Zoogeographical Relationships of Aquatic Insects (Ephemeroptera, Plecoptera, and Trichoptera) from the Eastern James Bay Drainage

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An analysis of the aquatic insect fauna of the eastern James Bay drainage was conducted on the basis of specimens assembled in 1973-1982 during several impact studies related to the major hydroelectric projects conducted in the area. 220 species were collected in the orders Plecoptera (22), Ephemeroptera (50), and Trichoptera (148). The faunistic elements recognized include the Holarctic (16 species), the northern transcontinental (42), the continental (28), the central (1) various eastern (113), and the Appalachian (14) elements. Endemism (2 species) is probably only apparent, and the two species are likely to belong to wider ranging assemblages. The arctic element was totally lacking. Two main pathways for colonization are suggested, one from Northwestern refugia and another from Southern refugia, probably through the Mississippi-St. Lawrence waterways. Dispersal appears to have been greatest in Trichoptera and least in Plecoptera; respective importances of the transcontinental fauna vary from 14% (Plecoptera) to 47.3% (Trichoptera), while the eastern fauna represents from 47.3% in the Trichoptera to 71% in the Plecoptera. Comparisons with six Northeastern sites show a high similarity (80% in the Trichoptera) with two sites at corresponding latitudes, but only a moderate (< 50%) similarity with more southerly sites (46-47° N). Though the fauna has few original elements, its peculiarity resides in its species composition and its position at the entry point for western boreal elements into the Québec-Labrador Peninsula.

Key Words: Aquatic insects, mayflies, stoneflies, caddisflies, James Bay, distribution, zoogeography.

Extensive and intensive collections of aquatic biota were carried out in 1973-1982 in the eastern drainage of James Bay (Québec) as part of preimpoundment environmental studies for giant hydroelectric projects. These studies conducted by various teams under the auspices of the Société d'Energie de la Baie James (S.E.B.J.) accumulated a large number of aquatic insects. Though various reports and theses (see below) contain information on some of the species, no comprehensive discussion of the fauna and its zoogeographical relationships has been attempted, except on limited groups (Pilon et al. 1978; Landry and Harper 1985).

This paper presents a critical list of the species collected in the orders Ephemeroptera, Plecoptera and Trichoptera, shows the relationships of this fauna with other North American assemblages, and discusses its origins.

Materials and Methods

The specimens examined are from four sources: (1) a general survey conducted during the summer of 1973 in the areas of Lakes Sakami (Figure 1:C) and Attila (Figure 1:A) in the La Grande Rivière drainage, of River Opinaca (Figure 1:D), and of Lake Low (Figure 1:E) (Pilon and Méthot 1974; Pilon et al. 1978). (2) a systematic study of the aquatic habitats in and around Lakes Hélène and Nathalie (= Detcheverry) in the drainage of the Rivière au Castor (Figure 1:B) in the summer 1974 (Pilon et al. 1975). (3) a continuing study in the same area in 1975 concentrating on Lake Hélène and the Rivière au Castor (Fréchette 1976). (4) an impact study in 1976-1978, and 1982 on the development of a reservoir on Rivière Desaulniers (Figure 1:A) within the drainage of La Grande Rivière (Boucher et Lemire 1980; Hunter 1985).

Insects were collected mainly from emergence traps. Some light-trapping was also conducted.

All the material has been deposited in the Ouellet-Robert Entomological Collection of the Département de Sciences biologiques (Université de Montréal).

Study Area

The sampling area is situated in a rectangle delimited by the meridians 76° and 78° W and the parallels 52° and 54° N (Figure 1). It extends from the lower drainage of the La Grande Rivière to those of the rivers Opinaca and Eastmain. In Rousseau's (1952) classification, the region belongs to the mid-subarctic bioclimatic zone which is characterized by a growing season of 1000 to 1200 degree-days (above 5°C), a frost-free period of some 90 days, a mean annual temperature of between -1 and -4°C, and annual precipitation of the order of 60-70 cm, 35% of which comes as snow. The altitude is generally

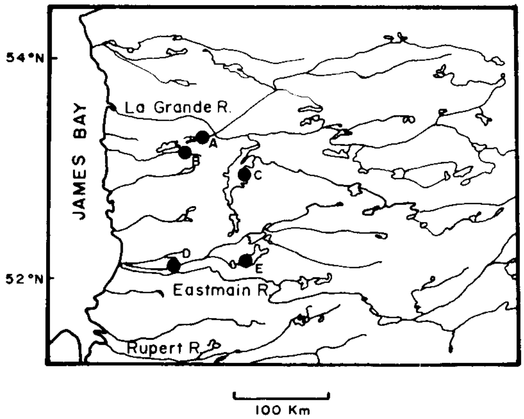

FIGURE 1. Map of the eastern shore of James Bay showing the main sampling sites: A: Lac Attila and Rivière Desaulniers, B: Rivière au Castor, C: Lac Sakami, D: Rivière Opinaca, E: Lac Low.

between 100 and 200 m. The region is part of the Eastmain and Larch Lowlands.

Following the last ice age, much of the area was covered by the Tyrrell Sea (Figure 3), an extension of Hudson and James Bays. The glaciers retreated and re-extended many times, the final retreat some 8000 years ago. The landscape is dominated by rolling hills of gneiss and granite interspersed with shallow glacial deposits (mainly clay and moraine), small glacial lakes, many aligned on an east-west axis, and many bogs. The terrestrial vegetation is dominated by open forests (10 to 55% cover) of Black Spruce (*Picea mariana*) (mean height 9 m) with an undercover of mosses and *Ledum* (Anonymous 1978).

