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Invertebrate Community Structure in a Freshwater Pond on Mayreau Island, St. Vincent and the Grenadines, West Indies

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ABSTRACT
A survey of macroinvertebrates inhabiting Canash Pond on the small island of Mayreau in the Grenadines was conducted between 2007 and 2009. Forty-four freshwater invertebrate taxa were collected from this small natural pond and three other species were found in a nearby temporary pool. Odonates, hemipterans, coleopterans, and dipterans were the most abundant groups present. All taxa are being reported from Mayreau and this group of small Grenadine Islands for the first time.

Key words: Freshwater invertebrates, Grenadines, Lesser Antilles, Caribbean island, Mayreau, pond.

INTRODUCTION

The Grenadines Archipelago is located at the southern end of the Lesser Antilles in the southeastern Caribbean Sea. These Grenadine Islands are the emergent residual portions of an elongated ridge that is part of a 4,000 km^2 now submerged former landmass currently referred to as the Grenadines Bank. The island of Mayreau and some of the other Grenadine Islands first emerged from the Caribbean Sea during the middle to late Eocene Era – sometime before 48 mya (Westercamp 1985). The Grenadines are generally low-lying and very dry islands with an average annual rainfall that rarely exceeds 100 cm per year. These small islands have many saline and brackish water ponds, but natural freshwater ponds are very few in number. Canash Pond is a freshwater pond located on the island of Mayreau. Mayreau is an extremely small island situated about midway along this Grenadine chain of islands, has a surface area of approximately 1.76 km^2, and rises 99 m above sea level. Canash Pond is a small circular body of water covering about 700 m^2 with an estimated maximum depth of about two metres. This pond is located at the base of a small valley in the north of the island and receives enough run-off during the rainy season to sustain the presence of water throughout the year, even during periods of prolonged drought. Much of this pond is surrounded and shaded with thick vegetation and the few emergent and submerged aquatic plants include a robust sedge (*Cyperus alopecuroides*), floating duckweed (*Lemna perpusilla*), and algae. Canash Pond has been reduced to mud only once within living memory, and on that occasion even at a distance of 150 metres from the sea, large freshwater eels (*Anguilla rostrata*) over 60 cm in length that are known to spawn in seawater, were collected. There is also a nearby temporary freshwater pool that exists for a few months during the rainy season.

Biodiversity surveys of aquatic macroinvertebrates and related ecological studies have been conducted on several Caribbean Islands including Grenada (Flint and Sykora 1993, Baumgardner *et al*. 2003, Bass 2004b), St. Vincent (Harrison and Rankin 1975, 1976), Barbados (Bass 2003a), Tobago (Hart 1980, Nieser and Alkins-Koo 1991, Botosaneanu and Alkins-Koo 1993, Flint 1996, Baumgardner *et al*. 2003, Bass 2003b), Trinidad (Hynes 1971, Alkins *et al*. 1981, Alkins-Koo 1990, Nieser and Alkins-Koo 1991, Botosaneanu and Alkins-Koo 1993, Flint 1996, Turner *et al*. 2008), St. Lucia (McKillop and Harrison 1980), Dominica (Flint 1968, 1970, Chace and Hobbs 1969, Stone 1969, Donnelly 1970, Starmuhlner 1984, Baumgardner *et al*. 2003, Bass 2004a, 2007), Guadeloupe (Starmuhlner 1984), Martinique (Starmuhlner 1984), Antigua (Bass 2005), St. Kitts (Bass 2006), Nevis (Bass 2000, 2006), Montserrat (Baumgardner *et al*. 2003), Saba (Cobben 1960, Bass 2008, Bass and Bass 2008), Guanaja (Bass 1993), and the Cayman Islands (Bass 2009). However, no such efforts have occurred on Mayreau or any of the other Grenadine Islands.

The objectives of this investigation were to: 1) determine the species of aquatic macroinvertebrates inhabiting Canash Pond on Mayreau and 2) compare the freshwater macroinvertebrate fauna of Canash Pond with that of other small Caribbean Islands.

