

A Survey of Freshwater Macroinvertebrates on Grenada, West Indies

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ABSTRACT

A survey of macroinvertebrates inhabiting the freshwater habitats of Grenada was conducted during May and June of 1996. Qualitative collections were made by sweeping a dip net through the water column and by hand examination of rocks, plants, and other debris submerged in both flowing and standing bodies of fresh water across the island. These collections yielded at least 32 species previously unknown from Grenada. When my collections were combined with those made by previous investigators, the total number of species recorded from the island is expanded to total at least 86. Dominant taxa collected included a few species of gastropods, decapod crustaceans, ephemeropterans, odonates, and hemipterans. Generally this macroinvertebrate fauna is sparse, most likely due to the oceanic origin of Grenada and periodic disturbance of freshwater environments across the island.

INTRODUCTION

Grenada is the southernmost island in the Windward Islands of the Lesser Antilles. It is volcanic in origin, rising 827 meters above sea level and comprising approximately 346 square kilometers. Grenada is estimated to have emerged in the eastern Caribbean 20-25 millions years ago, although much volcanic activity has occurred across the island since that time (Briden *et al.* 1979).

The freshwater habitats on Grenada are typical of other small volcanic islands of the Lesser Antilles (Bass 2003a). Numerous small, steep streams originate in upper elevations where water flows rapidly over a substrate that consists mostly of boulders, rocks, and cobble. Some of these streams merge together to form larger rivers whereas others remain small as they flow short distances toward the sea. Because these streams flow mostly through forested areas, leaf packs form on the upstream side of rocks and leaf debris accumulates in pools. A deep freshwater lake exists in a dormant volcanic crater near Mount Sinai and several small ponds, having varying salinities and muddy substrates, occur at lower elevations near the coast.

A limited amount of information regarding the freshwater invertebrates of the Lesser Antilles and other small Caribbean islands is available. Biodiversity surveys have been conducted on certain islands including Barbados (Bass 2003b), St. Vincent (Harrison and Rankin 1975, 1976a, 1976b; McKillop and Harrison 1980), Nevis (Bass 2000), Tobago (Nieser and Alkins-Koo 1991, Bass 2003c), and Trinidad (Hynes 1971; Alkins *et al.* 1981; Alkins-Koo 1990, Nieser and Alkins-Koo 1991), but similar published investigations are generally lacking for Grenada. While some invertebrate groups in the region have been studied, such as decapod crustaceans (Chace and Hobbs 1969; Hart 1980), odonates (Donnelly 1970), and trichopterans (Flint 1968, 1996; Botosaneanu and Alkins-Koo 1993), many others have yet to be surveyed. Previous efforts in Grenada have been limited to certain taxa (e.g., Trichoptera: Flint and Sykora 1993). Furthermore, additional collections may yield previously unknown populations or species (Bass and Volkmer-Ribeiro 1998; Bass 2003a).

The objectives of this investigation include: 1) to determine the species of aquatic macroinvertebrates inhabiting fresh waters of Grenada; 2) to note microhabitat preferences of each species; 3) to determine the relative abundance of each species; and 4) to compare the Grenada macroinvertebrate fauna with that of other small Caribbean islands.

METHODS

Sixteen sampling sites were established in various freshwater habitats across Grenada. Collections were made during May and June of 1996. Water temperature was also recorded from each site at the time of collection.

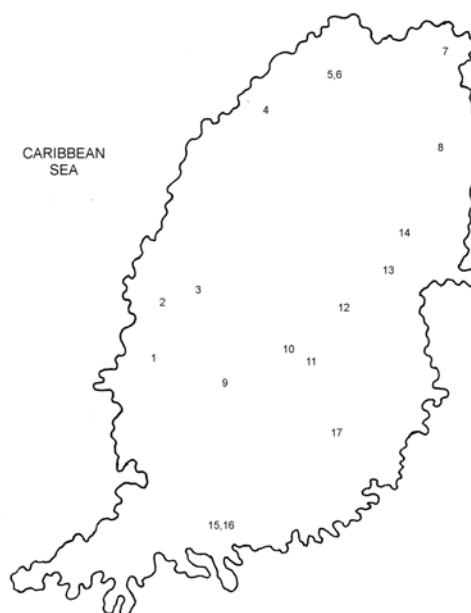


Fig. 1. Map indicating location of collecting sites in Grenada. Specific locations, dates, and approximate elevations of collections are listed below Table 1.

