Variations in lake-outlet Ephemeroptera, Plecoptera, and Trichoptera communities amongst regions of eastern Newfoundland, Canada

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Abstract: Ephemeroptera, Plecoptera, and Trichoptera communities at 23 lake-outlet sites in four regions of boreal eastern Newfoundland, Canada, are described and compared. Faunal richness was low, with a total of 51 taxa collected (14 for Ephemeroptera, 3 for Plecoptera, and 34 for Trichoptera). Hydropsychids (Trichoptera) predominated in both diversity and abundance of taxa. Analysis of variance revealed differences in taxon diversity and abundance among regions, even within the relatively small geographic area studied. Diversity and abundance also varied among sites within regions, despite the low diversity and large number of widespread taxa. The data show that lake outlets are useful for comparative studies, even in areas with a reduced insect fauna.

Résumé : On trouvera ici la description des communautés d'éphémères, plécoptères et trichoptères de 23 émissaires en quatre régions du nord-est de Terre-Neuve, Canada. La faune y était plutôt pauvre et seulement 51 taxons ont été récoltés (14 Ephéméroptères, 3 Plécoptères et 34 Trichoptères). Tant du point de vue de la diversité que de l'abondance, la faune était dominée par les hydropsychides (Trichoptères). Une analyse de variance a révélé des différences de diversité et d'abondance entre les régions, même si la région géographique étudiée était relativement restreinte. Il y avait également des différences de diversité et d'abondance entre les sites au sein d'une région, en dépit de la faible diversité et du grand nombre de taxons à vaste répartition. Les données démontrent que les sorties de lac sont des milieux qui se prêtent bien aux études comparatives, même dans les zones où la faune des insectes est limitée.

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Introduction

The richness and composition of aquatic insect faunas are the product of many scale-dependent processes. The composition of communities in a particular habitat type at different sites across a biome will depend on regional species-richness patterns as well as on the abiotic and biotic processes occurring within the individual site (e.g., Giller et al. 1994; Hildrew and Giller 1994; Vinson and Hawkins 1998). One goal of the present study was to examine whether significant differences in the composition of aquatic insect communities could be detected across regions within an area of reduced richness of aquatic insect taxa that was dominated by generalists.

Ephemeroptera, Plecoptera, and Trichoptera (EPT) communities were compared at lake-outlet sites among four regions, and among sites within these regions, in northeastern Newfoundland. The island of Newfoundland, located in the northern boreal region, has a reduced taxonomic richness (Larson and Colbo 1983). The limited fauna is attributed to the island's recent glaciation (< 10 000 years BP) and separation by salt water from the mainland faunal source, creating an effective dispersal barrier for many taxa. Larson and Colbo (1983) described the benthic fauna of Newfoundland and related faunal characteristics to the overall environment. They described the island as having a reduced habitat diversity, with most species in the Newfoundland fauna being generalists, occurring in many types of freshwater habitats. With the exception of a number of plecopteran species, most of the aquatic insect species were distributed across the island.

Sampling for the present study was restricted to lake outlets (in an area 1–5 m downstream of where the water surface breaks at the transition from lentic to lotic). The community in lake-outlet habitats is potentially useful for the study of the taxonomic richness of aquatic insect communities among sites and regions. Lake outlets are unique because they represent the area where the biological and physical characteristics of lotic and lentic habitats merge (Genge 1985). The fauna of lake outlets differs in composition and numerical density from that at downstream sites, in that production of the benthic macroinvertebrate fauna is enhanced and communities are dominated by filter-feeders such as net-spinning caddisflies (Hydropsychidae, Polycentropodidae, Philopotamidae) and black flies (Simuliidae) (Townsend et al. 1983; Bronmark and Malmqvist 1984; Richardson and Mackay 1991).