MATERIALS AND METHODS

Canash Pond was sampled on several occasions during 2007, 2008, and 2009. In addition, a temporary pool near Canash Pond was visited, and limited collections were made. All aquatic invertebrates were captured, photographed, and released unharmed by Mark de Silva,

and these photos were sent electronically to David Bass for identification. Due to logistical problems, biological specimens preserved in chemicals could not be shipped or transported from Mayreau. Therefore, names of the invertebrates in the photos were determined by use of the literature and comparing the photos to specimens in the University of Central Oklahoma Caribbean Freshwater Invertebrate Collection. The photographs of several specimens were sent to specialists for confirmation or further identification. Taxa that could not be identified to the species level were separated into morphospecies for subsequent analysis. Sorenson's index of similarity (1948) was used to compare the Mayreau collections with similar collections from other small Caribbean islands.

RESULTS AND DISCUSSION

A total of 44 taxa was collected from Canash Pond with odonates, hemipterans, coleopterans, and dipterans comprising over 80% of the species (Table 1). Three additional taxa, including an oligochaete worm, a spinicaudatan (Conchostraca), and mosquito larvae were collected from a small temporary freshwater pool on Mayreau. Although this is the first report of freshwater invertebrates from the Grenadine Islands, all of the taxa collected that we have been able to identify have been reported from other Caribbean Islands.

Table 1. List of freshwater macroinvertebrates, including life stages present, trophic status, and relative occurrence in Canash Pond, Mayreau during 2007, 2008, and 2009. Occurrence: *** abundant, ** common, * rare (observed no more than twice).

Taxa	Life Stage	Trophic Relationship[1]	Occurrence
Platyhelminthes			
Turbellaria	Adult	Predator	**
Oligochaeta			
Eiseniella sp.*	Adult	Collector	*
Limnodrilus sp.	Adult	Collector	**
Gastropoda			
Drepanotrema sp.	Adult	Grazer	***
Physella marmorata	Adult	Grazer	*
Cladocera			
Unknown Cladoceran	Adult	Collector	***
Spinicaudata (Conchostraca)			
Eocyzius? sp.*	Adult	Collector	***
Ostracoda			
Stenocypris cf *malcomsoni*	Adult	Collector	**
Decapoda			
Cardisoma guanhumi	Adult	Omnivore/Scavenger	**
Collembola			
Sminthuridae	Adult	Collector/Grazer	***
Odonata			
Brachymesia herbida	Adult	Predator	*
Erythemis vesiculosa	Adult	Predator	***
Erythrodiplax umbrata	Nymph, Adult	Predator	***
Ischnura ramburii	Nymph, Adult	Predator	***
Lestes forficula	Adult	Predator	*
Lestes tenuatus	Adult	Predator	*
Micrathyria didyma	Adult	Predator	**
Orthemis macrostigma	Nymph, Adult	Predator	***
Pantala flavescens	Nymph, Adult	Predator	***
Tramea abdominalis	Adult	Predator	**

Taxa	Life Stage	Trophic Relationship[1]	Occurrence
Hemiptera			
Belostoma subspinosum	Nymph, Adult	Predator	***
Buenoa? sp.	Nymph, Adult	Predator	***
Centrocorisa sp.	Nymph, Adult	Predator	***
Limnogonus francisanus	Nymph, Adult	Predator	***
Mesovelia mulsanti	Nymph, Adult	Predator	***
Microvelia puchella	Nymph, Adult	Predator	**
Paraplea puella	Adult	Predator	***
Coleoptera			
Aleocharinea	Adult	Predator	***
Carabidae	Adult	Shredder	***
Copelatus sp.	Adult	Predator	*
Hydrochara sp.	Adult	Collector	***
Hydrophilus insularis	Larva, Adult	Predator/Collector	**
Laccodytes sp.	Larva, Adult	Predator	*
Tropisternus sp.	Larva, Adult	Collector	***
Diptera			
*Aedes taeniorhynchus**	Larva, Adult	Collector	***
Anthomyia sp.	Adult		*
Ceratopogonidae	Larva	Predator	***
Chrysotus / *Diaphorus* spp.	Larva, Adult	Collector	***
Diaphorus sp.	Adult	Collector	***
Ephydridae	Adult		***
Goeldochironomus sp.	Larva, Adult	Collector	**
Lispe sp.	Adult		*
Orthocladiinae	Adult		***
Pelastoneurus taeniatus	Adult		**
Plagioneurus univittatus	Adult		**
Polypedilum sp.	Adult	Collector	**
Stenotabanus tobagensis	Adult	Collector	*