Because data in this investigation was to be compared with that from other small Caribbean islands, it was important that collecting methods were consistent in application from island to island. Several methods of collecting were employed to ensure as many species as possible were captured. Submerged debris, such as stones, leaves, and wood, was carefully examined and inhabitants were picked from the substrate using forceps. A dip net was swept through aquatic vegetation and the water column to capture macroinvertebrates occupying those microhabitats. The microhabitat from which each specimen occurred was noted. A drift net was used at two sites to capture organisms carried in the current during the night. All specimens were preserved in 70% ethanol and

returned to the laboratory for further identification. Taxa that could not be identified to the species level were separated into morphospecies for subsequent analysis and the taxonomic name to which they could be identified was used. A list of taxa known from Grenada, including those previously reported by other researchers, was composed. Sorenson's index of similarity (1948) was used to compare my collections in Grenada with similar endeavors on other small Caribbean islands.

RESULTS AND DISCUSSION

Water temperatures measured during this investigation ranged from 23°C in the outflow of Grand Etang to 31°C in Levera Pond. Generally, cooler temperatures were measured in small, shaded

streams at higher elevations whereas warmer temperatures occurred in exposed, lowland streams and ponds. A similar thermal pattern was observed in waters of Tobago (Bass 2003c).

At least 52 species were collected during this study, bringing the total number of freshwater macroinvertebrates known from Grenada to a minimum of 86 taxa (Table 1). Although more taxa are listed on Table 1, several of those may actually be listed multiple times. For example, *Potimirim* sp. from sites 1 and 2 may actually be *P. glabra*, but because all specimens collected from those sites were small juveniles, their identity cannot be confirmed. Therefore, both taxa are listed, but only *P. glabra* is included in the final count of taxa known from Grenada. At least 32 taxa in my collections are being reported from this island for the first time.

Table 1. List of freshwater macroinvertebrates, including collecting sites, life cycle stages present, relative occurrence, microhabitats, and proposed trophic relationships in Grenada during May and June 1996. Life cycle: A, adult; J, juvenile; L, larva; N, nymph. Occurrence: +++ abundant, ++ common, + uncommon.

Taxa	Collections	Life Cycle	Occurrence	Microhabitat	Trophic Relationship**
Platyhelminthes					
<i>Girardia</i> sp.*	4	J	+	Rock	Predator
Oligochaeta					
<i>Limnodrilus undekemianus</i> *	1, 4-5, 6	A	++	Sediment	Deposit
Gastropoda					
<i>Ampullaria glauca</i>	18	A			
<i>Gundlachia radiata</i>	18	A			
<i>Melanoides tuberculata</i> *	1-5, 8-10, 12-14, 17	J, A	+++	Detritus	
<i>Neritina clenchi</i> *	1, 3	A	++	Rock	Algivore
<i>Neritina punctulata</i> *	2-4, 9	J, A	++	Rock	Algivore
<i>Neritina virginia</i>	3, 18	A	++	Rock	Algivore
<i>Physella cubensis cubensis</i> *	9	J, A	+	Detritus	Detritivore
<i>Physella marmorata</i>	18	A		Detritivore	
<i>Potamopyrgus coronatus</i>	18	A			
<i>Tropicorbis pallidus</i> *	10	A	+	Detritus	
Amphipoda					
<i>Hyaella azteca</i> *	10	A	+	Detritus	Detritivore
<i>Quadrivisio</i> sp.*	16	A	+	Detritus	
Decapoda					
<i>Atya innocous</i> *	9	J, A	+	Detritus	Omnivore, Collector
<i>Atya</i> poss. <i>innocuous/scabra</i>	4, 5	J	++	Detritus	Omnivore, Collector
<i>Jonga serrei</i> *	15-16	J, A	++	Detritus	
<i>Macrobrachium faustinum</i> *	1-2, 4-5, 8-9, 12-13, 15-16	J, A	+++	Detritus	Omnivore, Predator
<i>Macrobrachium heterochirus</i>	18	A			Omnivore, Predator
<i>Macrobrachium jelskii</i> *	7	A	+	Detritus	Omnivore, Predator
<i>Macrobrachium</i> sp.	1	J	+	Detritus	Omnivore, Predator
<i>Micratya poeyi</i> *	3, 5, 9, 12, 13	J, A	+++	Detritus	Omnivore, Collector
<i>Potimirim glabra</i> *	3, 8, 9	J, A	++	Detritus	
<i>Potimirim</i> sp.	1, 2	J	++	Detritus	
<i>Xiphocaris elongata</i> *	1, 2	J, A	++	Detritus	
Ephemeroptera					
Baetidae	4, 8, 12, 13, 15, 16-17	N	+++	Detritus	Collector
<i>Baetodes</i> sp.	18	A		Scraper	
<i>Cleodes</i> sp.	18	A			
<i>Farrodes grenadae</i>	18	A			
<i>Farrodes</i> sp.	1, 4, 8, 12, 13, 16	N	+++	Detritus	Collector?
<i>Farrodes</i> sp. 2	14-15	N	+	Detritus	Collector?
<i>Leptohyphes zalope</i> *	4, 9, 12-14, 16-17	N	+++	Detritus	Collector?
<i>Leptohyphes</i> sp.	18	A			
Odonata					
<i>Argia concinna</i>	5, 8, 14, 18	N	++	Detritus, rock	Predator
<i>Brachymesia</i> sp.*	1, 9, 15	N	++	Detritus	Predator
<i>Brechmorhoga praecox grenadensis</i>	12, 18	N, A	+	Detritus	Predator