Thus, a further goal of the present study was to add data to the limited information on aquatic insect communities of lake outlets in northeastern North America, particularly on the island of Newfoundland. Currently, most of the published information on lake outlets pertains to black fly communities (Lewis and Bennett 1974; Colbo 1985; McCreadie and Colbo 1991, 1992; McCreadie et al. 1995). Genge (1985)

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studied the ecology of net-spinning Trichoptera in one Newfoundland lake outlet. Larson and Colbo (1983) described macroinvertebrate taxa of the entire island, including streams, and provided a general overview.

Materials and methods

Study area

In four study regions in northeastern Newfoundland, 23 sites in six water catchments were sampled (for a map of the study area refer to Lomond 1997). Larson and Colbo (1983) provide a detailed description of the Newfoundland climate, hydrology, and habitat; the following is a summary.

The Newfoundland climate is cool and humid with a strong seasonal lag in temperature. Precipitation exceeds evapotranspiration across the entire island. The boreal landscape consists of a mixture of barren areas (mainly dwarf shrub heaths, bogs, and shallow fens) and forest sections dominated by balsam fir (*Abies balsamea*). There are a large number of bodies of standing water, owing to low relief and irregularly glaciated topography. Pools, bogs, and fens are abundant. Thus, most water catchments are small and have a low gradient over most of their length, and the water plunges rapidly into the sea. Newfoundland streams are oligotrophic, with expected low biomass, except at lake outlets (Genge 1985). Most aquatic habitats are cool, only occasionally and briefly exceeding 25°C (Larson and Colbo 1983). Waters are generally acidic, with low levels of dissolved materials and limited buffering capacity.

The four study locations were chosen to provide a wide range of environmental characteristics and stream habitats so that broad comparisons could be made. Additional sampling sites were included in May 1996 to provide a wider range of habitat types and a larger sample size. Most sites sampled were narrow, low-order headwater streams located in forested areas, and the substrate consisted of large particles, primarily cobbles or boulders. Lomond (1997) provides detailed site descriptions and region maps.

Seven sites were sampled in the Bonavista region (48°39′N, 53°05′W). The Bonavista headland includes the town of Bonavista surrounded by several small settlements. Bonavista is a naturally harsh environment. The peninsula extends into the ocean and is exposed to cold, high winds. The area is a heathland covered by stunted forest.

Five sites were sampled on Random Island (48°06′N, 53°46′W; 70 km southwest of Bonavista), which is a large (ca. 35 km long) sheltered island in Trinity Bay surrounded by two narrow inlets. The water catchment sampled flows into Hickmans Harbour and is sheltered within a narrow, heavily forested valley. Most sites were in rural areas used for forestry and limited farming.

Four sites were sampled on the isthmus of the Avalon near Come-by-Chance (47°50′N, 53°56′W; 35 km southwest of Random Island). The Come-by-Chance system had extensive fen and bog development along the water course with patches of stunted coniferous trees in elevated areas.

Seven sites were sampled in the St. John's region (47°34′N, 52°43′W; 85 km east of Come-by-Chance). All sites were within the urbanized areas. The system is somewhat protected from the cold ocean winds by a range of hills along the coast rising to about 250 m above sea level. Originally, the drainage basins were forested predominantly by mixtures of balsam fir, white spruce, and black spruce but have been extensively reduced by urbanization.

Macroinvertebrate sampling

Quantitative macroinvertebrate samples were collected using artificial-substrate samplers made of crab-net bags (ca. 30 cm long, mesh size ca. 1.5 cm) containing 1 L of roadside gravel (ca. 2.5 cm in diameter). Four samplers were placed in close proximity to one another at each site in the area with the highest current velocity. All four samplers were placed in each outlet in June 1995 and collected, washed, and replaced in July 1995, May 1996, and July 1996. For data analysis, only three of the four artificial-substrate samplers from each site were processed for each sampling date. Samplers were washed several times to remove all macroinvertebrates.

