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Parasites as Potential Biological Tags of Atlantic Salmon (*Salmo salar*) smolts in the Miramichi River System, New Brunswick[1]

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Ten parasite species (one protozoan, eight helminth, one mollusc) were collected from 1262 smolts of Atlantic salmon (*Salmo salar*) in the eight tributaries and estuary of the Miramichi River, New Brunswick, Canada during 1970 and 1971. Three of these parasites, *Discocotyle sagittata*, *Diplostomum spathaceum*, and *Neoechinorhynchus rutili* showed restricted distributions within the study area. *Discocotyle sagittata* infected 32.6% of 435 smolts collected from tributaries draining into the Main Northwest Miramichi River but only 0.3% of 604 smolts collected from tributaries draining into the Main Southwest Miramichi River. *Diplostomum spathaceum* infected 18.9% of 148 smolts collected from the Southwest Miramichi River but was absent in 819 smolts collected from the remaining tributaries. *Neoechinorhynchus rutili* infected 18.8% of 144 smolts collected from the Bartholomew River but only 0.2% of 895 smolts collected from the other tributaries. Presence of *Discocotyle sagittata* on smolts collected in the estuary of the Miramichi River would identify smolts that originated in the Main Northwest Miramichi River, thus allowing for a separation of smolts from this branch and the other main branch, the Main Southwest Miramichi River. Presence of *Diplostomum spathaceum* in smolts collected in the Main Southwest Miramichi River or in the estuary of the Miramichi River would identify smolts that originated in the Southwest Miramichi River. Presence of *N. rutili* in smolts collected in the Main Southwest Miramichi River would identify smolts of Bartholomew River origin.

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Nous avons recueilli 10 espèces de parasites (1 protozoaire, 8 helminthes et 1 mollusque) chez 1 262 smolts de saumon atlantique (*Salmo salar*) dans huit tributaires et dans l'estuaire de la rivière Miramichi, Nouveau-Brunswick, Canada, en 1970 et 1971. Trois de ces parasites, *Discocotyle sagittata*, *Diplostomum spathaceum* et *Neoechinorhynchus rutili*, ont une distribution limitée à la région d'étude. *Discocotyle sagittata* infecte 32.6% des 435 smolts capturés dans les tributaires de la branche principale de la Miramichi Nord-Ouest, mais seulement 0.3% des 604 smolts provenant des tributaires de la branche principale de la Miramichi Sud-Ouest. *Diplostomum spathaceum* infecte 18.9% des 148 smolts capturés dans la Miramichi Sud-Ouest, mais est absent des 819 smolts capturés dans les autres tributaires. *Neoechinorhynchus rutili* infecte 18.8% des 144 smolts capturés dans la rivière Bartholomew, mais seulement 0.2% des 895 smolts provenant des autres tributaires. La présence de *Discocotyle sagittata* chez les smolts capturés dans la rivière Miramichi marquerait les individus provenant de la branche principale de la Miramichi Nord-Ouest et permettrait de séparer les smolts de cette branche d'avec ceux de l'autre branche, la Miramichi Sud-Ouest. La présence de *Diplostomum spathaceum* chez les smolts capturés dans la branche principale de la Miramichi Sud-Ouest ou dans l'estuaire de la Miramichi marquerait les smolts provenant de la Miramichi Sud-Ouest. La présence de *N. rutili* chez les smolts recueillis dans la branche principale de la Miramichi Sud-Ouest marquerait les saumons provenant de la rivière Bartholomew.

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PARASITES have been suggested as biological tags to trace the origin of downstream migrant sockeye salmon (*Oncorhynchus nerka*) in the Columbia River (Uzmann et al. 1957), to identify the origin of Asian and North American stocks of sockeye salmon in the North Pacific (Margolis 1965), and to indicate the tributary of origin of Atlantic salmon (*Salmo salar*) smolts in Irish river systems (Pippy 1969a).

The purpose of this study was to determine the abundance of parasites infecting smolts of Atlantic salmon (*S. salar*) in each of the eight main tributaries of the Miramichi River, New Brunswick, Canada, and to assess the usefulness of these parasites as biological tags to identify the tributary of origin of salmon smolts caught in the estuary of the Miramichi River. If a parasite is restricted to smolts in a particular tributary, it could be used to identify their origin when in the estuary. A preliminary survey by Pippy (1969b) suggested that there were differences in the abundance of parasites infecting salmon smolts in four tributaries of the Miramichi River.

Materials and Methods

A total of 1239 Atlantic salmon smolts from the eight tributaries and estuary of the Miramichi River were examined during May and June 1970 and 1971 (Table 1). In addition, 23 tagged smolts of Northwest Miramichi River origin were examined from the estuary (salinity 5–10‰) in 1971 to determine the effect of host migration on the incidence of infection of parasites. These smolts were marked with Carlin tags during a large tagging experiment at the Curventon counting fence on the Northwest Miramichi 5–12 days prior to recapture.