Table 1. (Continued).

Taxa	Collections	Life Cycle	Occurrence	Microhabitat	Trophic Relationship**
<i>Dythemis multipunctata</i>	18	A		Predator	
<i>Erythrodiplax fusca</i>	18	A		Predator	
<i>Erythrodiplax/Micranthyrina</i>	9	N	+	Detritus	Predator
<i>Ischnura ramburii*</i>	1, 10, 15	N	++	Detritus, rock	Predator
<i>Lestes spumarius</i>	18	A			
Hemiptera					
<i>Belostoma subspinosum*</i>	10	N, A	+	Detritus	Predator
<i>Brachymetra albinervis</i>	1-3, 5, 8-9, 11, 14-15, 18	A	+++	Neuston	Predator
<i>Brachymetra unca</i>	18	A		Predator	
<i>Buenoa gracilis</i>	18	A		Predator	
<i>Buenoa</i> sp.	2	A	+	Detritus	Predator
<i>Hebrus consolidus</i>	18	A		Predator	
<i>Limnogonus francisanus</i>	2, 18	A	+	Neuston	Predator
<i>Mesovelvia amoena</i>	18	A		Predator	
<i>Mesovelvia mulsanti*</i>	1	A	+	Neuston	Predator
<i>Microvelia leptomena</i>	18	A		Predator	
<i>Microvelia pulchella</i>	18	A		Predator	
<i>Nerthra raptoria</i>	18	A		Predator	
<i>Paraplea puella</i>	18	A		Predator	
<i>Rhagovelia angustipes*</i>	1-3, 5, 8-9, 11-16	A	+++	Neuston	Predator
<i>Rhagovelia elegans</i>	1-3, 5, 8, 9, 11-16, 18	N, A	+++	Neuston	Predator
<i>Trochopus plumbeus</i>	18	A		Predator	
Trichoptera					
<i>Bredinia appendiculata</i>	18	A			
<i>Cerasmatrichia</i> sp.	18	A			
<i>Chimarra caribea</i>	18	A			
<i>Chimarra</i> sp.	12	L	+	Detritus	Collector
<i>Helicopsyche grenadensis</i>	18	A			
<i>Helicopsyche margaritensis</i>	18	A			
<i>Hydroptila antilliarum</i>	18	A			
<i>Leptonema albobirens</i>	1, 4, 8-9, 12-18	L	+++	Detritus, rock	Collector
<i>Leucotrichia sarita</i>	18	A			
<i>Neotrichia nesiotis</i>	18	A			
<i>Neotrichia tauricornis</i>	18	A			
<i>Ochrotrichia ponta</i>	18	A			
<i>Oecetis pratti</i>	18	A			
<i>Oxyethira azteca</i>	18	A			
<i>Oxyethira janella</i>	18	A			
<i>Polyplectropus bredini</i>	18	A			
<i>Polycentropus insularis</i>	18	A			
<i>Smicridea astarte</i>	18	A			
<i>Smicridea grenadensis</i>	18	A			
<i>Smicridea palifera</i>	18	A			
<i>Wormaldia planae</i>	18	A			
<i>Xiphocentron lobiferum</i>	18	A			
<i>Zumatrichia anomaloptera</i>	4, 18	L	+	Rock	Scraper
<i>Zumatrichia antilliensis</i>	4, 18	L	+	Rock	Scraper
Lepidoptera					
<i>Petrophila</i> sp.	4, 18	L	++	Rock	Scraper
Coleoptera					
<i>Copelatus posticus*</i>	5, 6	A	+	Detritus	Predator
<i>Heterelmis</i> sp.	18	A		Collector?	
<i>Hexacylloepus smithi</i>	1, 18	A	+	Rock	Collector?
<i>Phanocerus congener</i>	18	A		Collector?	
<i>Psephenops smithi*</i>	3, 9, 12-14, 17	L, A	+++	Rock	Scraper
<i>Psephenops</i> sp.	18	A		Scraper	
<i>Thermonectes basillaris*</i>	7	A	+	Detritus	Predator
Diptera					
<i>Aedes</i> sp.*	6	L	++	Water column	Collector
<i>Anopheles</i> sp.*	3	L	+	Water column	Collector
Chironomidae	18				
<i>Culex</i> sp.*	6	L	+	Water column	Collector
Ephydriidae*	6	L	+	Detritus	