Qualitative data were collected during May and July 1995 and May and July 1996, using a D-frame hand net (mesh size ca. 1 mm). Kick-net samples (Bargos et al. 1990; Whitehurst and Lindsey 1990) were taken in the area of highest current velocity at each site. Sampling was done for 2 min over an area of 2 m^2. A general sweep around the edges of the outlet was also taken to sample macroinvertebrates present in areas of lowest current velocity. Current velocity was measured in the fastest flowing area of each outlet, using an Ott current meter held ca. 2.5 cm above the substrate.

In the laboratory, macroinvertebrates from quantitative samples were identified and counted using a dissecting microscope. For each date, data from three artificial-substrate samplers were pooled for each site and recorded as quantitative data (defined as abundance or number of individuals). The sweep-net samples were examined quickly to identify any macroinvertebrates not collected in the artificial-substrate samplers. Qualitative data (defined as richness or presence/absence) were derived from the data from both the artificial-substrate sampler and the sweep net. Since there were no quantitative samples for May 1995, all organisms were removed from the sweep-net samples and identified.

Macroinvertebrates were identified to the lowest taxonomic level possible (preferably species) using various published keys (Flint 1962; Morihara and McCafferty 1979; Marshall and Larson 1982; Peckarsky et al. 1990; Merritt and Cummins 1996; Wiggins 1996; D.J. Larson, unpublished data). Taxonomic identifications were confirmed by M. Colbo and (or) D.J. Larson of Memorial University of Newfoundland. Taxonomic lists consist of benthic macroinvertebrates identified at various taxonomic levels, and the level of identification for each taxon was consistent among sites.

Statistical analysis

Analysis of variance (ANOVA) was performed using the General Linear Model (GLM) to test whether the four study locations differed significantly ($p < 0.05$) with respect to various EPT diversity and abundance measures. If residuals did not meet the assumptions of the ANOVA model, randomization tests were performed. Fisher's pairwise comparisons were used to determine which study sites and regions were significantly different for those EPT diversity and abundance measures that differed significantly among study sites or regions. Statistical analyses were performed using Minitab Release 11.

Results

Richness and abundance of EPT taxa

A total of 51 taxa were collected from 23 lake-outlet sites (Table 1). Of the 18 genera and 28 species of Ephemeroptera known to occur in Newfoundland (Larson and Colbo 1983), 11 genera and 13 species were identified in the present study. Thirteen plecopteran species in 8 genera occur in Newfoundland (Larson and Colbo 1983); 3 genera and 2 species were recorded in the present study. Of the 46 genera and 124 species of Trichoptera that occur in Newfoundland (Marshall and Larson 1982), 21 genera and 17 species were recorded in the present study. Both taxon richness and abundance were dominated by Trichoptera, particularly Hydropsychidae.

Table 1. Ephemeroptera, Plecoptera, and Trichoptera (EPT) recorded at 23 lake-outlet sites at Bonavista, Random Island, Come-by-