The waters are slightly acidic (pH 6.2-6.8), unmineralized (conductivity = 14-38 umhos) and soft (hardness < 14 mg/L); phosphates are rare (< 0.07 mg/L), but total organic carbon is relatively high (4-19 mg/L). Surface temperatures reach 20°C in the summer.

The Fauna

Table I lists the 220 species from the three orders collected at the James Bay sites. Also indicated are each species' geographical distribution and its occurrence at comparison sites.

The geographical distributions are grouped into somewhat arbitrary types which for the most part follow Scudder (1979) and Nimmo (1971) and are based on commonly observed patterns; representative patterns are illustrated in Figure 2. In instances where it was not possible to assign a species to only one type, it was tallied in two categories, each as a half-unit.

Continental (CT): species which are found throughout most of North America, except in extreme environments.

Northern transcontinental (NT): species inhabiting the northern part of the continent, some extending south of the glaciated regions. NTd indicates a discontinuous distribution, with no records from central areas, and HL, Holarctic species.

Shield (SH): species with a wide distribution in the Northeast extending westwards into the Mackenzie drainage, but not crossing the Rockies. Some occur as far south as the Mississippi drainage.

Northeastern (NE): species typically distributed in the glaciated Northeast, but absent from the Prairies and the Northwest Territories.

Mississippian (MS): species whose distribution is centered on the Mississippi and Great Lakes-St. Lawrence drainages.

Appalachian (AP): species inhabiting the Appalachian range, often extending ito the Maritime Provinces and onto the Québec North Shore.

Cordilleran (CD): species typically distributed in the Rocky Mountains and other ranges of the Cordillera.

Central (CN): species colonizing the centre of the continent, the upper Mississippi drainage and the Great Plains (not illustrated).

The comparison sites are points of Québec and Ontario (Figure 3) from which data are available for comparison with the James Bay fauna (jb):

St. Martin Falls, Albany River (mf): specimens collected in the 1820s by George Barnston, a factor for the Hudson Bay Company, and deposited in the British Museum where they were studied by Walker (1852, Plecoptera [*see also* Ricker 1938, 1944; Trichoptera, *revised by* Betten and Mosely 1940] 1853, Ephemeroptera).

Algonquin Park (al): a stream system studied by Sprules (1947), with data on Plecoptera (*see also* Harper 1970) and Trichoptera.

Parc du Mont-Tremblant (tr): collections from the Rivière du Diable and tributaries; the Trichoptera were studied by Robert (1958) and Roy and Harper (1975), the Plecoptera by Ricker et al. (1968).

Station de Biologie de l'Université de Montréal, St-Hippolyte (sb): the Ephemeroptera were investigated by Harper and Harper (1982) and the Trichoptera by Roy and Harper (1981). The Plecoptera are from an unpublished list prepared by the author.

St. Lawrence River (sl): the Trichoptera are known from the study of Corbet et al. (1966) and the Ephemeroptera from Harper and Harper (1976).

Matamek River (mt): a partial list of Trichoptera is drawn from Williams and Williams (1979).

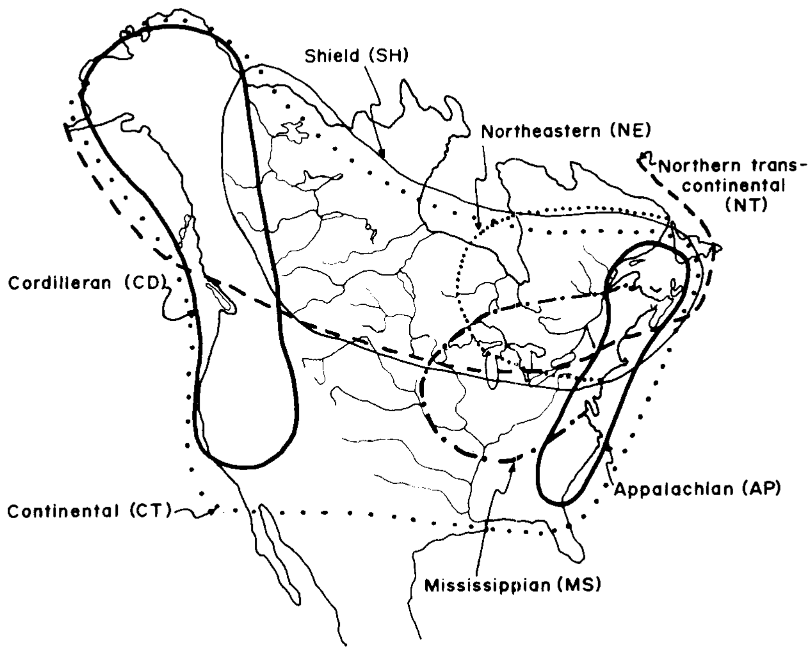

FIGURE 2. Distribution patterns used in this study (with abbreviations) superposed on a map of North America.

Ephemeroptera

Fifty species were collected of which 48 can be named (Table 1). Only one endemic element, *Caenis candida* (species number 44), was discovered (Harper and Harper 1981).

Three of the species are Holarctic (2, 6, 35), one is northern transcontinental (1), and eight continental (9, 11, 12, 31, 33, 46, 48, 49). The rest have an eastern distribution, most of these of type MS; some are Appalachian (5, 15, 28, 30, 40, 42, 50; *Siphloplecton basale* (5), though Appalachian, extends to the northwest to the Rockies). Finally one species (43) has a more south-central distribution (CN).

By comparison with other northeastern sites, the fauna is rich (45 species in sb and 25 in sl); about half the species are shared with the two southern sites (25/45, 11/25). Seven of the 11 species found at mf also occur in our list.