Table 1. (Continued)

Taxa	Collections	Life Cycle	Occurrence	Microhabitat	Trophic Relationship**
<i>Fittkauimyia</i> sp.*	16	L	+	Sediment	Predator?
<i>Psychoda</i> ? sp.*	6	L		Detritus	Collector
Psychodidae	18				
<i>Orthocladius</i> sp.*	5	L	+	Sediment	Collector
Tipulidae	18				

* Indicates specimen from this collection is first report of this taxon from Grenada.

** Determined for non-insects from Thorp and Covich (2001) and for insects from Merritt and Cummins (1996). Note this information is based on North American taxa and may not be applicable to Neotropical species.

Collections:

1. Beausejour River, West Coast Road, Grenada, 1 May 1996, elev. 35 m
2. Douce River, West Coast Road, Woodford Estate, Grenada, 1 May 1996, elev. 25 m
3. Black Bay River, Concord Valley Road, Davidall Estate, Grenada, 1 May 1996, elev. 170 m
4. St. Mark's River, Bocage Estate near Bonair Government School, Grenada, 1 May 1996, elev. 190 m
5. Samaritan River, Samaritan Estate, Grenada, 1 May 1996, elev. 220 m
6. Boiling Pot along bank of Samaritan River, Samaritan Estate, Grenada, 1 May 1996, 220 elev. m
7. Levera Pond, Levera Pond National Park, Grenada, 1 May 1996, elev. 5 m
8. Antoine River, Poyntzfield Estate, Grenada, 1 May 1996, elev. 110 m
9. Annadale Waterfall (Beausejour River), Willis Grenada, 2 May 1996, elev. 210 m
10. Grand Etang Lake, Grand Etang Forest Reserve, Grenada, 2 May 1996, elev. 580 m
11. Outflow-Grand Etang Lake, Grand Etang Forest Reserve, Grenada, 2 May 1996, elev. 575 m
12. Great River, Birch Grove, Grenada, 2 May 1996, elev. 190 m
13. Great River, Balthazer Estate, Grenada, 2 May 1996, elev. 130 m
14. Grand Bras River, Mount Horne Estate, Grenada, 2 May 1996, elev. 125 m
15. Chemin River, CARDI Field Station, Grenada, 2 May 1996, elev. 30 m
16. Drift Sample-Chemin River, CARDI Field Station, Grenada, 2-3 May 1996, elev. 30 m
17. Drift Sample-Crochu River, St. Andrews, Grenada, June 1996 (collected by CARDI staff), elev. 160 m
18. Reported by other researchers.

Platyhelminthes

Only one species of flatworm, *Girardia* sp., was collected and this came from submerged rocks in St. Mark's River. Unfortunately, only juveniles were present so a species name cannot be determined.

Oligochaeta

Limnodrilus undekemianus was the only species of oligochaete collected. It was found in shallow sediments of several small streams on the leeward side of Grenada and among the organic debris in a boiling pot, presumably abandoned and filled by rainwater.