	Bonavista							Random Island				
	B1	B2	B3	B6	B7	B8	B18	R9	R10	R11	R13	R19
Ephemeroptera												
Baetidae												
Acerpenna macdunnoughi	+									+	+	+
Acerpenna pygmaeus	++	++	–				+				+++	
Baetis flavistriga											++	
Baetis tricaudatus	+							+			++++	
Baetidae spp.	+							++				
Caenidae												
Caenis simulans												
Ephemerellidae												
Drunella cornuta								++			+	+
Ephemerella subvaria	++	–			+		+			++	+	
Eurylophella prudentalis	+	+	–		+	+	+	–			+	
Heptageniidae												
Epeorus pleuralis											–	
Heptagenia hebe											++	
Stenonema vicarium								+			+	+
Leptophlebiidae												
Habrophlebia vibrans			++								–	+
Leptophlebia cupida	++	+	+	++	++	+	+	+	++++	+	–	++
Paraleptophlebia spp.		+	++++		+	++	+	+	++	+++	+++	++
Leptophlebiidae spp.	++		+++	++	++++	+	+	+	++		++	
Plecoptera												
Leuctridae												
Leuctra spp.	++++	+	++++	++	+	+	+	++	++	+++	++	–
Nemouridae												
Nemoura macdunnoughi	++	–	+	++++	+	–	++	++	–	+	+++	–
Perlodidae												
Isoperla transmarina	++	–	++			+		++		++	++	
Unidentified Plecoptera								++++				
Trichoptera												
Hydropsychidae												
Cheumatopsyche pettiti	+++++	+++++	+++	+++++	++++	+++++	++++	+++++	+++++	++++		++++
Hydropsyche alternans					+	+	+	++++		+	+++	+
Hydropsyche betteni	+++++	+++++	++++	++++	++++	+++++	+++++	+++++	+++++	+++	–	++++
Hydropsyche slossonae		–			+		+	++		+	+	
Hydropsyche sparna	++++	+++++	++	+++	++++	+++++	+++	+++	++++	+	++	++
Hydropsychidae spp.	+++++	++++	++++	++++	+++	+++++	+++++	+++++	+++++	+++++	++++	
Philopotamidae												
Chimarra sp.	+	+	+++++	+++++	+++++	+++++	–	++++	+++++	+++	+++++	+++++
Dolophilodes distinctus						–				+	+++++	
Philopotamidae spp.						++++						
Polycentropodidae												
Polycentropus spp.	+++	+	+	++	++++	+	+	–	++	+	+	–
Lepidostomatidae												
Lepidostoma spp.	–	–	–	–	–	+	–	–	+	+	–	+
Leptoceridae												
Ceralcea sp.	+			+	+++	+		+	+			+
Mystacides sepulchralis						–			+	–	–	
Oecetis sp.						–		–	+		+	
Limnephilidae												
Limnephilus spp.	–	–		–	–				+		–	
Nemotaulius hostilis	–	–		–	–	+	–	–	+	–	–	
Neophylax spp.			–						++	+	–	++
Platycentropus sp.	–	–	–		–	–	–	–	–	–		–
Pycnopsyche spp.	–	–	+	+	–	+	+	–	++	+	+	+++
Limnephilidae spp.												

Chance, and St. John's, Newfoundland.

Come-by-Chance				St. John's						
C14	C15	C16	C17	S20	S21	S22	S23	S24	S25	S26
	++++		+							
	++		+							
		+	++	+	+		+++		++++	
					–			+		
			++							
			+		++		+		++	
+	–	+	–							
–	+		+							
–	++		+			+				
++	++	++	+	+	–	++	–	+	–	++
+	++	+	+						–	
+	+		+					++		
+	++	+	–							
	+	+	–	++	+	+			+	
	++	+	+	++	+		+		+++	
++++	++++	+++++	+++	+++++	+++++			++++	++++	++
	++	+	++	++			+	–	+++++	
++	+++++	++++	++	+++++	+++	++++	+	+	++++	
		+	+				+		++++	
	++++	++	+	++			+		+++	
+++	++++	++++	+++++		+++++	++++	+++	++++	++++	
	++++	+	+	++++	++++		–	–	+++++	
	+		+					–		
+	–							++		
	–	+	–	+	+			–	–	
	+		+						–	
		–					–	++		+
								+		+
		–		–	+			–	–	–
	–			+					–	–
				+						
–	–		–							
–	–	–	–	+		–			–	++
		+								

Table 1 (*concluded*).