*Collected in a small temporary pool on Mayreau.
Trophic relationship[1] – Trophic relationships of insects based on Merritt, Cummins and Berg (2008) and non-insects on Thorp and Covich (2001).

Platyhelminthes

Several turbellarians of an unidentified species were observed in the mud under rocks along the edge of Canash Pond (Table 1). All of these flatworms are free-living and are assumed to be predators of other small invertebrates.

Oligochaeta

Two species of oligochaetes were collected from Canash Pond and appear to belong to the genera *Limnodrilus* and *Eiseniella*. Definitive identification of these worms requires microscopic examination of their setae that could not be seen in the photographs. *"Limnodrilus"* was collected from sediments (Table 1). This common aquatic worm has been reported from nearby Grenada (Bass 2004b) and Antiguan ponds (Bass 2005). In addition, *"Eiseniella"* was observed beneath submerged wood debris in the nearby temporary pool.

Gastropoda

Physella marmorata and *Drepanotrema* sp. were found in Canash Pond (Table 1). *Physella marmorata* is probably the most widespread freshwater snail in the

Erythrodiplax umbrata (female)

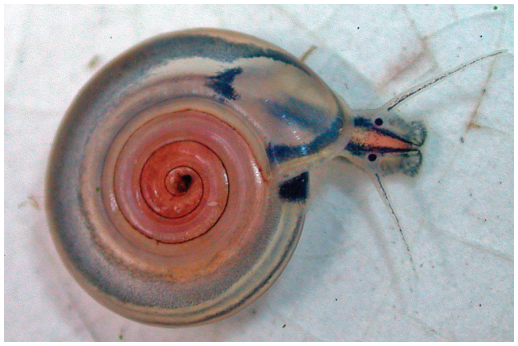
Plagioneurus univittatus

Tramea abdominalis (mating pair)

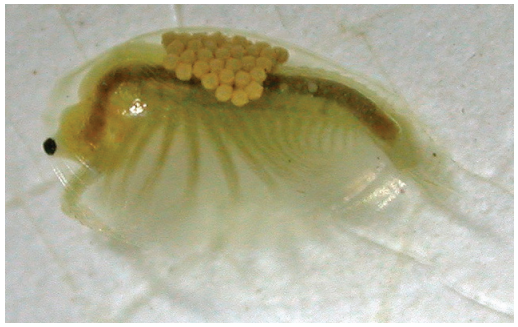
Erythemis vesiculosa

Pelastoneurus taeniatus

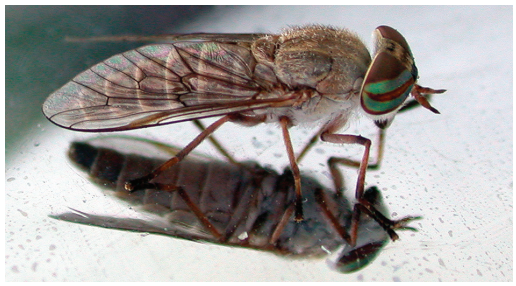
Tropisternus sp. larva



Drepanotrema sp.



Spinicaudata eocyzinus



Stenotabanus tobagensis

Ischnura ramburii (female red colour morph)

Canash Pond

Caribbean Basin (Bass 2003c) and has been reported from Guanaja, Honduras (Bass 1993), Barbados (Bass 2003a), Tobago (Bass 2003b), Grenada (Bass 2004b), Dominica (Bass 2007), Guadeloupe (Starmuhlner 1984), Martinique (Starmuhlner 1984), Antigua (Bass 2005), Nevis (Bass 2000, 2006), St. Kitts (Bass 2006), Saba (Bass 2008), and Grand Cayman (Bass 2009).