Fourteen species are exclusive to jb; of these, six are of particular interest and most are boreal (1, 3, 5, 6, 38, 39), particularly *Metretopus borealis* (6) and *Ameletus subnotatus* (1).

On the basis of early surveys (Harper et al. 1975; Harper and Harper 1981), other boreal elements, such as *Parameletus* spp. and *Rhithrogena jejuna* Eaton, would have been expected. No truly arctic species, such as *Baetis macani bundyae* Lehmkuhl and other specialized baetids (Harper and Harper 1981), were encountered.

Plecoptera

Twenty-two species (21 named) were found in the area. All are common, except a species (designated as *Cultus* cf. *aestivalis* (Needham and Claassen) by Stark et al. 1988) of Cordilleran affinities.

None of the species is Holarctic, and 3 are northern transcontinental (51, 54, 62). All the other species are restricted to the east, a majority (9 species) from the Mississippi-St. Lawrence fauna; 2 are Appalachian (61, 72).

The fauna is distinctly poorer than in the southern sites (31 species at al, 37 at sb, 31 at tr) and 10-11 species are common to jb and each of these sites. Of the 9 species known from the Albany River, only 3 (56, 62, 63) have been found in our samples.

Consequently, a number of northern species that were expected did not appear: *Allocapnia minima* (Newport), *Oemopteryx glacialis* (Newport), *Acroneuria lycorias* (Newman), *Isoperla citronella* (Walker), *Cultus decisus* (Walker), *Isogenoides olivaceus* (Walker), *Haploperla brevis* (Banks), *Acroneuria abnormis* (Newman), and *Paragnetina immarginata* (Say) from Ricker (1944); also lacking are *Paraleuctra sara* (Claassen), *Capnura manitoba* (Claassen), *Utacapnia labradora* (Ricker), *Zapada kathadin* Baumann and Mingo, *Taenionema atlanticum* Ricker and Ross, *Claassenia sabulosa* (Banks), *Helopicus subvar-*

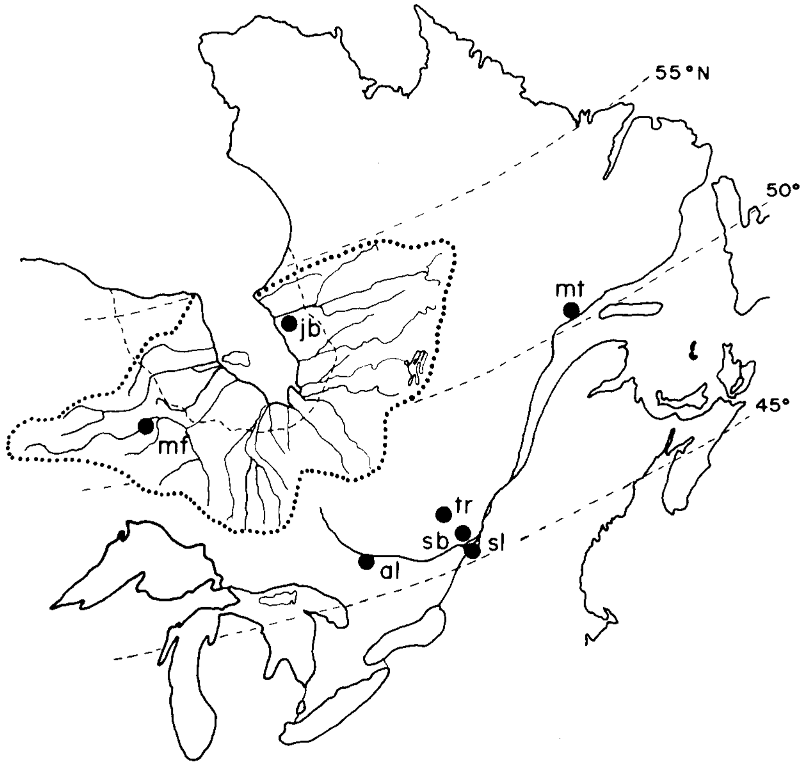

FIGURE 3. The James Bay drainage. The interrupted line around the Bay indicates the extension of the Tyrrell Sea. The comparison sites are also indicated: al: Algonquin Park, jb: this study, mf: St. Martin Falls, Albany River, mt: rivière Matamek, sb: Station de Biologie (St-Hippolyte), sl: St. Lawrence River, tr: Mont Tremblant Park.

ians (Banks), *Isoperla montana* (Banks), *Alloperla concolor* Ricker, *Suwallia marginata* (Banks), *Sweltsa naica* (Provancher), *S. onkos* Ricker from Ricker et al. (1968).

No truly arctic element (e.g. *Capnia sugluka* Ricker) was encountered, but 6 mostly boreal species (51, 56, 61, 64, 65, 66) did not occur in the southern comparison sites.

Trichoptera

The caddisfly list contains 148 species, which represents about half of those known from Québec (Roy and Harper 1979). Few seem to be endemic; *Oxyethira barnstoni* Harper has been shown to be Holarctic (= *O. mirabilis* Morton, *fide* Kelley 1982); *Goera radissonica* Harper and Méthot is still considered a valid species (Schmid 1983).

Twelve of the species are Holarctic and most of these are northern transcontinental; 38 others are northern Nearctic transcontinental, 8 of which have disjunct distributions (NTd), but in most species this is probably due to insufficient collecting. Twenty more are continental (CT). Some 47% of the species belong to a fauna widely distributed over at least the northern half of the continent. The others (47%) are typically eastern, again with a majority from the Mississippi-St. Lawrence fauna (36 species). Few are Appalachian (75, 77, 78, 129, 179 in part, 180, 217). One, *Wormaldia gabriella* (84), is Cordilleran.