The Miramichi River system (Fig. 1) is comprised of two main branches, the Main Northwest Miramichi and the Main Southwest Miramichi rivers which join to form the Miramichi River estuary. Three tributaries — Northwest Miramichi, Sevogle, and Little Southwest Miramichi — drain into the Main Northwest Miramichi branch; five tributaries — Renous, Dungarvon, Bartholomew, Southwest Miramichi, and Cains — drain into the Main Southwest Miramichi branch. Both branches are tidal for about 24 km. Smolts were collected from the eight tributaries by counting weirs, electrofishing, a modified stakenet (Hare 1973) and fyke nets, and from the estuary by a trapnet.

The following parts of each fish were examined for parasites: external surfaces, blood, eyes, gills, muscles, visceral cavity, mesenteries, heart, liver, gallbladder, spleen, kidney, swimbladder, and alimentary tract. The external surfaces were scanned by eye and a wet mount of a scraping from the skin of each fish was examined microscopically for the presence of protozoan and monogenean parasites. The muscle tissue, after shredding with a scalpel, and

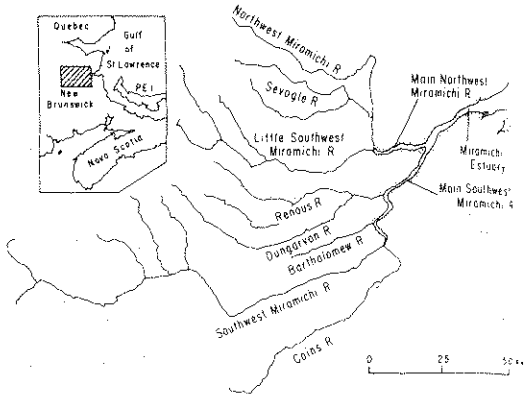

FIG. 1. Miramichi River system showing locations cited in the text.

the visceral cavity were examined visually for parasites. Blood smears, stained with Giemsa's stain, and wet mounts from the gallbladder were examined microscopically for protozoans and trematode larvae. No parasites were found in the blood, muscles, and gallbladder contents in the 1970 samples, and examination of these was discontinued for the 1971 samples. During 1970 all fish were examined immediately after death. In 1971 the fish were examined immediately after death for parasite infections of the external surfaces, gills, and eyes, then labeled and frozen for later dissection and examination.

After tentative identification of parasites to genus, random samples of the different genera were fixed and stored in 5% formalin, except for nematodes and molluscs which were preserved in 70% ethanol. Trematodes and acanthocephalans were stained with Mayer's carmine, dehydrated in ethanol series, cleared in oil of cedarwood, and mounted in Permount. Nematodes and molluscs were cleared in glycerin alcohol or lactophenol and mounted unstained in glycerin jelly. Final identifications of the parasites were made according to Hare and Burt (1975).

Results

Ten species of parasites (one protozoan, eight helminth, and one mollusc) were collected from smolts in the Miramichi River system (Table 1). Nine of these were recovered from smolts in the tributaries and the 10th was recovered from smolts in the estuary. The incidences of infection of the parasites showed considerable variation among smolts in the different tributaries. The intensities of infection (mean numbers of parasites per infected fish) were low for all parasites except *Crepidostomum farionis*, *Sterliadochona tenuissima*, and the glochidium that infected smolts in certain tributaries (Table 1). The large numbers of glochidia precluded enumeration.

Discocotyle sagittata, *Diplostomum spathaceum*

TABLE 1. Incidence (percentage of fish infected) and intensity (mean number of parasites per infected fish) of infection of parasites of Atlantic salmon (*Salmo salar*) smolts in the tributaries and estuary of the Miramichi River during May–June 1970 and 1971.