Cladocera

An unidentified cladoceran was found in abundance in Canash Pond (Table 1).

Spinicaudata (Conchostraca)

A clam shrimp of the family Cyzidae, possibly belonging to the genus *Eocyzius*, was collected from the small temporary pool near Canash Pond (Table 1). Smith (2001) reports conchostracans are commonly found in small, muddy, alkaline pools that exist for short periods of time.

Ostracoda

An extremely rare ostracod, *Stenocypris* cf *malcomsoni*, was collected at Canash Pond (Table 1). This species was last collected over 50 years ago from Aruba, Curaçao, and Bonaire (Klie 1933), Trinidad (Tressler 1959), northeast Brazil (Klie 1939, Tressler 1949), and the Yucatan Peninsula (Furtos 1936). Broodbaker (1984) conducted an extensive survey of freshwater ostracods in the West Indies and failed to find any specimens of *S. malcomsoni,* indicating the rarity of the species today. D. Delorme (personal communication) commented, "The continued presence of *Stenocypris* cf *malcomsoni* in Canash Pond is realistic as long as the present habitat is maintained. If the pond were to be filled or excavated, the eggs would be lost and the species would disappear".

Decapoda

The blue land crab, *Cardisoma guanhumi*, was frequently seen near the edge of Canash Pond where it visits the water to periodically moisten its gills and forage along the shoreline (Table 1). Numerous holes excavated by *C. guanhumi* exist around the shore of the pond. This species has a widespread distribution throughout the tropical western Atlantic Basin (Chace and Hobbs 1969). There are three additional decapod crabs (*Ucides cordatus, Gecarcinus ruricola,* and *Gecarcinus lateralis*) that have been observed in the general area of the pond but these did not appear to be associated directly with the pond and are not listed in the table.

Collembola

Numerous springtails belonging to the family Sminthuridae were observed on the water surface near the edge of Canash Pond. They feed on small organic particles, such as pollen, that settles there or possibly consume bits of the duckweed (*Lemna perpusilla*) floating at the pond's surface (Merritt *et al*. 2008).

Odonata

Ten species of odonates were observed at Canash Pond (Table 1). All of these species are considered to be strong fliers, resulting in their widespread distribution and common occurrence on many Caribbean Islands (Donnelly 1970; Bass 2000, 2003a, 2003b, 2003c, 2005, 2006, 2007, 2008, 2009). Odonate nymphs prey on small invertebrates (Merritt *et al*. 2008) and it is assumed they do so in Cansh Pond. Although *Brachymesia furcata* and another species, possibly *Orthemis discolor*, have been collected in the Grenadines, they were not seen on Mayreau.

Hemiptera

Seven species of hemipterans were present at Canash Pond (Table 1) and Merritt *et al*. (2008) reports all of these taxa are predators of other aquatic invertebrates. Due to the presence of nymphs, it appears most of these species have established themselves and are actively reproducing in the pond. The genera *Belostoma, Limnogonus, Microvelia,* and *Mesovelia* are widespread across the Caribbean Basin (Hynes 1948, Cobben 1960, Nieser and Alkins-Koo 1991, Bass 2003a, 2003b, 2003c, 2004b, 2005, 2006, 2007, 2008, 2009). Populations of water striders containing both winged and non-winged forms are common on small oceanic islands (Roff 1990) and this phenomenon has been widely observed on Caribbean Islands (Bass 2003c). The population of *Mesovelia mulsanti* in Mayreau included both winged and non-winged forms. An unidentified species from the family Saldidae has been collected at a similar pond on the nearby Grenadine Island of Mustique, but this family appears absent on Mayreau.