Affinities with other subarctic faunas (mf and mt) are high with some 80% of species in common (25/31 at mf, 39/46 at mt). Similarity with more southerly sites is lower, generally of the order of 50% or less (26/52 at al, 76/170 at tr, 88/180 at sb, 37/99 at sl). By comparison with southern sites, there are 35 particular species, 5 of which are Phryganeidae and 15 Limnephilidae, the latter a dominant group in northern faunas (Lehmkuhl and Kerst 1979).

A few species, mainly from Walker's list, were expected but not found; these are *Chimarra obscura* (Walker), *Ceraclea mentiaea* (Walker), *Chilostigma aerolatum* (Walker), and *Brachycen-*

TABLE 1. List of the species collected in the eastern James Bay drainage (1973-1982). Also given are the distribution type (AP: Appalachian, CD: Cordilleran, CN: Central, CT: Continental, HL: Holarctic, MS: Mississippian, NE: Northeastern, NT: Northern Transcontinental, SH: Canadian Shield). The other symbols indicate presence of the species at the comparison sites (al: Algonquin Park, mf: St. Martin's Falls, mt: Matamek, sb: Station de biologie, sl: St. Lawrence River, tr: Mont Tremblant Park).

EPHEMEROPTERA		
Family Siphlonuridae		
1.	*Ameletus subnotatus* Eaton	NT
2.	*Siphlonurus alternatus* (Say)	HL — sb, sl
3.	*Siphlonurus quebecensis* (Provancher)	MS
4.	*Siphlonurus rapidus* McDunnough	MS
Family Metretopodidae		
5.	*Siphloplecton basale* (Walker)	SH/AP
6.	*Metretopus borealis* (Eaton)	HL
Family Baetidae		
7.	*Acerpenna pygmaea* (Hagen)	MS — sb
8.	*Baetis brunneicolor* McDunnough	MS
9.	*Baetis flavistriga* McDunnough	MS — sb
10.	*Baetis propinquus* (Walsh)	CT — sb
11.	*Baetis tricaudatus* Dodds	CT
12.	*Callibaetis ferrugineus* (Walsh)	CT — sb, sl
13.	*Centroptilum album* McDunnough	MS
14.	*Centroptilum rufostrigatum* McDunnough	MS — sb
15.	*Centroptilum venosum* Traver	AP
16.	*Cloeon rubropictum* McDunnough	NE
17.	*Cloeon* sp. 1	
18.	*Pseudocloeon parvulum* McDunnough	MS
19.	*Pseudocloeon* sp. 1	
Family Heptageniidae		
20.	*Arthroplea bipunctata* McDunnough	NE — sb, sl
21.	*Epeorus vitreus* (Walker)	NE — mf
22.	*Heptagenia lucidipennis* (Clemens)	NE
23.	*Heptagenia pulla* (Clemens)	NE — sb, sl
24.	*Stenacron interpunctatum canadense* (Walker)	MS — mf, sb, sl
25.	*Stenacron interpunctatum frontale* (Banks)	NE — sb, sl
26.	*Stenonema femoratum* (Say)	MS — sb
27.	*Stenonema vicarium* (Walker)	MS — sb, sl
Family Leptophelebiidae		
28.	*Habrophlebia vibrans* Needham	AP — sb
29.	*Leptophlebia cupida* (Say)	MS/SH - sb
30.	*Leptophlebia johnsoni* McDunnough	AP — sb
31.	*Leptophlebia nebulosa* (Walker)	CT — mf, sb
32.	*Paraleptophlebia adoptiva* (McDunnough)	MS — sb
33.	*Paraleptophlebia debilis* (Walker)	CT — sb
34.	*Paraleptophlebia mollis* (Eaton)	MS
Family Ephemerellidae		
35.	*Ephemerella aurivillii* Bengtsson	HL
36.	*Ephemerella* nr *excrucians* Walsh	NE
37.	*Emphemerella invaria* (Walker)	NE — mf, sl
38.	*Ephemerella needhami* McDunnough	NE
39.	*Ephemerella septentrionalis* McDunnough	NE
40.	*Euryllophella prudentalis* McDunnough	AP
41.	*Euryllophella temporalis* McDunnough	MS — sb, sl
42.	*Euryllophella verisimilis* McDunnough	AP — sb
Family Caenidae		
43.	*Brachycercus* prob. *prudens* (McDunnough)	CN
44.	*Caenis candida* Harper & Harper	—
45.	*Caenis forcipata* McDunnough	MS
46.	*Caenis simulans* McDunnough	•CT — sb, sl
Family Baetiscidae		
47.	*Baetisca laurentina* McDunnough	MS
Family Ephemeridae		
48.	*Ephemera simulans* Walker	CT — mf, sb, sl
49.	*Hexagenia limbata* Walker	CT — mf, sb, sl