Gastropoda

Ten aquatic snails are now known from Grenada. Of these, six were collected in this study, with five of them being found in Grenada for the first time. The introduced species, *Melanoides tuberculata*, was the most abundant and widespread freshwater snail in aquatic habitats of the island, often occurring among detritus. It seems once this species is introduced to these small Caribbean islands, it is able to rapidly spread and develop large populations (Bass 2003a). Although two species of the widespread pulmonate *Physella* have been reported from Grenada, only one, *P. cubensis*, was present in my collections.

Amphipoda

Two species of amphipods were collected from Grenada. The eurytolerant and widespread *Hyaella azteca* was found among bottom debris in shallow water near the shore of Grand Etang. *Quadrivisio* sp. was collected in a drift sample taken during the night in the Chemin River. Both species are negatively phototactic and hide among submerged detritus during the daylight hours.

Decapoda

Ten of the 11 species listed on Table 1 were found in my collections. These shrimps were primarily associated with detritus. Three of those taxa, *Atya* poss. *innocuous/scabra*, *Macrobrachium* sp., and *Potimirim* sp., are likely to belong to species already reported, but the immature condition of those specimens prevents precise identification. The omnivorous predatory shrimp, *Macrobrachium faustinum*, was found at over half the collection sites. Another widespread shrimp occurring across Grenada is the atyid *Micratya poeyi*. *Macrobrachium jelskii* was possibly the most noteworthy species of shrimp collected in Grenada. It has been found previously on the South American mainland, but there are no records of this species occurring on West Indian islands (Hurlbert and Villalobos-Figueroa 1982). Unlike many species of *Macrobrachium*, *M. jelskii* lacks a marine planktonic stage, and that presumably limited its ability to disperse to oceanic islands. Although it remains unknown how this species arrived on Grenada, possible mechanisms include transport by humans or migrating waterfowl.

Ephemeroptera

Several species of mayflies are known from Grenada. *Leptohyphes zalope* was abundant in my collection and further studies by Baumgardner *et al.* (2003) indicated it to be a new record on Grenada and Tobago. Equally abundant were mayflies of the genus *Farrodes* and the family Baetidae. All of these mayfly nymphs were found living among submerged leaf debris.

Odonata

At least seven species of odonates are reported from Grenada: three are damselflies and four are dragonflies. Populations of the former appear to be considerably more widespread and abundant than the latter. Based on the microhabitat from where the nymphs were collected, they seem to have a preference for areas of the stream where flow is reduced and detritus accumulates among the rocky substrate. Both the aquatic nymph and the aerial adult stages of odonates are predators.

Hemiptera

Hemipterans are common at collecting sites across Grenada and at least 15 species are known from the island. Three species of water striders, *Brachymetra albinervis*, *Rhagovelia angustipes*, and *R. elegans*, were abundant, being found in collections from most sites. Both nymphs and adults are predators in the aquatic environment.

Several populations of water striders exhibited wing polymorphism and flightlessness. The loss of wings is a widespread phenomenon that has been well documented in water striders living in isolated habitats (Roff 1990; Schuh and Shlater 1995; Thorp and Covich 2001; Bass 2003a). Because these collections in Grenada took place only near the end of the dry season, it is unknown if this polymorphism occurs throughout the year or if it is simply a seasonal phenomenon.

Trichoptera

Twenty-two species of caddisflies are known from Grenada with four having been reported only from this island (Flint and Sykora 1993, Flint *et al.* 1999, Botosaneanu 2002). Based on my collections and those of Flint and Sykora (1993), it appears *Leptonema albovirens*, *Chimarra caribea*, *Zumatruchia antilliensis*, and *Z. anomalopectera* are the most common trichopterans on Grenada. *Leptonema albovirens* is a widespread species, ranging from the USA (Texas) and Mexico across Central America, Colombia, and Venezuela and northward into the Lesser Antilles (Flint and Sykora 1993, Flint *et al.* 1999). *Chimarra caribea* is known only from the southeastern Caribbean islands of Grenada, Mustique, Tobago, Trinidad, and Margarita (Botosaneanu and Alkins-Koo 1993, Flint *et al.* 1999, Botosaneanu 2002) whereas *Zumatruchia antilliensis* and *Z. anomalopectera* are known from numerous islands of the Lesser Antilles and the nearby region (Flint and Sykora 1993, Flint *et al.* 1999, Botosaneanu 2002).

