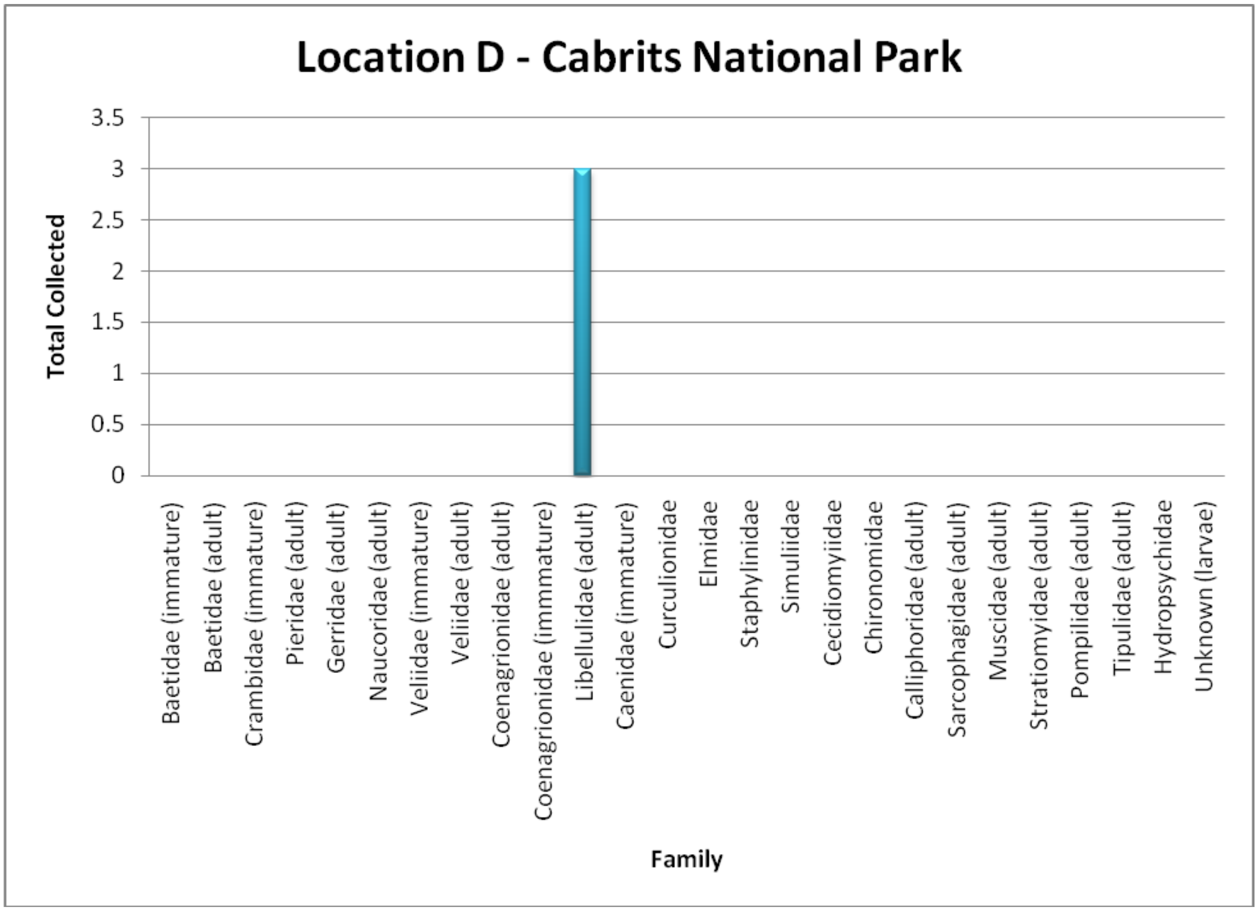


Figure 4 illustrates the total individuals collected in each family during the collection at the Cabrits National Forest. Cabrits National Park only produced three specimens of adult Libellulidae. They were caught by hand. Dominica did not have a dry season this year; as a result, Cabrits National Forest was uncharacteristically lush. It is difficult to analyze then what is a normal insect fauna for the forest. It may be that the lack of a dry season allowd the Libellulidae to survive.

Figure 5:

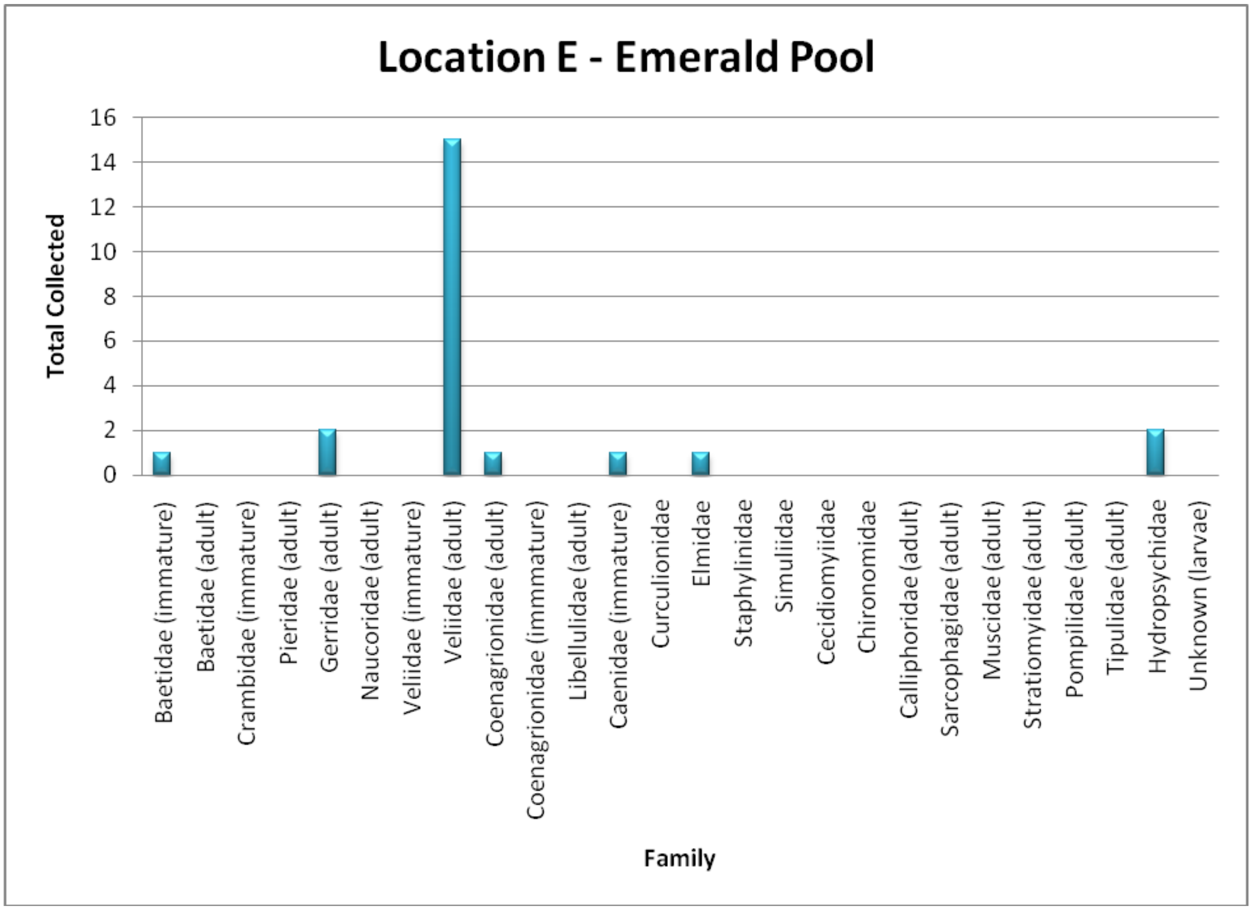


Figure 5 illustrates the total individuals collected in each family during the collection at the Emerald Pool. Although Emerald Pool did not produce extradorinarily high numbers of specimens, it did produce a wide range of aquatic insect diversity. There were an overwhelming number of the adults found were Veliidae. Other than that, collecting ranged from Baetidae, Gerridae, Coenatrionidae adults, Caenidae immatures, Elmidae, and Hydropsychidae. Emerald Pool is at a moderate elevation and is under a relatively dense canopy. The foliage from the canopy could account for the range in species diversity; as dead leaves and twigs drop into the water, the aquatic insects have more to feed and live on.

Figure 6:

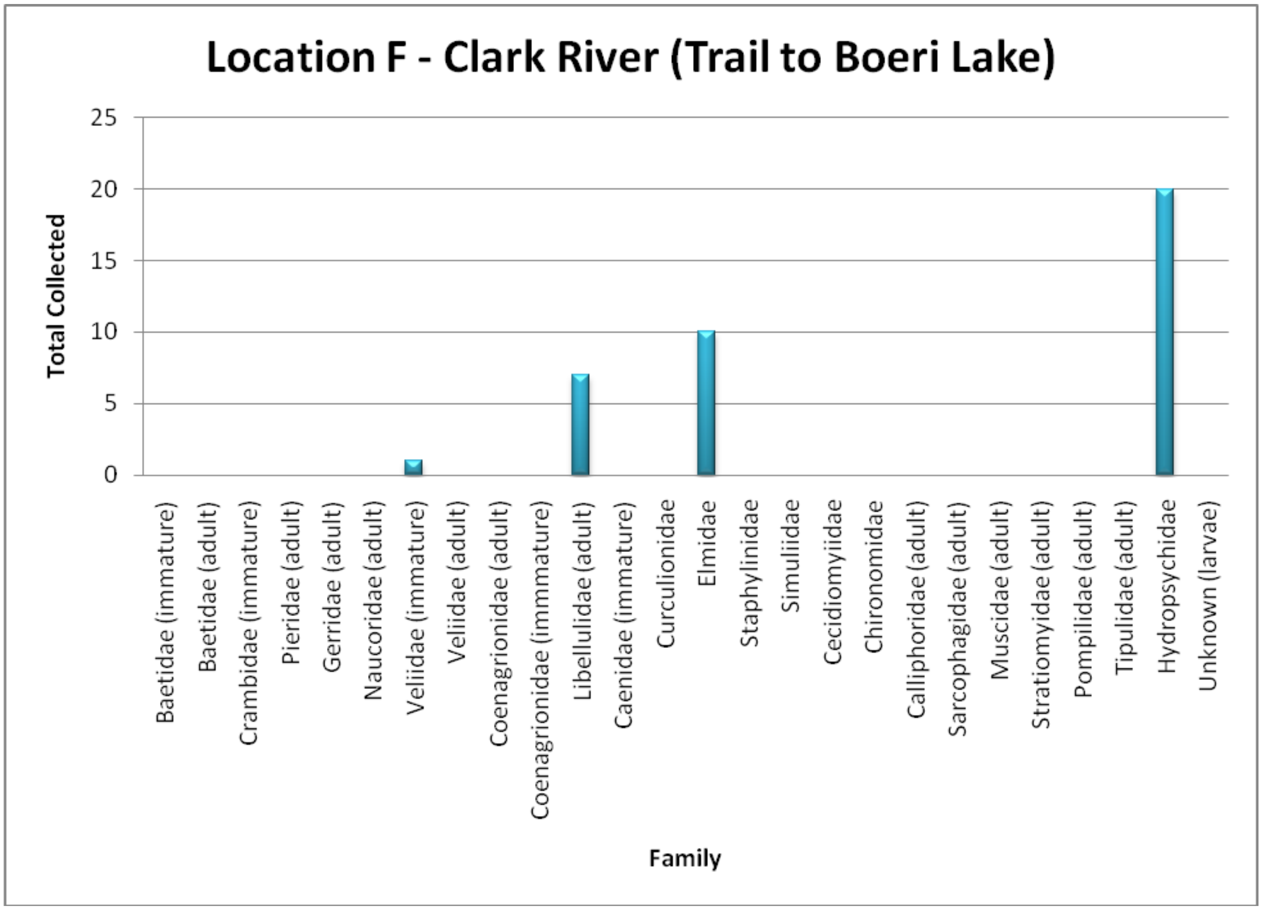


Figure 6 illustrates the total individuals collected in each family from the collection at the Clark River which is on the trail to Boeri Lake. The Clark River, on the trail to Boeri Lake, is 914.4 m – 1066.8 m in elevation. There were a great number of Hydropsychidae found in the river. Elmidae and Libellulidae adults as well as nymphs of Libellulidae. The Veliidae immatures were found in lentic pools along the sides of the river. This range in diversity and high number of specimens found could be related somewhat to the relatively low elevation. There was also a good amount of low foilage, as the Clark River runs through an Elfin Forest. Elfin forests are marked by high elevation and a unique range in plant fauna.