Coleoptera

Seven species of beetles were found in Canash Pond (Table 1). All of these have been reported previously from other small Caribbean Islands. The presence of larval *Hydrophilus insularis, Laccodytes* sp., and *Tropisternus lateralis* indicate these species are reproducing in this pond. *Tropisternus lateralis* possibly has the most widespread distribution of any beetle in freshwater environments of the Caribbean region (Bass 2003a, 2003b, 2003c, 2005, 2006, 2008, 2009). In addition to the samples collected from Canash Pond on Mayreau, Mark de Silva took photographs of adults of *Copelatus, Laccobius,* and Dytiscidae found in a small muddy pond during a recent trip to Mustique. Of

these, only *Copelatus* is known to occur on both Mayreau and Mustique.

Diptera

Dipteran larvae are common in aquatic environments. Although many additional species of "aquatic" Diptera (Tipulidae, Culicidae, Chironomidae, Dolichopodidae, etc.) were collected on Mayreau, only 13 species representing seven families were actually collected at the Canash Pond (Table 1). Because only the adult stages of some taxa were encountered, it is uncertain how many species had established reproductive populations on the island. However, most of these species are not strong fliers and they were observed numerous times, so it is likely their populations were already established and reproducing on Mayreau.

The adult *Stenotabanus tobagensis* observed at this pond is included because its larvae have been collected from the leaves of the floating aquatic plant *Pistia stratiotes* at a pond on the nearby Grenadine Island of Mustique. Also, *Anthomyia* (Anthomyiidae) and *Lispe* (Muscidae) have never been seen in any other habitat except Canash Pond and a Mustique Island pond. No mosquito larvae have ever been observed or collected at Canash Pond, probably because they are easy prey for the large numbers of natural predators there. However, the nearby temporary pool, which mostly lacked these predators, did contain both larvae and adults of the common mosquito *Aedes taeniorhynchus*. The presence of hemoglobin in the red blood cells allows *Goeldochironomus* larvae to tolerate the low oxygen conditions occurring where it lives in the bottom sediments (Wiederholm 1983).

Sorensen's similarity index revealed an interesting, although expected, trend (Table 2). Most of the islands sharing the greatest similarity values with Mayreau were relatively flat and showed little relief in elevation. Flat islands generally have little flowing water present and standing water composes most of the freshwater habitats. Those islands having the greatest similarity values were part of the Lesser Antilles chain (Antigua and Barbados), although they were not always in close proximity to Mayreau. It appears there are a few eurytolerant pond taxa widely distributed across the Caribbean Basin. These include *Physella marmorata, Ischnura ramburii, Limnogonus francisanus, Belostoma subspinosum, Microvelia puchella, Mesovelia musanti, Tropisternus lateralis, Hydrophilus insularis,* and *Goeldochironomus* sp. It is interesting to note that some of the closest islands (Grenada, Tobago, and Dominica) showed very few taxa in common. This was because these three islands are steep and mountainous, and most of their freshwater species are different because they are adapted for life in flowing streams and rivers.

Table 2. Sorensen's index of similarity values comparing the freshwater macroinvertebrate fauna of Mayreau to that of other small Caribbean Islands, including approximate distances to those islands from Mayreau and approximate island sizes. Range of values: 0.00 = 0% common taxa and 1.00 = 100% common taxa.

Island	Approximate Distance (km)	Approximate Size (km^2)	Similarity Value
Grenada	55	346	0.19
Tobago	170	300	0.11
Barbados	200	430	0.30
Dominica	285	751	0.12
Montserrat	455	83	0.14
Antigua	485	280	0.34
Nevis	510	94	0.24
St. Kitts	520	177	0.27
Saba	585	13	0.16
Little Cayman	2095	28	0.19
Cayman Brac	2165	38	0.13
Grand Cayman	2225	197	0.27
Guanaja	2650	69	0.06

CONCLUSIONS

A total of 44 species of invertebrates was collected from Canash Pond in Mayreau. In addition, three species were observed in a nearby temporary pool. One species, *Cardisoma guanhumi*, is primarily terrestrial, but it uses the pond to moisten its gills and forage.