TABLE 1. *Continued*

50. *Litobrancha recurvata* (Morgan)	AP — sb
PLECOPTERA	
Family Nemouridae	
51. *Amphinemura linda* (Ricker)	NT — sb
52. *Nemoura trispinosa* Claassen	NE — al, tr
53. *Podmosta macdunnoughi* (Ricker)	NE — tr
54. *Shipsa rotunda* Claassen	NT — al, tr
Family Taeniopterygidae	
55. *Taeniopteryx parvula* Banks	MS
Family Capniidae	
56. *Capnia vernalis* Newport	SH — mf
57. *Paracapnia* sp.	
Family Leuctridae	
58. *Leuctra ferruginea* Walker	MS — al, sb, tr
59. *Leuctra tenella* Provancher	NE — al, sb, tr
60. *Leuctra tenuis* Pictet	MS — al, sb, tr
61. *Leuctra triloba* Claassen	AP
Family Pteronarcyiidae	
62. *Pteronarcys dorsata* (Say)	NT — tr
Family Perlidae	
63. *Paragnetina media* (Walker)	MS — sb, mf, tr
Family Perlodidae	
64. *Cultus* cf. *aestivalis* (Needham & Claassen)	AP — mf
65. *Isogenoides frontalis* (Newman)	SH
66. *Isoperla bilineata* (Say)	SH
67. *Isoperla cotta* Ricker	MS — sb
68. *Isoperla frisoni* Illies	MS — al, sb, tr
69. *Isoperla lata* Frison	MS — al, sb
70. *Isoperla marlynia* (Needham & Claassen)	MS — al, sb
71. *Isoperla transmarina* (Newman)	MS — al, sb, tr
Family Chloroperlidae	
72. *Alloperla atlantica* Baumann	AP — al, sb, tr
TRICHOPTERA	
Family Rhyacophilidae	
73. *Rhyacophila angelita* Banks	NTd
74. *Rhyacophila brunnea* Banks	NTd — mt
75. *Rhyacophila carolina* Banks	AP — al, sb, tr
76. *Rhyacophila fuscula* (Walker)	MS — al, mf, mt, tr
77. *Rhyacophila invaria* (Walker)	AP — al, tr
78. *Rhyacophila minora* Banks	AP — tr
Family Glossosomatidae	
79. *Glossosoma intermedium* (Klapalek)	HL/NT — mt
80. *Glossosoma lividum* (Hagen)	NE — sl, tr
81. *Glossosoma nigrior* Banks	MS — sb, sl
Family Philopotamidae	
82. *Chimarra aterrima* Hagen	MS — al, mt, sb, tr
83. *Dolophilodes distinctus* (Walker)	MS — al, mt, sb, tr
84. *Wormaldia gabriella* (Banks)	CD
Family Psychomyidae	
85. *Lype diversa* (Banks)	SH/MS — al, mt, sb, tr
Family Hyalopsychidae	
86. *Phylocentropus lucidus* (Hagen)	MS
87. *Phylocentropus placidus* (Banks)	MS — al, mt
Family Polycentropodidae	
88. *Neureclipsis crepuscularis* (Walker)	SH/MS — al, mf, mt, sb, sl, tr
89. *Neureclipsis valida* (Walker)	SH — sb, sl, tr
90. *Nyctiophylax moestus* Banks	NT — mt, sb, sl
91. *Polycentropus albipunctus* (Banks)	SH — sb, tr
92. *Polycentropus aureolus* (Banks)	NT — sb
93. *Polycentropus cinereus* Hagen	CT — al, sb, sl, tr
94. *Polycentropus confusus* Hagen	MS — al, mt, sb, tr

TABLE 1. *Continued*

95. *Polycentropus flavus* (Banks)	CT — sb, tr
96. *Polycentropus iculus* Ross	SH — mt, sb, tr
97. *Polycentropus pentus* Ross	MS — al, sb, tr
99. *Polycentropus remotus* Banks	NT – sb, tr
100. *Polycentropus smithae* Denning	NT — sb, tr
101. *Polycentropus weedi* Morse & Blickle	NT — sb
Family Arctopsychidae	
102. *Arctopsyche ladogensis* (Kolenati)	HL/NT — mt
Family Hydropsychidae	
103. *Cheumatopsyche campyla* Ross	CT al, sb, sl, tr
104. *Cheumatopsyche gracilis*	CT — al, mt, sb, sl, tr
105. *Cheumatopsyche pettiti* Banks	CT — al, sb, sl, tr
106. *Cheumatopsyche speciosa* (Banks)	MS — sl, tr
107. *Hydropsyche alhedra* Ross	MS — sb
108. *Hydropsyche alternans* (Walker)	NT — al, mf, sb, tr
109. *Hydropsyche betteni* Ross	MS — al, sb, tr
110. *Hydropsyche bifida* Banks	CT — sb, sl
111. *Hydropsyche confusa* (Walker)	NT — sl
112. *Hydropsyche morosa* (Hagen)	MS — al, mt, sb, sl, tr
113. *Hydropsyche slossonae* Banks	NT — sb
114. *Hydropsyche sparna* Ross	MS — al, mt, sb, tr
115. *Hydropsyche walkeri* Betten & Mosely	MS – mf, sb, sl, tr
116. *Parapsyche apicalis* (Banks)	MS — al, sb, tr
Family Hydroptilidae	
117. *Agraylea multipunctata* Curtis	HL/NT — sl
118. *Hydroptila rono* Ross	CT
119. *Hydroptila wyomia* Denning	SH — sb
120. *Hydroptila xera* Ross	CT
121. *Oxyethira aeola* Ross	CT
122. *Oxyethira allagashensis* Blickle	NE
123. *Oxyethira anabola* Blicke	NE —tr
124. *Oxyethira araya* Ross	NE
125. *Oxyethira grisea* Betten	NE – sb
126. *Oxyethira michiganensis* Moseley	CT — sb
127. *Oxyethira mirabilis* Morton	HL/NE
128. *Oxyethira obtatus* Denning	NE
129. *Oxyethira rivicola* Blickle & Morse	NE/AP — sb
130. *Oxyethira serrata* Ross	NT — tr
131. *Oxyethira zeronia* Ross	MS — sb
Family Phrygaeneidae	
132. *Agrypnia colorata* (Milne)	NT
133. *Agrypnia deflata* (Milne)	NT
134. *Agrypnia glacialis* Hagen	NT
135. *Agrypnia improba* (Hagen)	NT — mt, sb
136. *Agrypnia macdunnoughi* (Milne)	NT
137. *Agrypnia straminea* Hagen	NT — sb, sl, tr
138. *Agrypnia vestita* (Walker)	MS — sb, sl, tr
139. *Banksiola crotchi* Banks	NT — sb
140. *Banksiola dossuaria* (Say)	NE — sb, sl
141. *Beothukus complicatus* (Banks)	NE
142. *Oligostomis ocelligera* (Walker)	MS? — tr
143. *Oligostomis pardalis*	NE — mt
144. *Phryganea cinerea* Walker	NT — mf, sb, tr
145. *Ptilostomis semifasciata* (Say)	NT — mf, mt, sb, tr
Family Limnephilidae	
146. *Anabolia bimaculata* (Walker)	CT – mf, mt, sb, tr
147. *Anabolia consocia* (Walker)	MS - al. sb, tr
148. *Anabolia sordida* Hagen	MS
149. *Apatania nigra* (Walker)	NE — mf
150. *Apatania stigmatella* (Zetterstedt)	HL/NT
151. *Apatania zonella* (Zetterstedt)	HL/NT — sb
152. *Arctopora pulchella* (Banks)	NTd — sb, tr