Figure 7:

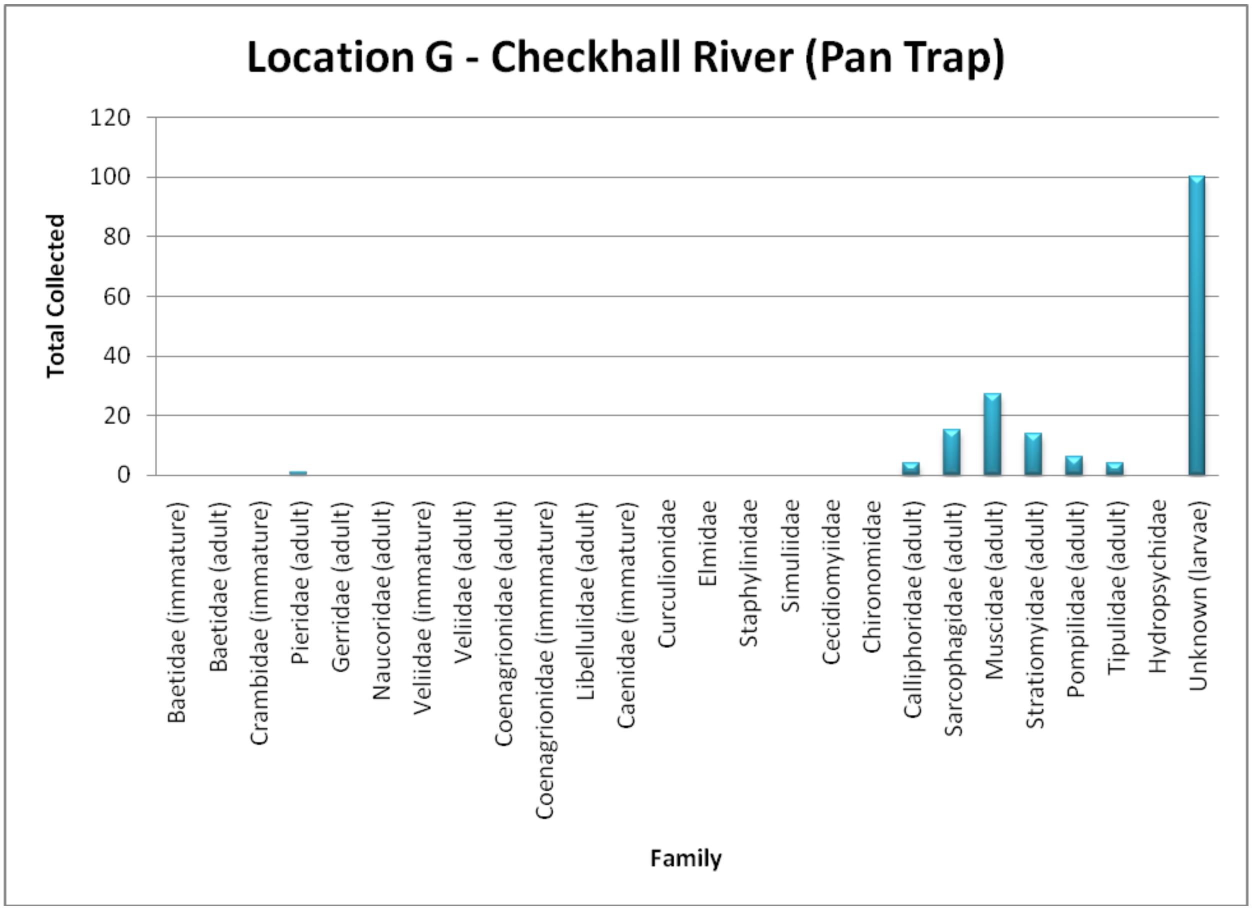


Figure 7 illustrates the comarrision of the total individuals collected in each family during the collection at the Checkhall River Pan Traps. The pan traps set up at the Checkhall River provided some interesting results. There were a number of adult flies, as seen above. Muscidae adults made up the majority of the specimens found. There were also over 100 very small unknown larvae found in the pan traps. These larvae are orange and, most likely, first instar. There is plenty of low foliage along the Checkhall River edges providing habitat for the different flies found.

Note: Calliphoridae, Sarcophagidae, Muscidae, Stratiomyidae, and Pompilidae are not aquatic insects. Their numbers were included to give a well rounded view of what was collected at the Checkhall River Pan Traps.

Figure 8:

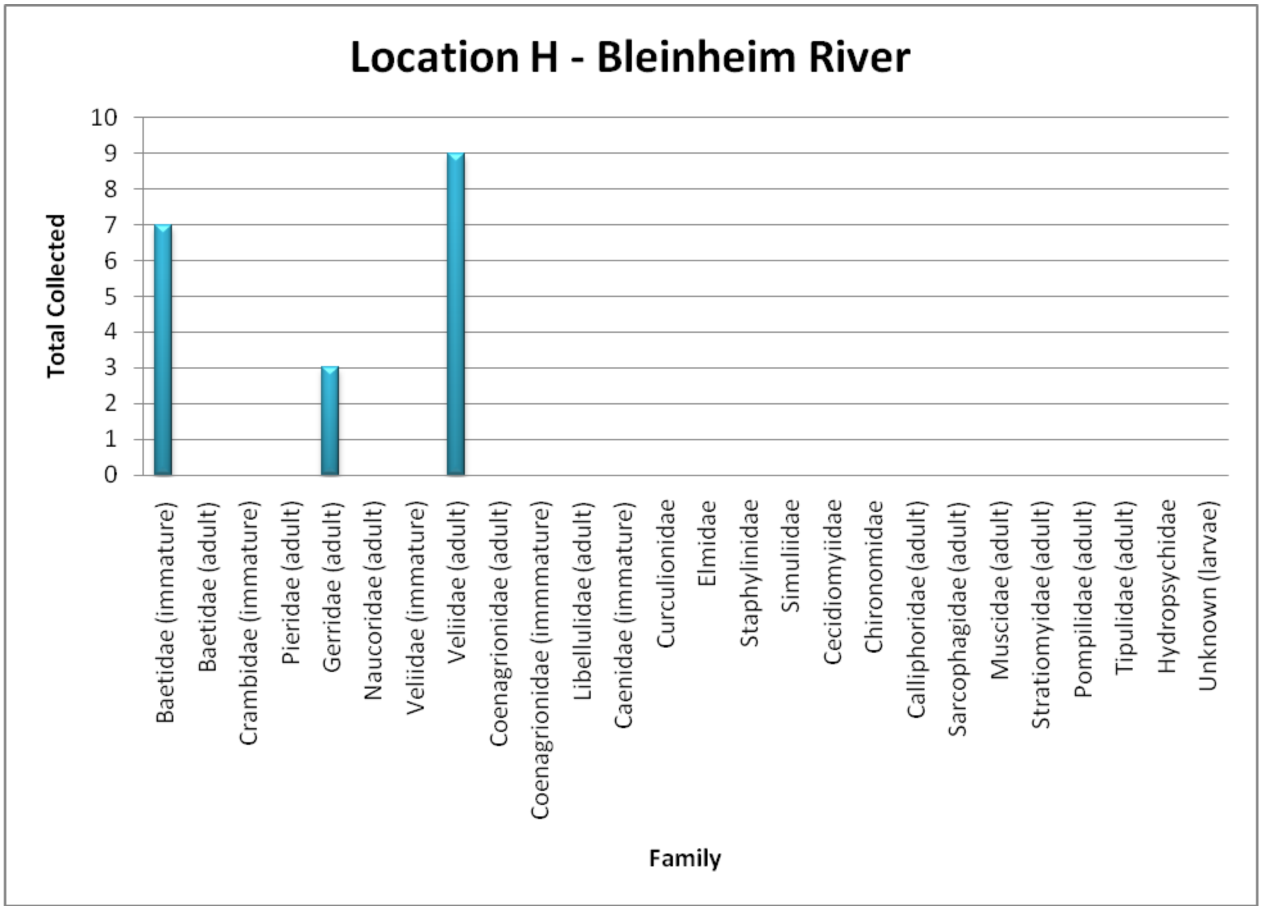
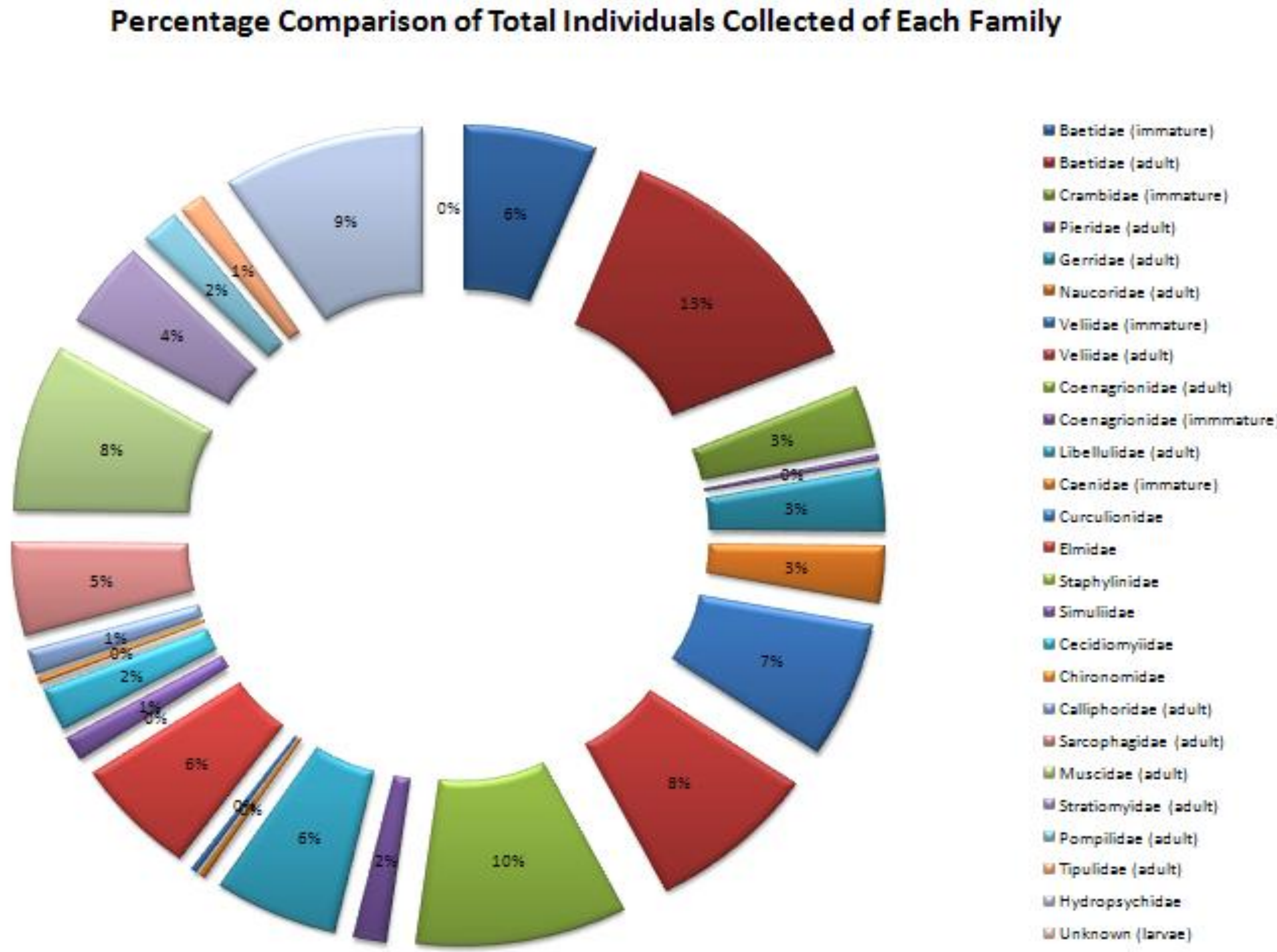


Figure 8 illustrates the total individuals collected in each family during the collection at the Bleinheim River. The Bleinheim River provided specimens of Baetidae, Gerridae, and Veliidae. The Baetidae were found in the *Hydrilla verticillata.* The Gerridae and the Veliidae specimens were found in lentic pool along the edges of the River. The day of collection in the Bleinheim River, a rainshower came through. This could possibly account for the lack of species diversity. The Bleinheim River is relatively shallow with plenty of sand and rocks for aquatic immature to cling to; as such, it was a surprise to find so few families.