This is the only published investigation describing freshwater invertebrates from the Grenadines, so all of these taxa are being reported for the first time from this island chain. Species richness in Canash Pond is relatively high when compared to other freshwater ponds on small Caribbean Islands, especially considering the oceanic origin of Mayreau, its extremely small size, periodic natural and human disturbances, and challenges colonizing a freshwater pond on a marine island. This relatively high species richness in Canash Pond may be due to the presence of many microhabitats, including floating aquatic plants, submerged and emergent aquatic plants, together with a variety of decomposing leaf debris and low sedimentation rate. Because all invertebrate taxa present in the Grenadines have been reported from other Caribbean Islands, it seems they are tolerant of a broad range of environmental conditions and capable of wide dispersal.

Almost all of the few remaining ponds

found on the Grenadine Islands are either saline or brackish. Today, standing bodies of water such as Canash Pond are very rare natural freshwater habitats. In recent years, there has been a tremendous and overwhelming expansion in tourism development throughout the region and this is particularly evident on these tiny Grenadine Islands. The very few remaining freshwater ponds have been largely destroyed or sanitized during this process. Through the centuries, these natural ponds were prime resources for drinking water, for cooking and washing, for plantation and domestic agriculture, and for animal husbandry. Agriculture is now replaced by tourism, and large desalination water-treatment plants provide for the new and heavy demand for water. Wetlands, mangroves, and freshwater ponds are considered ideal places for additional development and cash-strapped governments welcome this additional foreign investment in spite of the universal awareness of the long-term value in protecting these few remaining natural habitats and the biodiversity they contain. As this paper was being prepared, the little remaining land on Mayreau was all sold to developers and the bulldozers had already cut a new road at the very edge of Canash Pond. The people of Mayreau have always cared for Canash Pond, but now they and our government anxiously and hopefully await the employment and other benefits that the new development promises. This paper will nevertheless serve as an important permanent record of Canash Pond and the biodiversity that still exists there at the beginning of the 21st century.

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REFERENCES

Alkins-Koo, M. 1990. The aquatic fauna of two intermittent streams in the Southwestern Peninsula, Trinidad. *Living World, Journal of The Trinidad and Tobago Field Naturalists' Club,* 1989/90: 36-42.

Alkins, M., Desouza, G., Koo, M., Lip, R. L. C. and **Shadid, S.** 1981. A study of the aquatic fauna of the Aripo Savannas. *Living World, Journal of The Trinidad and Tobago Field Naturalists' Club,* 1981/82: 16-19.

Bass, D. 1993. A preliminary survey of stream invertebrates from Guanaja Island, Bay Islands, Honduras. *Brenesia*, 39-40: 175-178.

Bass, D. 2000. Freshwater invertebrates. *In* **D. Robinson** and **J. Lowery,** eds. The Natural History of the Island of Nevis. Ithaca, NY: Nevis Historical and Conservation Society Press. 69 p.

Bass, D. 2003a. Freshwater macroinvertebrates of Barbados. *Journal of the Barbados Museum and Historical Society*, 49: 269-280.

Bass, D. 2003b. A survey of freshwater macroinvertebrates in Tobago, West Indies. *Living World, Journal of The Trinidad and Tobago Field Naturalists' Club*, 2003: 64-69.

Bass, D. 2003c. Comparison of freshwater macroinvertebrate communities from small Caribbean Islands. *BioScience*, 53: 1094-1100.

Bass, D. 2004a. Diurnal stream drift of benthic macroinvertebrates on the small oceanic island of Dominica, West Indies. *Caribbean Journal Science*, 40: 245-252.

Bass, D. 2004b. A survey of freshwater macroinvertebrates on Grenada, West Indies. *Living World, Journal of The Trinidad and Tobago Field Naturalists' Club*, 2004: 26-31.

Bass, D. 2005. A survey of freshwater macroinvertebrates on Antigua, West Indies. *Living World, Journal of The Trinidad and Tobago Field Naturalists' Club*, 2005: 11-14.

Bass, D. 2006. A comparison of the freshwater macroinvertebrate assemblages of St. Kitts and Nevis, West Indies. *Living World, Journal of The Trinidad and Tobago Field Naturalists' Club*, 2006: 30-37.