Lepidoptera

Petrophila was the only aquatic lepidopteran found on Grenada. Larvae were collected from their small, self-spun silken retreats covering indentations of rocks in shallow stream environments. These larvae scrape algae and other organic material from the surface of submerged rocks, probably during hours of darkness (Bass 2003a, 2003c). *Petrophila* appears to be widespread across the Lesser Antilles.

Coleoptera

Three of the four species of aquatic beetles found in my collections were previously unknown from Grenada. When studies from Darlington (1936) and Hinton (1971) are included, a total of six species of aquatic beetles may be reported from Grenada. *Psephenops smithi* seems to be the most widespread aquatic beetle in mountain streams of this island, usually observed inhabiting the underside of rocks.

Diptera

Ten taxa of aquatic dipterans may be found in the species list. However, two of the families listed, the Chironomidae and Psychodidae, were reported from Grenada by earlier researchers

using only those family names. More recent collections have yielded genus names for some specimens belonging to those families. Over half of the dipterans now known from Grenada are mosquitoes and midges.

Taxa richness varied between the sites sampled. As in Tobago (Bass 2003c), sites in Grenada having the greatest number of taxa generally were those of streams having stable cobble substrates and flowing through forested land where human impact appeared minimal. Such sites occurred in the Beausejour River, Black Bay River, St. Mark's River, Samaritan River, Annadale Waterfall area, and Great River. Taxa richness was lowest in Levera Pond, probably due to salt water intrusion.

Hynes (1971) concluded that the zonation of stream macroinvertebrates in the Arima River system of Trinidad was based largely on elevational differences. However, Bass (2003c), based on the results of macroinvertebrate samples from seventeen different sites at varying elevations on nearby Tobago, found it is difficult to conclude which, if any, of the parameters of elevation, water temperature, suitable microhabitat, or some other environmental factor was more important in determining whether a species could exist at a site. Alkins-Koo (personal communication) suggested this lack of distinct elevational zonation is because these small islands have steep slopes along much of their lengths and a very short lower reach near the sea. Results of this study in Grenada more resemble those from Tobago with few species seeming to have little, if any, elevation preference. Many taxa, including representatives of gastropods, shrimps, ephemeropterans, hemipterans, and trichopterans were collected at several elevations (Table 1).

Generally faunal similarity is reduced as distance between islands increases (Table 2). Of the 13 other islands listed in Table 2 for which similar collections were made by the author, Grenada shares the greatest faunal similarity with Tobago and St. Lucia.

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

Island	Approximate Distance (km)	Approximate Size (km ²)	Similarity Value
Tobago	125	300	0.22
St. Lucia	175	616	0.22
Barbados	230	430	0.16
Dominica	335	751	0.17
Montserrat	505	83	0.08
Antigua	540	402	0.08
Nevis	560	93	0.09
St. Kitts	575	176	0.10
Saba	610	13	0.03
Cayman Brac	2,075	37	0.00
Little Cayman	2,100	26	0.01
Grand Cayman	2,180	197	0.00
Guanaja	2,595	69	0.03

These are the two islands sampled in this study nearest Grenada and all three islands possess a similar terrain. Grenada showed no species in common with Cayman Brac and Grand Cayman. Both of these are small, low-lying distant islands that possess fewer and very different freshwater habitats. It appears that distance between these small islands is the most critical factor determining faunal similarity, but other factors such as prevailing winds and currents,

island area, island elevation, and habitat similarity should also be considered (Bass 2003a, 2003c).

Grenada is an oceanic island and has never been connected to any other landmass (Briden *et al.* 1979) so all species present must have come from elsewhere or have evolved on the island. Species that colonized the island may have done so by either actively flying (e.g., winged insect adults) or being passively carried by wind or water currents (e.g., larvae of nerites and shrimps). Those species that were carried by water currents must have been tolerant of seawater during the period of dispersal. Due to its close proximity to South America, it seems likely that much of the fauna of Grenada would be dominated by species tracing their ancestral origins to the freshwaters on the South American mainland, as suggested by the distributions of shrimps (Hart 1980) and trichopterans (Hamilton 1988; Flint 1996). Upon arrival, it appears some groups, such as the caddisflies (Flint and Sykora 1993), have evolved and further speciated in isolation on this island. Further studies of macroinvertebrates in fresh waters of Grenada are likely to find additional species, including some that may be endemic.

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