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The Black Fly (Diptera: Simuliidae) Fauna of Prince Edward Island, Canada

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Abstract - A cytological and morphological survey of the black flies of Prince Edward Island revealed 20 species of which 13 represent new provincial records. An additional three species have been recorded in the literature but were not found in this study. All 20 species are widely distributed on the North American mainland. Three species are significant pests of humans, six feed on birds, two species do not take blood, and the remaining species feed on non-human mammals.

Introduction

Black flies are among the most ecologically and economically important insects in north temperate North America. The larvae and pupae dwell in the majority of freshwater streams in North America and have specific habitat requirements that vary among species (Adler and McCreadie 1997). They often comprise a major component of the diets of other aquatic invertebrates and a variety of vertebrates (Adler et al. 2004). In addition, they process fine particulate organic matter and dissolved organic matter, which then becomes available to larger organisms (Malmqvist et al. 2004).

The ecological benefits of the immature stages contrast with the economic drawbacks of the adults. Blood-feeding habits of the females of some species negatively affect outdoor tourism, agriculture, and industry (Adler et al. 2004, Crosskey 1990). Low morale and reduced productivity of pulpwood-cutting workers in Quebec, for example, have been attributed to physical and psychological stress caused by biting black flies (Peterson and West 1960, West et al. 1960).

An understanding of the ecological benefits and economic problems associated with black flies requires reliable species identification. Both morphological and cytological methods are used to identify black flies (Adler et al. 2004). Many species, known as sibling species, are reproductively isolated yet are often morphologically similar to, or indistinguishable from, one another (Rothfels 1988). Identifications based solely on

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morphology often result in the loss of biological information (Ciborowski and Adler 1990). Sibling species have been distinguished by examination of the polytene chromosomes in larval silk glands, which have species-specific chromosomal rearrangements (Rothfels 1988).

We use both morphological and cytological methods to characterize the black fly fauna of Prince Edward Island, one of the Maritime Provinces of Canada. The island is located in the Gulf of St. Lawrence at least 13 km from New Brunswick and Nova Scotia. Most of the freshwater streams on this island are small, spring-fed flows that issue from sandstone and run through agricultural lands and woodlands.

The black fly fauna of the province is poorly studied. Lewis and Bennett (1979) compiled a list of black flies from the Maritime Provinces, including 10 nominal species from Prince Edward Island, based on collections made from 1973 to 1976, previous literature records, and specimens in the Canadian National Collection in Ottawa. All of these identifications, however, were based on morphology, and did not allow the detection of sibling species. Our study of larvae and pupae is the first systematic survey of black flies on Prince Edward Island and the first to include chromosomal identifications.

Methods

Larval and pupal black flies on Prince Edward Island were collected intensively from four streams, three of which were in Prince Edward Island National Park, and sporadically from 15 streams in 1994 and from 1998 to 2001. All sites were in the northeastern portion of Prince Edward Island, encompassing approximately 30% of the province.

Collections were conducted at Balsam Hollow Brook, Cavendish Beach pond outlet, North Rustico pond outlet, and Winter Creek. Four sites on Balsam Hollow Creek, within Prince Edward Island National Park, were sampled on a weekly to biweekly basis from May to mid-August 1999 and monthly to November in 1998. The stream includes both well shaded and open stretches and, in its lower reaches, receives runoff from a golf course. The Cavendish Beach pond outlet is part of the same drainage system as Balsam Hollow Brook and is located downstream. The North Rustico pond outlet is located on North Rustico Beach, also within the Park boundaries. Both Cavendish Beach and North Rustico pond outlets were sampled on a weekly to biweekly basis from June to mid-August 1998 and 1999. Winter Creek is outside the Park boundaries in York, and was sampled at four sites on a weekly to biweekly basis from May to mid-August 1998 and 1999. This stream also was inspected in September and October 1998, but no larvae or pupae were found. Winter Creek is well shaded and remote from the impact of agricultural runoff.

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Larvae and pupae were hand collected from all available substrates (e.g., rocks, trailing vegetation, logs, organic debris, and trash). Approximately 200 larvae and pupae were collected from each site on each collection date. Half of the specimens were fixed in 95% ethanol and the other half in Carnoy's solution (3 parts 95% ethanol: 1 part glacial acetic acid). Larvae and pupae from both fixatives were used for morphological identification, but only larvae in Carnoy's solution were used for cytological identification.