TABLE 1. *Continued*

153. *Asynarchus curtus* (Banks)	CT — mt, sb
154. *Chyrandra centralis* (Banks)	NTd — mt
155. *Glyphopsyche irrorata* (Fabricius)	NTd — mf, sb, sl
156. *Hesperophylax designatus* Banks	NE — mf
157. *Hydatophylax argus* (Harris)	NE — sb, tr
158. *Lenarchus crassus* (Banks)	NTd — sb
159. *Limnephilus argenteus* Banks	MS
160. *Limnephilus canadensis* Banks	SH
161. *Limnephilus externus* Hagen	HL/NT — sb
162. *Limnephilus extractus* Walker	MS — mf
163. *Limnephilus femoralis* Kirby	HL/NT
164. *Limnephilus hageni* Banks	NT
165. *Limnephilus indivisus* Walker	MS — mf, sb, sl, tr
166. *Limnephilus infernalis* (Banks)	CT — sb, sl, tr
167. *Limnephilus minusculus* (Banks)	CT
168. *Limnephilus moestus* Banks	NTd — mt, sb, sl, tr
169. *Limnephilus nimmoi* Roy & Harper	SH — tr
170. *Limnephilus ornatus* Banks	HL/NT — sb, sl, tr
171. *Limnephilus partitus* Walker	NT — mf
172. *Limnephilus parvulus* (Banks)	SH
173. *Limnephilus rhombicus* (Linné)	HL/NT — mf, sb, tr
174. *Limnephilus rossi* Leonard & Leonard	NE
175. *Limnephilus sericeus* (Say)	NTd — mf, sb, tr
176. *Limnephilus sublunatus* (Provancher)	CT — tr
177. *Nemotaulius hostilis* Hagen	CT — sb, sl, tr
178. *Neophylax aniqua* Ross	NE — sb
179. *Neophylax concinnus* MacLachlan	NE/AP — al, sb
180. *Neophylax nacatus* Denning	AP — met, sb, tr
181. *Neophylax oligius* Ross	NE — sb, tr
182. *Onocosmoecus unicolor* (Banks)	NT — mt, sb, tr
183. *Phanocoelia canadensis* (Banks)	SH
184. *Platycentropus amicus* (Hagen)	NE
185. *Platycentropus radiatus* (Say)	MS — sb, tr
186. *Psychoglypha subborealis* (Banks)	CT — sb
187. *Pycnopsyche guttifer* (Walker)	CT — al, mf, mt, sb, tr
188. *Pycnopsyche lepida* (Hagen)	MS — mf, mt, sb, sl, tr
189. *Pycnopsyche limbata* (Maclachlan)	NE — sb, tr
Family Goeridae	
190. *Goera radissonica* Harper & Méthot	HL/NE
Family Leptoceridae	
191. *Ceraclea albosticta* (Hagen)	MS
192. *Ceraclea ancylus* (Vorhies)	MS — sb, sl, tr
193. *Ceraclea annulicornis* (Stephens)	HL/NT — sl, tr
194. *Ceraclea cancellata* (Betten)	MS — sb, tr
195. *Ceraclea diluta* (Hagen)	MS — al, sb, tr
196. *Ceraclea excisa* (Morton)	HL/NT
197. *Ceraclea resurgens* (Walker)	NT — mf, sb, sl, tr
198. *Ceraclea transversa* (Hagen)	MS — sb, sl
199. *Mystacides interjecta* (Banks)	NT — sb
200. *Mystacides sepulchralis* (Walker)	NT — al, mf, sb, tr
201. *Nectopsyche albida* (Walker)	NT — mf, sl, tr
202. *Oecetis immobilis* (Hagen)	NT — sl
203. *Oecetis inconspicua* (Walker)	Ct — al, sb, sl, tr
204. *Oecetis nocturna* Ross	MS — sb, tr
205. *Setodes incertus* (Walker)	MS — mf, sb, tr
206. *Triaenodes baris* Ross	NT — sb, tr
Family Odontoceridae	
207. *Psilotreta indecisa* (Walker)	NE — mf, mt, sl, tr
Family Molannidae	
208. *Molanna blenda* Sibley	NE — sb
209. *Molanna flavicornis* Banks	NT — sl
210. *Molanna tryphena* Betten	NE — sb, tr