Figure 9:



Percentage Comparison of Total Individuals Collected of Each Family
Baetidae (immature)
Baetidae (adult)
Crambidae (immature)
Pieridae (adult)
Gerridae (adult)
Naucoridae (adult)
Veliidae (immature)
Veliidae (adult)
Coenagrionidae (adult)
Coenagrionidae (immmature)
Libellulidae (adult)
Caenidae (immature)
Curculionidae
Elmidae
Staphylinidae
Simuliidae
Cecidiomyiidae
Chironomidae
Calliphoridae (adult)
Sarcophagidae (adult)
Muscidae (adult)
Stratiomyidae (adult)
Pompilidae (adult)
Tipulidae (adult)
Hydropsychidae
Unknown (larvae)
6%
15%
3%
0%
3%
3%
7%
8%
10%
2%
6%
0%
6%
1%
0%
2%
0%
1%
5%
8%
4%
2%
1%
9%
0%

Figure 9 shows the percentage comparison of the total individuals collected of each family throughout the duration of this experiment which helps to get a full grasp on the relative diversity. At 13% for adults and 6% for immature, Baetidae was the most abundant aquatic family found on Dominica. As seen in Table 1, all of these specimens were found at a Mercury Vapor light at the Bee Pond on the ATREC Springfield Station. The second highest population percentage sampled was adults of the family Coenagrionidae. All of these Coenagrionidae were collected by hand, Table 1. They were found at four of the locations: A, B, C, and E. Staphyllinidae larvae were collected in very high numbers at location B. They were all found in one clump. No others were found throughout the duration of the experiment. Average numbers of Veliidae(7% immatures and 8% adults), Muscidae (8% adults), Hydropsychidae (9%), Elmidae (6%), and Libellulidae (6% adults) were found on the island at varying locations by varying collection methods.

Table 2

Location Diversity Assessment

Taxonomic Classification		Bee Pond			
Order	Family	A	pi	logpi	pi(logpi)
Ephemeroptera	Baetidae (immature)	12	0.099173554	-1.003604124	-0.099530988
	Baetidae (adult)	42	0.347107438	-0.45953608	-0.159508391
Lepidoptera	Crambidae (immature)	9	0.074380165	-1.128542861	-0.083941205
	Pieridae (adult)		-	-	-
Hemiptera	Gerridae (adult)	3	0.024793388	-1.605664116	-0.039809854
	Naucoridae (adult)	9	0.074380165	-1.128542861	-0.083941205
	Veliidae (immature)	21	0.173553719	-0.760566076	-0.131999071
	Veliidae (adult)		-	-	-
Odonata	Coenagrionidae (adult)	10	0.082644628	-1.08278537	-0.089486394
	Coenagrionidae (immmature)	5	0.041322314	-1.383815366	-0.057182453
	Libellulidae (adult)	9	0.074380165	-1.128542861	-0.083941205
	Caenidae (immature)		-	-	-
Coleoptera	Curculionidae	1	0.008264463	-2.08278537	-0.017213102
	Elmidae		-	-	-
	Staphylinidae		-	-	-
Diptera	Simuliidae		-	-	-
	Cecidiomyiidae		-	-	-
	Chironomidae		-	-	-
	Calliphoridae (adult)		-	-	-
	Sarcophagidae (adult)		-	-	-
	Muscidae (adult)		-	-	-
	Stratiomyidae (adult)		-	-	-
	Pompilidae (adult)		-	-	-
	Tipulidae (adult)		-	-	-
Trichoptera	Hydropsychidae		-	-	-
UNKOWN	Unknown (larvae)		-	-	-
TOTAL		**121**			
Shannon Weiner Index					**0.846553867**
Evenness					**0.598282553**
Richness					**10**

Table 3

Location Diversity Assessment

Taxonomic Classification		Checkhall River (By Hand)			
Order	Family	B	pi	logpi	pi(logpi)
Ephemeroptera	Baetidae (immature)		-	-	-
	Baetidae (adult)		-	-	-
Lepidoptera	Crambidae (immature)	1	0.006896552	-2.161368002	-0.014905986
	Pieridae (adult)		-	-	-
Hemiptera	Gerridae (adult)	2	0.013793103	-1.860338007	-0.025659835
	Naucoridae (adult)		-	-	-
	Veliidae (immature)		-	-	-
	Veliidae (adult)		-	-	-
Odonata	Coenagrionidae (adult)	20	0.444444444	-0.352182518	-0.156525564
	Coenagrionidae (immmature)		-	-	-
	Libellulidae (adult)		-	-	-
	Caenidae (immature)		-	-	-
Coleoptera	Curculionidae		-	-	-
	Elmidae	8	0.055172414	-1.258278015	-0.069422235
	Staphylinidae	100	0.689655172	-0.161368002	-0.111288277
Diptera	Simuliidae	4	0.027586207	-1.559308011	-0.043015393
	Cecidiomyiidae		-	-	-
	Chironomidae	1	0.006896552	-2.161368002	-0.014905986
	Calliphoridae (adult)		-	-	-
	Sarcophagidae (adult)		-	-	-
	Muscidae (adult)		-	-	-
	Stratiomyidae (adult)		-	-	-
	Pompilidae (adult)		-	-	-
	Tipulidae (adult)		-	-	-
Trichoptera	Hydropsychidae	9	0.062068966	-1.207125493	-0.074925031
UNKOWN	Unknown (larvae)		-	-	-
TOTAL		**145**			
Shannon Weiner Index					**0.510648307**
Evenness					**0.360888993**
Richness					**8**