	Bonavista							Random Island				
	B1	B2	B3	B6	B7	B8	B18	R9	R10	R11	R13	R19
Molannidae												
Molanna sp.									–			–
Odontoceridae												
Psilotreta frontalis									+			–
Phryganeidae												
Banksiola sp.						–	–					
Glossosomatidae												
Glossosoma sp.											+	
Hydroptilidae												
Hydroptila metoeca	+	+		+	+	++	+	+	++	+	–	+
Oxytheria sp.	++++	++	++++	+	+++++	++++	+	++	++		++	+
Rhyacophilidae												
Rhyacophila carolina									–		–	
Rhyacophila fuscula	+	+						–		+	+++	
Rhyacophila invaria									+			+
Rhyacophila melita										+	+	
Rhyacophila minora									–	+		
Rhyacophila nigrita												
Rhyacophila vibox												+
Rhyacophila spp.										+		
Diversity	24	22	18	16	21	25	21	25	27	26	36	26
Total abundance	5918	4779	5053	3392	3557	7353	1632	9959	8168	1087	4758	1909

Note: –, taxon present but abundance not recorded; +, 1–9 individuals recorded; ++, 10–49 individuals recorded; +++, 50–99 individuals recorded;

Ephemeroptera

Taxa collected belonged to five families and 12 genera. Only one species per genus was identified, with the exception of the genera *Acerpenna* and *Baetis*: two species were identified for each. *Baetis tricaudatus* was the most widespread and abundant of the four. The family Leptophlebiidae was the most uniformly dispersed and abundant group in most regions, *Leptophlebia cupida* being the only taxon recorded at all sites. This species is the most abundant and widely distributed ephemeropteran in Newfoundland (Larson and Colbo 1983). *Paraleptophlebia* spp., and *Eurylophella prudentalis* were common in all regions except St. John's, whereas *B. tricaudatus* was more common at St. John's sites and *Caenis simulans* occurred only at St. John's sites. Representatives of the family Heptageniidae occurred at Random Island and Come-by-Chance sites only, and in very low numbers. Members of the family Ephemerellidae were widespread but never exceeded 10–49 individuals per taxon at any site.

Plecoptera

Three plecopteran taxa were recorded in the present study, each belonging to a different family. Individuals of the genus *Leuctra* could not be identified to species level. All three taxa were relatively widespread across sites, occurring at 14–19 of the 23 sites, although *Leuctra* spp. did not occur at St. John's sites. Abundance was dominated by *Leuctra* spp.

Trichoptera

Trichopteran taxa recorded in the present study belonged to 12 families and 21 genera. Most taxa could not be identified beyond genus. Of those identified to species, only one taxon was identified for each genus except *Hydropsyche* and *Rhyacophila*. The most widely dispersed and abundant group of Trichoptera were the hydropsychids, the abundance of which often reached 1000+ individuals per taxon per site. Other dominant taxa were of the families Philopotamidae and Hydroptilidae. The abundance of remaining taxa was low, rarely exceeding more than 10–49 individuals per taxon per site. Rhyacophilidae were common at Random Island and Come-by-Chance sites but rare at Bonavista and St. John's sites. Polycentropodidae were common at Bonavista and Random Island sites but rare at Come-by-Chance and St. John's sites.

Comparison of richness and abundance of EPT taxa amongst study regions

Total and mean taxon richness per site were highest at Random Island and lowest at St. John's for all three insect orders (Table 2). ANOVA showed that all richness measures differed significantly among study regions, with the most significant differences between St. John's sites and the remaining three study regions.

Mean ephemeropteran abundance and plecopteran abundance were highest at Random Island and lowest at St. John's (Table 2). Mean trichopteran abundance and total abundance were highest at Bonavista and lowest at Come-by-Chance. ANOVA showed that only total abundance differed significantly among study regions, being significantly higher at Random Island sites than at Come-by-Chance and St. John's sites. Total abundance was also significantly higher at Bonavista sites than at Come-by-Chance sites.