Morphological identifications were made using the keys of Wood et al. (1963) and Adler and Kim (1986). Giant silk-gland chromosomes of representative larvae of all morphospecies were stained using the Feulgen technique of Rothfels and Dunbar (1953). Standard maps of the chromosomal banding patterns were used for cytological identifications (Adler unpublished, Basrur and Rothfels 1959, Brockhouse 1985, Hunter and Connolly 1986, Landau 1962, Leonhardt 1985, Rothfels and Featherston 1981, Rothfels and Freeman 1977, Rothfels et al. 1978). Voucher specimens are deposited in the Clemson University Arthropod Collection and the Department of Biology at the University of Prince Edward Island.

Annotated Species List

The following is an annotated list of species found on Prince Edward Island during our survey. Information on the seasonality and collection sites for each species is summarized in Table 1. Also included are brief notes on the bionomics of each species. All general information on the bionomics and distribution of each species is drawn from the work of Adler et al. (2004).

Family Simuliidae
Subfamily Simuliinae
Genus *Helodon* Enderlein
Subgenus *Parahelodon* Peterson

Helodon decemarticulatus (Peterson): Collected only from Launching (30 April 1994). This early spring, univoltine species feeds on birds and breeds in small headwater streams. It has been recorded from the northern United States, Alaska, and Canada.

Genus *Prosimulium* Roubaud

Prosimulium fuscum Syme & Davies: A single larva, identified chromosomally, was collected from the Naufrage River on 6 May 2001. This species matures early in the year and occurs from Saskatchewan eastward, south to Pennsylvania.

Prosimulium mixtum Syme & Davies: Larvae and pupae of *P. mixtum* were collected from small, cool streams. The majority of collections were made in the spring, with occasional larvae

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found into August. This common species overwinters as larvae and occurs in all Canadian provinces east of Manitoba, as well as throughout the eastern United States.

Table 1. Month and site from which each species of black fly was collected on Prince Edward Island.

Species	April	May	June	July	Aug.	Sept.	Oct.	Nov.
Helodon decemarticulatus	12							
Prosimulium fuscum		19						
P. mixtum	1	1,2	1,2,7,10	1	1			
Twinnia tibblesi		13	13					
Stegopterna diplomutata	12	2	2					
St. mutata	12	2						
Simulium bracteatum			9		14			
S. aestivum		2	2,10	2	2			
S. craigi	12	1						
S. moultoni	1	1,2	7	1,2	1,2	1	1	
S. silvestre		1	1					
S. vittatum			1,3,5,8,11,14, 15,16,17,18	1,3,4,5	1,3,5	1	1	1
S. conundrum		2	2,7					
S. tuberosum "cytotype AB"			14,16					
S. vandalicum		1,2	1,2,7,10,11	1,2,6	1,2	1	1	
S. decorum			14		5	14		
S. rostratum			3,14,16			14		
S. molestum			10					
S. venustum	12	1,2	1,2,7,10,11	1,2				
S. verecundum			9,14,15					

Site	Coordinates	
1 Balsam Hollow Brook, Cavendish	46º28'16"N	63º23'54"W
2 Winter Creek, York	46º21'34"N	63º05'10"W
3 Cavendish Beach pond outlet	46º29'37"N	63º25'13"W
4 Long Pond outlet, near Dalvay	46º24'48"N	63º06'05"W
5 Rollins Pond outlet, North Rustico	46º26'07"N	63º17'10"W
6 Forest Hill Creek, Quigly's Dam, St. Peter's	46º23'58"N	62º33'09"W
7 Bristol Creek, Cemetery Road	46º24'22"N	62º44'26"W
8 Doyle's Pond, Mount Stewart	46º23'09"N	62º52'14"W
9 Beaver Pond outlet, Revel Road	46º21'37"N	62 º48'45"W
10 Tannery Creek, Cherry Hill	46º22'52"N	62º49'06"W
11 Cheese Factory Creek, Fort Augustus	46º18'59"N	62º56'14"W
12 Launching	46º13'26"N	62º25'48"W
13 Spring-fed stream, Selkirk	46º25'28"N	62º25'57"W
14 Morell River, Indian Bridge	46º22'03"N	62º42'44"W
15 Mooney's Pond, Peakes, Highway 22	46º17'51"N	62º46'20"W
16 Clark's Pond, Clark Creek, Pisquid	46º20'04"N	62º52'43"W
17 MacKinnon's Pond, near Fort Augustus	46º24'48"N	62º44'45"W
18 Warren's Dam, Hillsborough River, Cherry Hill	46º22'18"N	62º49'05"W
19 Naufrage River, Hermitage Road	46º27'40"N	62º23'48"W