Table 4

Location Diversity Assessment

Taxonomic Classification		Middleham Falls			
Order	Family	C	pi	logpi	pi(logpi)
Ephemeroptera	Baetidae (immature)		-	-	-
	Baetidae (adult)		-	-	-
Lepidoptera	Crambidae (immature)		-	-	-
	Pieridae (adult)		-	-	-
Hemiptera	Gerridae (adult)		-	-	-
	Naucoridae (adult)		-	-	-
	Veliidae (immature)		-	-	-
	Veliidae (adult)	2	0.2	-0.698970004	-0.139794001
Odonata	Coenagrionidae (adult)	1	0.1	-1	-0.1
	Coenagrionidae (immmature)		-	-	-
	Libellulidae (adult)		-	-	-
	Caenidae (immature)		-	-	-
Coleoptera	Curculionidae		-	-	-
	Elmidae		-	-	-
	Staphylinidae		-	-	-
Diptera	Simuliidae		-	-	-
	Cecidiomyiidae	7	0.7	-0.15490196	-0.108431372
	Chironomidae		-	-	-
	Calliphoridae (adult)		-	-	-
	Sarcophagidae (adult)		-	-	-
	Muscidae (adult)		-	-	-
	Stratiomyidae (adult)		-	-	-
	Pompilidae (adult)		-	-	-
	Tipulidae (adult)		-	-	-
Trichoptera	Hydropsychidae		-	-	-
UNKOWN	Unknown (larvae)		-	-	-
TOTAL		**10**			
Shannon Weiner Index					**0.348225373**
Evenness					**0.246100305**
Richness					**3**

Table 5

Location Diversity Assessment

Taxonomic Classification		Cabrits National Forest			
Order	Family	D	pi	logpi	pi(logpi)
Ephemeroptera	Baetidae (immature)		-	-	-
	Baetidae (adult)		-	-	-
Lepidoptera	Crambidae (immature)		-	-	-
	Pieridae (adult)		-	-	-
Hemiptera	Gerridae (adult)		-	-	-
	Naucoridae (adult)		-	-	-
	Veliidae (immature)		-	-	-
	Veliidae (adult)		-	-	-
Odonata	Coenagrionidae (adult)		-	-	-
	Coenagrionidae (immmature)		-	-	-
	Libellulidae (adult)	3	1	0	0
	Caenidae (immature)		-	-	-
Coleoptera	Curculionidae		-	-	-
	Elmidae		-	-	-
	Staphylinidae		-	-	-
Diptera	Simuliidae		-	-	-
	Cecidiomyiidae		-	-	-
	Chironomidae		-	-	-
	Calliphoridae (adult)		-	-	-
	Sarcophagidae (adult)		-	-	-
	Muscidae (adult)		-	-	-
	Stratiomyidae (adult)		-	-	-
	Pompilidae (adult)		-	-	-
	Tipulidae (adult)		-	-	-
Trichoptera	Hydropsychidae		-	-	-
UNKOWN	Unknown (larvae)		-	-	-
TOTAL		**3**			
Shannon Weiner Index					**0**
Evenness					**0**
Richness					**1**

Table 6

Location Diversity Assessment

Taxonomic Classification		Emerald Pool			
Order	Family	E	pi	logpi	pi(logpi)
Ephemeroptera	Baetidae (immature)	1	0.043478261	-1.361727836	-0.059205558
	Baetidae (adult)		-	-	-
Lepidoptera	Crambidae (immature)		-	-	-
	Pieridae (adult)		-	-	-
Hemiptera	Gerridae (adult)	2	0.086956522	-1.06069784	-0.092234595
	Naucoridae (adult)		-	-	-
	Veliidae (immature)		-	-	-
	Veliidae (adult)	15	0.652173913	-0.185636577	-0.121067333
Odonata	Coenagrionidae (adult)	1	0.043478261	-1.361727836	-0.059205558
	Coenagrionidae (immmature)		-	-	-
	Libellulidae (adult)		-	-	-
	Caenidae (immature)	1	0.043478261	-1.361727836	-0.059205558
Coleoptera	Curculionidae		-	-	-
	Elmidae	1	0.043478261	-1.361727836	-0.059205558
	Staphylinidae		-	-	-
Diptera	Simuliidae		-	-	-
	Cecidiomyiidae		-	-	-
	Chironomidae		-	-	-
	Calliphoridae (adult)		-	-	-
	Sarcophagidae (adult)		-	-	-
	Muscidae (adult)		-	-	-
	Stratiomyidae (adult)		-	-	-
	Pompilidae (adult)		-	-	-
	Tipulidae (adult)		-	-	-
Trichoptera	Hydropsychidae	2	0.086956522	-1.06069784	-0.092234595
UNKOWN	Unknown (larvae)		-	-	-
TOTAL		**23**			
Shannon Weiner Index					**0.542358755**
Evenness					**0.383299626**
Richness					**7**

Table 7

Location Diversity Assessment

Taxonomic Classification		Clark River (Trail to Boeri Lake)			
Order	Family	F	pi	logpi	pi(logpi)
Ephemeroptera	Baetidae (immature)		-	-	-
	Baetidae (adult)		-	-	-
Lepidoptera	Crambidae (immature)		-	-	-
	Pieridae (adult)		-	-	-
Hemiptera	Gerridae (adult)		-	-	-
	Naucoridae (adult)		-	-	-
	Veliidae (immature)	1	0.026315789	-1.579783597	-0.041573253
	Veliidae (adult)		-	-	-
Odonata	Coenagrionidae (adult)		-	-	-
	Coenagrionidae (immmature)		-	-	-
	Libellulidae (adult)	7	0.184210526	-0.734685557	-0.135336813
	Caenidae (immature)		-	-	-
Coleoptera	Curculionidae		-	-	-
	Elmidae	10	0.263157895	-0.579783597	-0.152574631
	Staphylinidae		-	-	-
Diptera	Simuliidae		-	-	-
	Cecidiomyiidae		-	-	-
	Chironomidae		-	-	-
	Calliphoridae (adult)		-	-	-
	Sarcophagidae (adult)		-	-	-
	Muscidae (adult)		-	-	-
	Stratiomyidae (adult)		-	-	-
	Pompilidae (adult)		-	-	-
	Tipulidae (adult)		-	-	-
Trichoptera	Hydropsychidae	20	0.526315789	-0.278753601	-0.146712422
UNKOWN	Unknown (larvae)		-	-	-
TOTAL		**38**			
Shannon Weiner Index					**0.476197118**
Evenness					**0.336541404**
Richness					**4**