Bass, D. 2007. Freshwater macroinvertebrates and their habitats in Dominica. *Living World, Journal of The Trinidad and Tobago Field Naturalists' Club*, 2007: 21-30.

Bass, D. 2008. Freshwater macroinvertebrates and their habitats in Saba. *Living World, Journal of The Trinidad and Tobago Field Naturalists' Club*, 2008: 33-38.

Bass, D. 2009. A comparison of macroinvertebrate communities and their freshwater habitats in the Cayman Islands. *Living World, Journal of The Trinidad and Tobago Field Naturalists' Club,* 2009: 1-10.

Bass, C. and **Bass, D.** 2008. Aquatic invertebrates associated with *Heliconia caribaea* from Saba. *Bulletin of the Heliconia Society International*, 14 (3): 11-13.

Baumgardner, D., Burian, S. and **Bass, D.** 2003. Life stage descriptions, taxonomic notes, and new records for the mayfly family Leptohyphidae (Ephemeroptera). *Zootaxa*, 332: 1-12.

Botosaneanu, L. and **Alkins-Koo, M.** 1993. The caddisflies (Insecta: Trichoptera) of Trinidad and Tobago, West Indies. *Bulletin de L'Institut Royal des Sciences Naturelles de Belgique, Entomologie*, 60: 39-48.

Broodbaker, N. W. 1984. The distribution and zoogeography of freshwater Ostracoda (Crustacea) in the West Indies, with emphasis on species inhabiting wells. *Bijdragen tot de Dierkunde,* 54: 25-50.

Chace Jr., F. A. and **Hobbs, H. H.** 1969. Bredin-Archbold-Smithsonian Biological Survey of Dominica. The freshwater and terrestrial decapod crustaceans of the West Indies with special reference to Dominica. *United States National Museum Bulletin*, 292. 258 p.

Cobben, R. H. 1960. The Heteroptera of the Netherlands Antilles-I. Foreword. Gerridae, Veliidae, Mesovelliidae (Waterstriders)-II. Saldidae (Shorebugs). *Studies on the Fauna of Curaçao*

and other Caribbean Islands, XI: 1-97.

Donnelly, T. W. 1970. The odonata of Dominica, British West Indies. *Smithsonian Contributions in Zoology*, 37: 1-20.

Flint Jr., O. S. 1968. Bredin-Archbold-Smithsonian Biological Survey of Dominica. 9. The Trichoptera (Caddisflies) of the Lesser Antilles. *Proceedings of the United States National Museum*, 125: 1-86.

Flint Jr., O. S. 1970. The Megaloptera of Dominica. *Proceedings of the Entomological Society of Washington,* 72: 240-242.

Flint Jr., O. S. 1996. Studies of Neotropical caddisflies LV: Trichoptera of Trinidad and Tobago. *Transactions of the American Entomological Society,* 122: 67-113.

Flint Jr., O. S. and **Sykora, J.** 1993. New species and records of caddisflies (Insecta: Trichoptera) from the Lesser Antilles, with special reference to Grenada. *Annals of Carnegie Museum*, 62: 47-62.

Furtos, N. C. 1936. On the Ostracoda from the Cenotes of Yucatan and Vicinity; The Cenotes of Yucatan, a Zoological and Hydrographic Survey. Carnegie Institution of Washington, Publ. Number 457: 89Å115.

Harrison, A. D. and **Rankin, J. J.** 1975. Forest litter and stream fauna on a tropical island, St. Vincent, West Indies. *Verhanderlungen International Vereins Limnologie,* 19: 1736-1745.

Harrison, A. D. and **Rankin, J. J.** 1976. Hydrobiological studies of eastern Lesser Antillean Islands. II. St. Vincent: freshwater fauna – its distribution, tropical river zonation and biogeography. *Archives of Hydrobiology/Supplement,* 50: 275-311.

Hart Jr., C. W. 1980. New freshwater shrimp records for Tobago, West Indies, with a summary of records for the Lesser Antilles (Atyidae and Palaemonidae). *Proceedings of the Biological Society of Washington*, 93: 845-848.