Collectors: P.H. Adler, C.L. Brockhouse, M. Coulson, M. Dobrin, D.J. Giberson, T. Homer, M.S. Minhas (née M.L. Smith), and L.A. Purcell.

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Genus *Twinnia* Stone & Jamnback

Twinnia tibblesi Stone & Jamnback: Larvae and pupae of *T. tibblesi* were collected at one site (Selkirk) on Prince Edward Island on 5 June 1998 and 16 May 1999. Larvae lack labral fans and must graze their food from the substrate. Larvae and pupae were attached to mosses and submerged grasses at the headwaters of a spring-fed trickle for a distance of about 10 m. The species has been reported previously from northeastern North America as far south as Pennsylvania.

Genus *Stegopterna* Enderlein

Stegopterna diplomutata Currie and Hunter: Larvae of this univoltine species were found in pristine streams about a meter wide. This species overwinters as larvae, and is known from Nova Scotia, Ontario, Quebec, and the eastern United States.

Stegopterna mutata (Malloch): This parthenogenetic, triploid species was collected from the same streams that harboured its diploid counterpart, *S. diplomutata*. It also has been reported from New Brunswick, Newfoundland, Ontario, Quebec, and the eastern and midwestern United States. This species also overwinters as larvae.

Genus *Simulium* Latreille

Subgenus *Eusimulium* Roubaud

Simulium bracteatum Coquillett: *Simulium bracteatum* has also been known cytologically in North America as *S. aureum* "A." It was collected only twice: once from the Morell River (4 August 1994) and once from the outlet of a beaver pond on Revel Road (23 June 1999). This species is multivoltine and overwinters in the egg stage. It occurs throughout most of Canada, Alaska, and the eastern United States.

Subgenus *Nevermannia* Enderlein

Simulium aestivum Davies, Peterson and Wood: Larvae and pupae of *S. aestivum* were most abundant in May and June, with some individuals found in July and one pupa in August. They were collected from heavily shaded streams about a meter wide. The species also is known from Labrador, Ontario, Quebec, and New Hampshire.

Simulium craigi Adler & Currie: Larvae and pupae of *S. craigi* were found in small streams in late April and May. This species is univoltine on Prince Edward Island. It is known from all Canadian provinces and territories except Nova Scotia and the Yukon Territory, and occurs throughout much of the mountainous regions of the United States.

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Simulium moultoni Adler, Currie & Wood: *Simulium moultoni*, previously known cytologically as *S. pugetense* "C," is multivoltine on Prince Edward Island, occurring as larvae from April through October. It was collected from small, cool streams. It also occurs in Quebec and New Hampshire.

Simulium silvestre (Rubtsov): Larvae of *S. silvestre* were found only in Balsam Hollow Brook in May and June. The species has been reported from all Canadian provinces and territories except Nova Scotia, and from much of the mountainous regions of the continental United States. It also occurs in the Palearctic Region.

Subgenus *Psilozia* Enderlein

Simulium vittatum Zetterstedt: *Simulium vittatum* is multivoltine on Prince Edward Island. It is one of the most common species of black flies on the island and is especially prevalent at the outlets of impounded waters and in enriched streams. It is the most pollution-tolerant species of black fly on the island. It was found, for example, in the lower reaches of Balsam Hollow Brook, which is heavily impacted by runoff from an adjacent golf course, and in the heavily polluted Wilmot Creek, which has experienced fish kills. It also is the only species on the island that breeds in streams flowing across beaches. At the Rustico Beach stream, for example, larvae and pupae were found below the high tide mark where they attached to rocks, logs, and shells of molluscs. *Simulium vittatum* on Prince Edward Island has undifferentiated sex chromosomes (XoYo) (sensu Rothfels and Featherston 1981). Populations with undifferentiated sex chromosomes tolerate high salinities on Prince Edward Island and have colonized other North Atlantic islands.