There were also notable differences among sites within regions, based on community structure, further demonstrating

Come-by-Chance				St. John's						
C14	C15	C16	C17	S20	S21	S22	S23	S24	S25	S26
				–						
				–						
	+++	+	+	+	+			+		
+++	++++	++	+	+	++	++		++		
	–		+							
			++	+	+		+		++	
	+		+							
			+							
			++							
	+									
–	+		+							
			++				+		++++	
14	28	19	32	19	14	6	10	14	18	7
384	2454	1413	763	4344	3334	600	180	636	5164	39

++++, 100–499 individuals recorded; +++++, 500+ individuals recorded.

that differences in aquatic community structure could be detected across a small area with a reduced fauna (Table 1). For example, at Bonavista, site B6 had very low taxon richness and abundance. Of the Random Island sites, R13 had comparatively high taxon richness. Both Come-by-Chance sites and St. John's sites had a wide range of taxon richness, from 14 to 32 at Come-by-Chance and from 6 to 19 at St. John's.

Discussion

Overall, taxon richness was low compared with similar studies on the North American mainland (Frison 1935; Ricker 1947; Burks 1953; Wiggins and Mackay 1978; Peterson and van Eeckhaute 1990; Burian and Gibbs 1991), including those carried out in northern boreal regions (Sprules 1947; Singh et al. 1984; Harper 1989). However, richness of EPT fauna was similar to that found by Stirling and Clemens (1986; 42 taxa) in the Waterford River System in St. John's, Newfoundland, and by Clarke and Scruton (1997; 26 taxa) in a survey of riffle communities in 20 Newfoundland rivers.

Taxonomic lists and distributions were comparable to those reported by Larson and Colbo (1983). Those authors described most taxa recorded in the present study as having a general distribution across the island, with the exception of *Rhyacophila*. Five of the nine species of this genus on the island were believed to be restricted to the Long Range Mountains in the western portion of the island; however, seven species were recorded in the present study. Therefore, *Rhyacophila* species are more broadly distributed than was previously believed.

Most taxa in the present study were previously observed at outflows (Larson and Colbo 1983), with a small number of exceptions. These include the ephemeropterans *Epeorus pleuralis*, *Stenonema vicarium*, *Paraleptophlebia* spp., and *C. simulans* and the trichopterans *Cheumatopsyche pettiti*, *Chimarra* sp., *Dolophilodes distinctus*, *Lepidostoma* spp., *Nemotaulius hostilis*, *Neopyhlax* spp., *Platycentropus* sp., and *Psilotreta frontalis*, all of which have a lotic distribution except *C. simulans*. This taxon is primarily lentic but does occur in areas of flowing water (Larson and Colbo 1983). No new species were reported in the present study.

The present data support the hypothesis that regional differences in the composition of aquatic insect communities can be detected on the island of Newfoundland despite the reduced insect fauna dominated by widespread taxa. Differences in taxon richness and abundance among regions, and among sites within regions, were sufficient to show regional richness and abundance patterns. For example, Random Island had the richest fauna and highest recorded abundance, although faunal composition and abundance differed markedly among sites. In contrast, site C14 at Come-by-Chance had the lowest richness and abundance outside the urbanized St. John's region. St. John's sites generally had the most reduced taxon richness, although richness and abundance at four sites remained relatively high. These patterns were evident even when the comparison was restricted to four regions within 120 km of St. John's in eastern Newfoundland. These findings support the argument of Vinson and Hawkins (1998) that although regional effect has not often been taken into account when comparing habitats, it is clearly necessary.

Our results indicate that lake-outlet habitats in Newfoundland have diverse EPT faunas relative to the total fauna of

Table 2. Results of ANOVAs (*p* values) and Fisher's pairwise comparisons for EPT richness and abundance measures (0.05 significance level).