Table 8

Location Diversity Assessment

Taxonomic Classification		Checkhall River (Pan Trap)			
Order	Family	G	pi	logpi	pi(logpi)
Ephemeroptera	Baetidae (immature)		-	-	-
	Baetidae (adult)		-	-	-
Lepidoptera	Crambidae (immature)		-	-	-
	Pieridae (adult)	1	0.005847953	-2.23299611	-0.013058457
Hemiptera	Gerridae (adult)		-	-	-
	Naucoridae (adult)		-	-	-
	Veliidae (immature)		-	-	-
	Veliidae (adult)		-	-	-
Odonata	Coenagrionidae (adult)		-	-	-
	Coenagrionidae (immmature)		-	-	-
	Libellulidae (adult)		-	-	-
	Caenidae (immature)		-	-	-
Coleoptera	Curculionidae		-	-	-
	Elmidae		-	-	-
	Staphylinidae		-	-	-
Diptera	Simuliidae		-	-	-
	Cecidiomyiidae		-	-	-
	Chironomidae		-	-	-
	Calliphoridae (adult)	4	0.056338028	-1.249198357	-0.070377372
	Sarcophagidae (adult)	15	0.211267606	-0.67516709	-0.142640934
	Muscidae (adult)	27	0.38028169	-0.419894585	-0.159678222
	Stratiomyidae (adult)	14	0.197183099	-0.705130313	-0.13903978
	Pompilidae (adult)	6	0.084507042	-1.073107098	-0.090685107
	Tipulidae (adult)	4	0.056338028	-1.249198357	-0.070377372
Trichoptera	Hydropsychidae		-	-	-
UNKOWN	Unknown (larvae)	100	1.408450704	0.148741651	0.209495283
TOTAL		**171**			
Shannon Weiner Index					**0.476361961**
Evenness					**0.336657904**
Richness					**8**

Note: Calliphoridae, Sarcophagidae, Muscidae, Stratiomyidae, and Pompilidae are included in the analysis of Shannon Weiner, Evenness, and Richness even though they are not aquatic insects.

Table 9

Location Diversity Assessment

Taxonomic Classification		Bleinheim River			
Order	Family	H	pi	logpi	pi(logpi)
Ephemeroptera	Baetidae (immature)	7	0.368421053	-0.433655561	-0.159767838
	Baetidae (adult)		-	-	-
Lepidoptera	Crambidae (immature)		-	-	-
	Pieridae (adult)		-	-	-
Hemiptera	Gerridae (adult)	3	0.157894737	-0.801632346	-0.126573528
	Naucoridae (adult)		-	-	-
	Veliidae (immature)		-	-	-
	Veliidae (adult)	9	0.473684211	-0.324511092	-0.15371578
Odonata	Coenagrionidae (adult)		-	-	-
	Coenagrionidae (immmature)		-	-	-
	Libellulidae (adult)		-	-	-
	Caenidae (immature)		-	-	-
Coleoptera	Curculionidae		-	-	-
	Elmidae		-	-	-
	Staphylinidae		-	-	-
Diptera	Simuliidae		-	-	-
	Cecidiomyiidae		-	-	-
	Chironomidae		-	-	-
	Calliphoridae (adult)		-	-	-
	Sarcophagidae (adult)		-	-	-
	Muscidae (adult)		-	-	-
	Stratiomyidae (adult)		-	-	-
	Pompilidae (adult)		-	-	-
	Tipulidae (adult)		-	-	-
Trichoptera	Hydropsychidae		-	-	-
UNKOWN	Unknown (larvae)		-	-	-
TOTAL		**19**			
Shannon Weiner Index					**0.440057147**
Evenness					**0.311000308**
Richness					**3**

Discussion

Both nymphs and adults of the order Ephemeroptera are recognized by two or three long caudal filaments. Membranous wings are found on adults and lateral lanceolate or plumose abdominal gills are found on the naiads, or aquatic nymphs (Triplehorn 2005).

Small minnow mayflies, Baetidae, have only two caudal filaments in both adults and larvae. Adults also have a reduced or absent hindwing (Triplehorn 2005).

Small square-gill mayflies, Caenidae, are characterized by three caudal filaments in adults and larvae with adults also lacking a hindwing (Triplehorn 2005).

Adults of the order Lepidoptera can be easily recognized by large fore and hind wings bearing scales, sucking mouth parts formed by the maxillary palps into a long proboscis, and large compound eyes (Triplehorn 2005).

Grass moths, Crambidae, can be recognized by the praecinctorium present in the larval stage and a tympanum that is open mesally in adults (Triplehorn 2005).

Figure 10: Crambid

True bugs in the order Hemiptera can be recognized by piercing-sucking mouthparts, which consist of four piercing stylets enclosed in a protective, segmented sheath. The forewings of this order are composed of a thickened basal portion, a membranous apical portion, and completely membranous hind wings (Triplehorn 2005).

Water striders, Gerridae, are characterized by short front legs and long mid- and hind legs in which the mid legs arise closer to the hind legs than the front legs. The tarsi are covered in fine hydrophobic setae that allow the insect to "skate" across the water (Triplehorn 2005).

Figure 11: Gerridae

Broad-shouldered water bugs or riffle bugs, Veliidae, are wingless and have mid legs that are closer to the hind legs than front legs, a less prominent showing than in Gerridae. The hind femora extends slightly above the apex of the abdomen.

Figure 12: Veliidae

Creeping water bugs, Naucoridae, are flattened and oval with greatly thickened front femora (Triplehorn 2005).