Subgenus *Simulium* Latreille

Simulium conundrum Adler, Currie & Wood: *Simulium conundrum*, previously known cytologically as *S. tuberosum* "FGH," was found in small, shaded streams from May through June. It is univoltine and occurs across Canada and in forested areas of the eastern United States.

Simulium tuberosum (Lundström): *Simulium tuberosum* was collected from a river approximately 3 m wide and at the outflow of an impoundment. The species is typically multivoltine, but was found only in June on Prince Edward Island. The larvae sampled from the island are members of cytotype "AB" (*sensu* Landau 1962). The species occurs across Canada and most of the United States.

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Simulium vandalicum Dyar & Shannon: *Simulium vandalicum*, previously known cytologically as *S. tuberosum* "FG," is multivoltine on Prince Edward Island, having been collected in small streams from early May to October. It is abundant throughout most of the continent.

Simulium decorum Walker: *Simulium decorum* was collected from June through August, indicating multiple generations on the island. This species is typically associated with the outlets of impoundments, although we also found small numbers of larvae in the Morell River. It has been recorded throughout most of Canada and all but the southwestern United States.

Simulium rostratum (Lundström): The immature stages of *S. rostratum* were found in rivers approximately 3 m wide and at the outlets of impoundments. It is multivoltine and abundant across Canada and in the northern United States, as well as Greenland and the Palearctic Region.

Simulium molestum Harris: *Simulium molestum*, formerly known cytologically as *S. venustum* "A/C," was taken only from Tannery Creek at Cherry Hill (23 June 1999). The species also is known from Quebec, Michigan, and New Hampshire.

Simulium venustum Say: *Simulium venustum*, previously known cytologically as *S. venustum* "CC," occurs from April through July on Prince Edward Island. It is one of the most abundant species of black flies and the major human biter on the island. This species occurs throughout most of North America.

Simulium verecundum Stone & Jamnback: *Simulium verecundum* was collected in June on the island. Larvae and pupae of this multivoltine species were attached to trailing vegetation. This species is known from eastern and central Canada and the eastern United States.

Discussion

Twenty-three species of black flies are now recorded from Prince Edward Island, representing an increase of 13 species over the previous number reported by Lewis and Bennett (1979). The use of cytological identifications accounts for the increase. Lewis and Bennett (1979) listed 10 morphospecies, of which three were not found in our survey: *Cnephia dacotensis* (Dyar and Shannon), *Simulium croxtoni* Nicholson and Mickel, and *S. furculatum* (Shewell). Our failure to find these three species might be the consequence of limited sampling. Alternatively, they might represent misidentifications.

The number of species now known from Prince Edward Island is similar to the number known from the Avalon Peninsula of New-

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foundland (25 species), an area in Atlantic Canada of similar size for which a cytotaxonomic approach to identification also has been used (McCreadie et al. 1995). All species found on Prince Edward Island are widespread on the mainland, although populations of *S. vittatum* with undifferentiated sex chromosomes might be endemic to the Atlantic Islands. More collecting on Prince Edward Island, especially from April to June, might reveal additional species. Nonetheless, the number of species is unlikely to exceed 30, as Prince Edward Island is limited to one ecoregion, the Acadian woodland. Species richness for a given geographic area typically increases with an increase in the number of ecoregions, which provides a greater diversity of habitats (Adler and McCreadie 1997).

Of the 23 species known from Prince Edward Island, only three are major biting pests of humans: *Prosimulium mixtum*, *Simulium molestum*, and *S. venustum*. *Twinnia tibblesi* does not have biting mouthparts and, therefore, cannot take blood. *Cnephia dacotensis*, recorded from the island by Lewis and Bennett (1979), also lacks biting mouthparts. Six species feed on birds: *Helodon decemarticulatus* and the five members of the subgenera *Eusimulium* and *Nevermannia*. The remaining species feed on mammals other than humans, although they might occasionally swarm around humans or infrequently take blood from them. Because only three of the species on Prince Edward Island are significant pests of humans, management programs can target the breeding sites of these species.

The results of this survey provide baseline faunistic data for monitoring changes in water quality across Prince Edward Island and in streams in the National Park. Changes in water quality typically alter species composition of streams. Many of these changes would remain undetected without cytological identifications, emphasizing the need for detailed taxonomic surveys.

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