TABLE 1. *Concluded.*

211. *Molanna ulmerina* Navas	MS — sb, sl, tr
212. *Molanna uniophila* Vorhies	NE — sl
Family Lepidostomatidae	
213. *Lepidostoma costale* (Banks)	NE — al, sb, tr
214. *Lepidostoma modestum* (Banks)	NE
215. *Lepidostoma prominens* (Banks)	NE — mt, sb, tr
216. *Lepidostoma strophis* Ross	NT
217. *Lepidostoma swannanoa* Ross	AP — mt, sb, tr
218. *Lepidostoma togatum* (Hagen)	MS — mt, sb, sl, tr
219. *Lepidostoma unicolor* (Banks)	NT
Family Helicopsychidae	
220. *Helicopsyche borealis* (Hagen)	CT — sb, sl

trus fuliginosus Walker. Others include *Agrypnia pagetana* Curtis, *Limnephilus picturatus* McLachlan, and *Asynarchus lapponicus* Zetterstedt, all Holarctic species (Lehmkuhl and Kerst 1979), as well as *Limnephilus perpusillus* Walker and *Rhyacophila melita* Ross (Harper et al. 1975).

Discussion

As could be expected, the fauna presently inhabiting the west coast of the James Bay drainage is an assemblage of diverse elements of various origins. Their present coexistence depends on the geological and climatic history of the area and the dispersal patterns of the species.

Species richness

By comparison with the other sites studied in Québec and Ontario, the James Bay collections yielded a relatively large number of species. The inventory appears to have been more thorough in Trichoptera than in Plecoptera, where a long list of additional species were expected (Ricker et al. 1968) but not found. Perhaps this was due to the sampling scheme, but it is more likely caused by the absence of varied stonefly habitats in this rather low-altitude area.

The endemic element

As the territory under investigation is located in the middle of a huge glaciated area and far from any known refugium, an endemic element is unexpected. Indeed, both species of Trichoptera described as new from the area appear to be Holarctic (see above). *Caenis candida* Harper and Harper (1981) is the only remaining endemic element; it appears to be a valid species among North American taxa (A. Provonsha, personal communication) but it too may eventually prove to have a much wider distribution.

The Holarctic species

Three of the mayflies and 13 of the caddisflies but none of the stoneflies have Holarctic distributions. Relatively few North American mayflies have circumpolar distributions. The three recorded here are those which have the most extensive ranges in North America; other Holarctic species are restricted to the northwest in North America (e.g. *Baetis macani bundyae* Lehmkuhl, *Ephemerella mucronata* Bengtsson) or else they are more temperate (e.g. *Cloeon dipterum* (L.), *C. cognatum* Stephens). There are few Holarctic stoneflies and all (*Nemoura arctica* Esben-Petersen, *Diura bicaudata* (L.), *D. nanseni* (Kempny)) are either alpine or arctic. In the Trichoptera, dispersal seems to have been greater and this is reflected in the larger Holarctic element. This element is very characteristic of northern and arctic latitudes; its relative importance increases northward in most groups (Lehmkuhl and Kerst 1979; Scudder 1979; Danks 1981).

The transcontinental element

Nine mayflies, 3 stoneflies and 58 caddisflies have a more-or-less transcontinental distribution. These species are typically distributed across the northern half of the continent, but some mayflies (8) and caddisflies (20) have dispersed over virutally all of North America. This corresponds to the boreal element of Scudder (1979), deemed by him to be the most characteristic in the Canadian fauna.

The eastern element

The dominant element of the fauna (57% of mayflies, 71% of stoneflies and 47% of caddisflies), eastern species are typically centered around the Saint Lawrence drainage. One tenth of these species extend westwards to the Rockies and north into the Mackenzie drainage (SH), and one third are restricted to the eastern glaciated areas (NE).

The Appalachian element

Few (14) Appalachian species enter the study area. They are all inhabitants of small streams and they appear to reach in the James Bay area their northernmost geographical extension.

The central element

One species of mayfly, *Brachycercus prudens*, is distributed in the Central United States, and its presence in the study area was not anticipated. It represents a northward extension from a fauna normally confined to the upper Mississippi valley drainage. Such distributions are unusual because the Great Lakes and the surrounding lowlands seem to have been an insurmountable barrier for many organisms, especially lotic species. The fact that *Brachycercus* prefers lentic habitats may explain this exception.

The Cordilleran element

Two of the species, *Cultus* cf. *aestivalis* (Plecoptera) and *Wormaldia gabriella* (Trichoptera), have been identified as Cordilleran elements. The status of the former is uncertain. The typical distribution of *W. gabriella* being the Western ranges, its presence at James Bay represents a considerable extension to the East. Other species not recorded in this study have similar distributions; such are *Claassenia sabulosa* (Banks) in the Plecoptera (Ricker et al. 1968) and *Limnephilus picturatus* in the Trichoptera (Harper et al. 1975).