Figure 13: Naucoridae

Members of the order Odonata are easily recognized by their large compound eyes, small bristle-like antennae, large chewing mouthparts, and two pairs of elongate membranous wings (Triplehorn 2005). Odonates also have "basket" legs in which all 3 pair of legs for a basket-like shape for aerial predation.

Skimmers, Libellulidae, can be identified by a prominent anal loop on the hind wing. Many usually have spots of various colors on the wing (Triplehorn 2005).

Figure 14: Libellulidae Adult

Pond damsels, Coenagrionidae, are recognized by long, close set spurs on the tibia and varying wing colors (Triplehorn 2005).

Figure 15: Coenagrionidae Adult

The order Coleoptera can be readily distinguished between other insect orders by the fact that the forewings are sclerotized and meet in a straight line down the dorsum of the insect. This elytra acts to protect the membranous hind wings and body. The mouthparts are chewing and the mandibles are well developed (Triplehorn 2005

Snout-nosed beetles or true weevils, Curculionidae, can be easily identified by elongate mouthparts that form a well developed snout (Triplehorn 2005).

Figure 16: Curculionidae

Riffle beetles, Elmidae, are found in stream riffles. Both larvae and adults are aquatic and only one species *Hexanchorus caraibus* is found on the island of Dominica. These beetles have a cuticle that is black to reddish black with a ventral surface full of golden yellow, hair-like setae. (Spangler 1992)

Rove beetles, Staphylinidae, are recognized by their shortened elytra and exposed membranous hind wings (Triplehorn 2005).

The order Diptera can be distinguished by having only one pair of wings and a pair of gyroscopic halteres in the place of hind wings (Triplehorn 2005).

Figure 17: Staphylinidae

Black flies, Simuliidae, have a humpbacked appearance with biting mouthparts. Larvae have a disc-like sucker on the ventral portion of their body and are somewhat club shaped (Triplehorn 2005).

Gall midges, Cecidomyiidae, are miniscule flies with long legs and antennae. Wing venation is reduced in adults. Larvae have a poorly developed head and very small mouthparts. The body of larvae are often brightly colored (Triplehorn 2005).

Midges, Chironomidae, can be distinguished from mosquitoes by an absence of scale on the wings and lack of a proboscis. The front legs are generally longer than the other legs. The metanotum has a unique keel (Triplehorn 2005). Larvae are generally of uniform thickness and usually show distinguishable prolegs near thoracic region. Respiration apparatuses are usually a simple tube to a pair of branched filaments (Chu 1992).

Figure 18: Chironomidae larva

Blow flies, Calliphoridae, are medium sized flies that generally have metallic blue, green or bronze bodies and two to three notopleural bristles (Triplehorn 2005).

Flesh flies, Sarcophagidae, are large black flies, similar to Calliphorids, that generally have prominent gray thoracic stripes and are never metallic (Triplehorn 2005).

House or face flies, Muscidae, can be distinguished by having a short anal vein (Cu_2+2A) that does not meet the wing margin and an apically narrowed R_5 cell (Triplehorn 2005).

Soldier flies, Stratiomyidae, are large, sometimes brightly colored flies that can be identified by heavy branches of the R wing vein being crowded in the anterior portion of the wing and a small discal cell. Some larvae are aquatic and feed on algae, decaying matter or small insects (Triplehorn 2005).

Members of the order Trichoptera are small insects that possess four membranous wings which may bear setae that are held roof-like over the abdomen. The antennae can be very long and are always slender. Larvae are eruciform with a well developed head and legs. Larvae also possess hook-like appendages and filamentous gills at the end of the abdomen. All larvae are aquatic.

Net-spinning caddisflies, Hydropsychidae, can be recognized by a 5-segmented maxillary palp, no ocelli and a lack of warts on the mesoscutum (Triplehorn 2005). Larvae posses a tuft of long hairs at the base of the anal claw (Chu 1992).

Figure 19: Hydropsychidae larva

The order Hymenoptera can be identified by the winged members possessing four membranous wings attached to each other by tiny rows of hooks called hamuli. The wing venation is relatively reduced, mouthparts are either mandibulate or modified into a tonguelike structure, and the ovipositor is usually well developed (Triplehorn 2005).

Spider wasps, Pompilidae, are slender with very long, spiny legs, a quadrate pronotum and a transverse mesopleural sulcus (Triplehorn 2005). Pompillidae are not aquatic

Dobson flies, Corydalidae, range in size from 40-75 mm. Many species are black, brown or gray bodied with smoky wings. The head has three ocelli and males generally have a set of very long mandibles while females have smaller, functional mandibles. (Merritt 2008) This particular specimen was collected away from a water source and was not included in the evaluation of biodiversity.

Figure 20: Corydalidae

Biodiversity can be analyzed in two different ways: richness and evenness. Richness is defined as the total number of families found. Evenness represents the relative distribution of individuals found within each family. The Shannon Weiner Index is one method for analyzing family richness and evenness. The Shannon Weiner Index takes the negative sum of the proportion of the total sample and multiplies by the log of the proportion of the total sample. The Simpsons Index is a theoretical way to calculate evenness. The Simpsons Index takes diversity and divides it by the log of the number of species in the sample. Richness is calculated by simply adding the number of families found.

It was observed that the eight different locations had exactly the same ranking in their Shannon Weiner Index value and Evenness (Simpson Index). This observation suggests that evenness is more important in calculating Shannon Weiner than richness. Of the eight locations surveyed, Location A (Bee Pond) had the highest Shannon Weiner Index value at 0.846553. Location E (Emerald Pool) had the second highest Shannon Weiner Index value of 0.521358. Location A ranked first for evenness (Simpson Index) and richness as well. Note also that though not exactly equal, the rankings in richness were within the same range as the Shannon Weiner Index and the Simpson Index rankings.

After analysis of these calculated samples from the eight locations, it is determined that Bee Pond (Location A) is the most valuable habitat for aquatic insects of the sites we sampled on the island of Dominica, West Indies. Bee Pond is the most valuable because it has the most concentrated evenness of equal family numbers. This was deduced by comparing Bee Pond's rank in the Shannon Weiner Index, Simpson Index, and richness between the eight sampled locations.

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