Hynes, H. B. N. 1948. Notes on the aquatic Hemiptera-Heteroptera of Trinidad and Tobago, B.W.I., with a description of a new species of *Martarega* B. White (Notonectidae). *Transactions of the Royal Entomological Society of London*, 99: 341-360.

Hynes, H. B. N. 1971. Zonation of the invertebrate fauna in a West Indian stream. *Hydrobiologia,* 38: 1-8.

Klie, W. 1933. Zoologische Ergebnisse einer Reise nach Bonaire, Curaçao und Aruba im Jahre 1930. No. 5. Süß=und Brackwasser=Ostracoden von Bonaire, Curaçao und Aruba. *Zoologische Jahrbücher, Abteilung für Systematik, Ökologie und Geographie der Tiere,* 64: 369-390.

Klie, W. 1939. Brackwasserostracoden von Nordostbrasilien. *Zoologische Jahrbücher, Abeilung für Systematik, Ökologie und Geographie der Tiere,* 72: 359-372.

MacArthur, R. H. and **Wilson, E. O.** 1967. The Theory of Island Biogeography. Princeton, NJ: Princeton University Press. 203 p.

McKillop, W. B. and **Harrison, A. D.** 1980. Hydrobiological studies of eastern Lesser Antillean Islands. I. St. Lucia: freshwater habitats, water chemistry and distribution of freshwater mollusks. *Archives of Hydrobiology/Supplement*, 57: 251-290.

Merritt, R. W., Cummins, K. W. and **Berg, M. B.** 2008. An Introduction to the Aquatic Insects of North America. 4th ed. Dubuque, IA: Kendall/Hunt Publishing Co. 1158 p.

Nieser, N. and **Alkins-Koo, M.** 1991. The Water Bugs of Trinidad and Tobago. St. Augustine, Trinidad and Tobago: Zoology Department, University of the West Indies, Occasional Paper No. 9.

Roff, D. A. 1990. The evolution of flightlessness in insects. *Ecological Monographs*, 60: 389-421.

Smith, D. G. 2001. Pennack's Freshwater Invertebrates of the United States. 4th ed. New York, NY: John Wiley & Sons, Inc. 638 p.

Sorenson, T. 1948. A method of establishing groups of equal amplitude in a plant society based on similarity of species content and its application to analysis of vegetation on Danish commons. *Biologiske Skrifter Kongelige Danske Videnskabernes Selskab*, 5: 1-34.

Starmuhlner, F. 1984. Occurrence, longitudinal distribution and geographical range of the fresh- and brackish water molluscs of the Lesser Antillean Islands (Guadeloupe, Dominica, and Martinique). *Soosiana*, 12: 83-102.

Stone, A. P. 1969. The black flies of Dominica. *Proceedings of the Entomological Society of Washington*, 71: 312-318.

Thorp, J. H. and **Covich, A. P.** 2001. Ecology and Classification of North American Freshwater Invertebrates. 2nd ed. San Diego, CA: Academic Press. 1056 p.

Tressler, W. L. 1949. Freshwater Ostracoda from Brazil. *Proceedings of the United States National Museum*, 100: 61-83.

Tressler, W. L. 1959. Ostracoda. p. 657-734. *In* **W. T. Edmondson,** ed. Freshwater Biology. New York: John Wiley.

Turner, D., Williams, D. D. and **Alkins-Koo, M.** 2008. Longitudinal changes in benthic community composition in four Neotropical streams. *Caribbean Journal of Science*, 44: 380-394.

Westercamp, D. 1985. Géologie de l'archipel des Grenadines (Petites Antilles Méridionales) étude Monographique. Documents du B.R.G.M., No. 92, Service Géologique National, B.R.G.M., France. 198 p.

Wiederholm, T. 1983. Chironomidae of the Holarctic Region. Keys and Diagnoses. Part 1. Larvae. *Entomologica Scandinavica Supplement No. 19,* 457 p.