	N	Total	Mean ± SD	*p**
Richness				
Ephemeroptera				
Bonavista	7	8	4.14±1.68*ab*	<u>0.007</u>
Random Island	5	13	6.60±3.78*a*	
Come-by-Chance	4	10	6.50±2.65*a*	
St. John's	7	6	2.57±1.13*b*	
Plecoptera				
Bonavista	7	3	2.57±0.53*a*	0.006
Random Island	5	3	2.60±0.55*a*	
Come-by-Chance	4	3	2.50±1.00*a*	
St. John's	7	2	1.14±0.90b	
Trichoptera				
Bonavista	7	23	14.29±2.69*a*	**0.002**
Random Island	5	30	18.80±2.28*b*	
Come-by-Chance	4	24	14.25±5.19*ab*	
St. John's	7	22	9.14±4.10*c*	
Total richness				
Bonavista	7	34	21.00±3.16*a*	**0.001**
Random Island	5	46	28.00±4.53*b*	
Come-by-Chance	4	37	23.00±8.60*ab*	
St. John's	7	30	12.86±4.98*c*	
Abundance				
Ephemeroptera				
Bonavista	7	711	101.57±323.60*a*	0.542
Random Island	5	854	170.8±382.55*a*	
Come-by-Chance	4	436	109±272.94*a*	
St. John's	7	407	58.14±255.39*a*	
Plecoptera				
Bonavista	7	650	92.86±307.94*a*	<u>0.146</u>
Random Island	5	490	98±220.14*a*	
Come-by-Chance	4	69	17.25±53.08*a*	
St. John's	7	100	14.29±61.54*a*	
Tricoptera				
Bonavista	7	30 323	4331.86±4948.22*a*	<u>0.056</u>
Random Island	5	24 537	4907.4±8509.38*a*	
Come-by-Chance	4	4 509	1127.25±1545.34*a*	
St. John's	7	13 790	1970±5553.88*a*	
Total abundance				
Bonavista	7	31 684	4526±1865*ab*	<u>0.030</u>
Random Island	5	25 881	5176±3853*b*	
Come-by-Chance	4	5 014	1254±906*c*	
St. John's	7	14 297	2042±2170*ac*	

Note: Values followed by the same letter are not significantly different.
*Boldface type denotes residuals that met the assumptions of the ANOVA model; underlined values were randomized.

the island. Although Plecoptera were poorly represented at the outlets, species number is known to decrease from west to east, with only five species previously recorded on the eastern Avalon Peninsula (Larson and Colbo 1983). Furthermore, Newfoundland outlets conform to the general pattern of outlet communities summarized by Richardson and Mackay (1991). Taxon richness was dominated by Trichoptera, particularly filter-feeders, at all sites, a finding similar to those of Richardson and Mackay (1991) and Townsend et al. (1983).

Only one other Newfoundland study of aquatic insect communities exists for comparison, therefore we cannot determine whether insect communities in Newfoundland outlets are indeed unique. Clarke and Scruton (1997) studied aquatic insect communities of riffle areas in 20 rivers across the island. Fewer ephemeropteran and trichopteran genera were recorded than in the present study, and plecopterans were identified to order only. Eight ephemeropteran genera were reported compared with 12 in the present study; 6 of these were observed in both studies. Clarke and Scruton (1997) recorded 17 trichopteran genera compared with 21 in the present study; 12 of these were recorded in both. There were also notable differences in dominance and frequency of taxa between the two studies. Several genera including *Acerpenna*, *Baetis*, *Cheumatopsyche*, *Leptophlebia*, and *Chimarra* were widespread throughout the outlets but occurred infrequently or were absent from the riffle sites. None of the five limnephilid genera recorded at the outlets were present at the riffle sites, where only one limnephlid genus was recorded. Genera more widespread at the riffle sites included *Heptagenia*, *Habrophlebia*, *Dolophilodes*, and *Glossosoma*.

Although we cannot conclude that outlet insect communities are indeed unique, the data do show that outlets are useful for comparative studies. This is beneficial, as outlets may offer easier assess and more uniform sampling across sites than lentic areas or areas farther downstream. Furthermore, because this is the first extensive comparative study of Newfoundland outlet communities, it provides a base-line measure for comparing the results of future studies of Newfoundland aquatic insects, particularly at outlets.

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