The arctic element

No truly arctic species were collected, these being restricted to the tundra ecosystem which lies northward. Such species would have included *Baetis macani bundyae* in the Ephemeroptera, *Capnia nearctica* and *Diura bicaudata* in the Plecoptera, and *Grensia praeterita* (Walker) and *Limnephilus pallens* Banks in the Trichoptera. Surprisingly, none of the these typical tundra dwellers occurs east of James Bay. All are restricted to the west of Hudson's Bay and may be supposed to have survived glaciations in the Northwestern refugium. Consequently, the tundra of Ungava is devoid of this element except for the endemic and still problematical *Capnia sugluka* Ricker (Ricker 1964). Since James Bay appears to act as a barrier to the dispersal of tundra forms, the eastern dispersal of arctic species must be rather recent: in earlier times colder climates would have provided a continuous band of tundra biotopes around the bays, though the presence of the Tyrrell Sea and, to lotic species at least, Lake Ojibway-Barlow might have hampered dispersal. That these species, at least in the Trichoptera, seem to be strictly associated with tundra conditions is shown by their presence at Rankin Inlet and their absnce from Churchill at the boreal forest border (Lehmkuhl and Kerst 1979); this does not seem to hold true for Plecoptera (Ricker 1964).

An overview

Table II summarizes much of the information and allows comparisons among the three orders. Three main elements can be recognized in the fauna: (1) Holarctic-transcontinental, (2) eastern, and (3) Appalachian, and the proportions of these vary considerably among the orders. There is a distinct gradient of increasing importance of element (1) from the Plecoptera to the Trichoptera, and a corresponding decrease in element (2).

The Holarctic-transcontinental element is richest in Trichoptera where it comprises just less than half of the fauna. Within this element, the Holarctic and the northern transcontinental groups predominate. In Ephemeroptera, the continental species are dominant, few of them being restricted to northern latitudes. In Plecoptera, the element is poorly represented. Such differences among the orders seem to reflect differences in dispersal potential, but other factors could be involved such as ecological valency. Nonetheless, the caddisflies combine good flight abilities, a long adult life, and relative hardiness,

TABLE 2. Distribution patterns in the Plecoptera (Pl), the Ephemeroptera (Ep), and the Trichoptera (Tr): number of species or units (some species occurring in two categories) in each category and percentages in major types. The last column (T) and the two last rows give totals of rows and columns respectively. Codes give distribution types: HL: Holarctic, NT: Northern Transcontinental, ds: discontinuous, CT: Continental, SH: Canadian Shield, NE: Northeastern, MS: Mississippian, CD: Cordilleran, CN: Central, AP: Appalachian, ED: Endemic.

	HL	NT	NTds	CT	SH	NE	MS	CD	CN	AP	ED	T
Pl	-	3	-	-	3	3	9	1	-	2	-	21
		14%				71.4%				9.5%		
Ep	3	1	-	8	1	10	16.5	-	1	6.5	1	48
		25%				57.3%				13.5%		
Tr	12	30	8	20	9	25	36	1	-	6	1	148
		47.3%				47.3%				4%		
	15	34	8	28	13	38	61.5	2	1	14.5	2	217
		39.2%				51.8%				6.7%		

factors that are conducive to high dispersal. The other groups lack such characteristics.

The eastern element follows the inverse gradient to the widely distributed elements, being greatest in Plecoptera and least in Trichoptera. In the three orders, about 50-60% of this element is typically distributed in the St. Lawrence/Mississippi drainages, the rest (25-36%) is restricted to the St. Lawrence and other northern drainages, and a minority of species (4-25%) extends westward to the foot of the Rockies.

The Appalachian element (4-13.5%) is poorly represented in the three orders, and surprisingly so in the Trichoptera. This cannot be due to a lack of dispersal ability of the adults. Perhaps as most of these species inhabit small spring-fed forest streams as larvae, their northward extension is hindered by the lack of such habitats.

Origins

The faunal composition is thus a blend of species with various distribution patterns and doubtless many dispersal routes. It is difficult to assess its origin from present patterns except by surmise.

Fifteen (7.4%) of the species are Holarctic and most of these seem to have western affinities. There is no evidence of any of them spreading from an Eastern refugium. *Utacapnia labradora* (Ricker), which was collected from the same drainage near Mistassini (Harper et al. 1975), could be a candidate for such an origin (Ricker 1964), but it did not show up in this series. There may be one amphi-Atlantic species: *Oxyethira mirabilis* fits the pattern, being distributed as well in northern Europe (Britain and Fennoscandia) where it is the only Old World representative of the *aeola* group of the subgenus *Oxytrichia*, which has radiated in the New World (Kelley 1984).

Of the 70 transcontinental species, 42 are mor or less restricted to the boreal zone. Many seem to have western affinities, though it is impossible to generalize. The two Cordilleran species could belong here, and actually be species gradually dispersing towards the east.

The eastern element must have survived glaciations south of the ice sheet and have migrated back with the retreating ice. Some species have been more successful than others and have reached as far as the Mackenzie drainage and the arctic coast.

The Appalachian element is thought to have migrated up and down the range with the ice movements and is characterized by a high level of endemism in the south and by species with high dispersal in the north. The species that have reached James Bay are among the more mobile. In Quebec, this element is most conspicuous in the east, and decreases markedly westwards.

Conclusion

Although this fauna shows few if any original elements, its composition is highly interesting. The extension of James Bay to the south into the boreal forest seems to act as a barrier for the eastwards dispersal of the species of western origin and, with the apparent lack of adequate refugia in the northeast, explains the relative poverty of the tundra and high arctic aquatic insect faunas of the Québec-Labrador peninsula in comparison with similar faunas from the Northwest territories. Rather, the habitats are taken over by the hardiest species of the eastern fauna.

The position of the sampling sites on the direct route of colonization of this region makes the fauna potentially one of the most interesting of middle latitudes in Québec. A similar course of dispersal seems to have been followed by freshwater fishes (Legendre and Legendre 1984).

However, so little is known of the fauna of the whole Nouveau-Québec area, that this systematic investigation of an aquatic insect fauna is but a first building block in understanding the biogeography of the aquatic insect fauna of northern Québec.

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