Parasite species	Yr	Main Northwest Miramichi: Northwest Miramichi 59; 125[a]	Main Northwest Miramichi: Sevogle 26; 81	Main Northwest Miramichi: Little Southwest Miramichi 36; 108	Main Southwest Miramichi: Renous 16; 71	Main Southwest Miramichi: Dungarvon 8; 84	Main Southwest Miramichi: Bartholomew 102; 42	Main Southwest Miramichi: Southwest Miramichi 18;130	Main Southwest Miramichi: Cains 21; 112	Miramichi Estuary 200; —
Protozoa										
Peritrichia										
Trichodina sp.	1970									0.5 / 1.0(1)
Helminth										
Monogenea										
Discocotyle sagittata (Leuckart, 1842)	1970	67.7[b] / 2.1(1–6)[c]	0	16.7 / 1.8(1–3)	0	0	0	0	0	12.0 / +[d]
	1971	50.4 / 2.3(1–9)	18.5 / 1.7(1–3)	12.0 / 1.4(1–3)	0	0	0	1.5 / 1.0(1)	0	
Digenea										
Crepidostomum farionis (Müller, 1784)	1970	50.8 / 5.5(1–28)	30.1 / 2.3(1–5)	11.1 / 3.8(1–7)	56.3 / 2.8(1–6)	37.5 / 2.7(1–4)	39.2 / 3.0(1–21)	55.6 / 44.1(12–94)	0	29.0 / +
	1971	31.2 / 6.5(1–29)	24.6 / 3.8(1–16)	13.9 / 2.6(1–11)	33.8 / 4.2(1–18)	21.4 / 3.4(1–14)	42.9 / 3.1(1–12)	26.2 / 22.5(1–94)	19.6 / 1.1(1–3)	
Diplostomum spathaceum (Rudolphi, 1819)	1970	0	0	0	0	0	0	16.7 / 1.3(1–2)	0	8.0 / +
	1971	0	0	0	0	0	0	19.2 / 1.9(1–11)	0	
Nematoda										
Capillaria salvelini (Polyanski, 1952)	1970	16.9 / 1.8(1–6)	34.6 / 1.1(1–2)	27.8 / 1.2(1–2)	18.8 / 1.0(1)	25.0 / 1.0(1)	8.8 / 1.3(1–2)	11.1 / 1.0(1)	14.3 / 1.3(1–2)	15.5 / +
	1971	4.8 / 1.0(1)	13.6 / 1.6(1–4)	27.8 / 1.1(1–2)	11.3 / 1.1(1–2)	6.0 / 1.0(1)	7.1 / 1.0(1)	5.4 / 1.4(1–3)	7.1 / 1.3(1–2)	
Raphidascaris sp.	1970	0	0	0	0	0	44.1 / 3.2(1–15)	0	0	8.5 / +
	1971	4.8 / 1.0(1–2)	8.6 / 1.1(1–2)	0	16.9 / 1.4(1–3)	10.7 / 1.6(1–4)	38.1 / 1.8(1–8)	12.3 / 1.2(1–3)	10.7 / 1.3(1–4)	
Sterliadochona tenuissima (Zeder, 1800)	1970	98.3 / 24.6(1–86)	100 / 94.0(23–187)	50.0 / 3.9(1–10)	50.0 / 3.0(1–7)	50.0 / 3.8(2–6)	23.5 / 2.6(1–10)	66.7 / 43.6(19–81)	90.5 / 48.5(19–86)	88.5 / +
	1971	100 / 16.3(1–128)	100 / 59.6(7–210)	63.0 / 5.1(1–19)	78.9 / 15.3(1–72)	48.8 / 7.0(1–33)	33.3 / 1.6(1–6)	87.7 / 41.2(1–147)	98.2 / 63.3(7–213)	
Acanthocephala										
Neoechinorhynchus rutili (Müller, 1780)	1970	0	0	0	0	0	16.7 / 3.2(1–17)	0	0	1.5 / +
	1971	0	2.5 / 1.0(1)	0	0	0	23.8 / 2.7(1–7)	0	0	
Echinorhynchus lateralis (Leidy, 1851)	1970	1.7 / 11.0(11)	0	16.7 / 1.0(1)	0	0	0	5.6 / 1.0(1)	0	1.0 / +
	1971	0	0	4.6 / 1.0(1)	1.4 / 1.0(1)	1.2 / 1.0(1)	0	1.0 / 1.0(1)	4.5 / 1.0(1)	
Mollusca										
Pelecypoda										
Glochidium	1970	11.9 / +	0	11.1 / +	0	0	0	0	0	6.5 / +
	1971	14.4 / +	4.9 / +	7.4 / +	0	13.1 / +	0	0	4.5 / +	

[a]Numbers of fish examined in 1970; 1971.
[b]Incidence.
[c]Intensity (range).
[d]Parasites not enumerated.

and *Neoechinorhynchus rutili* showed restricted distributions (Table 1). *Discocotyle sagittata* infected smolts in each of the three tributaries draining into the Main Northwest Miramichi River, but it was absent in tributaries draining into the Main Southwest Miramichi River except for the Southwest Miramichi River. The incidences of infection of *D. sagittata* on smolts examined from the Main Northwest Miramichi River tributaries ranged from 12.0% (Little Southwest Miramichi River) to 67.7% (Northwest Miramichi River), and its incidence on smolts examined from the Southwest Miramichi River was 1.5%. *Diplostomum spathaceum* had incidences of 16.7 and 19.2% in smolts examined from the Southwest Miramichi River, but it was absent in smolts examined from all other tributaries. *Neoechinorhynchus rutili* had incidences of 16.7 and 23.8% in smolts examined from the Bartholomew River, but it was absent in smolts examined from other tributaries except for its presence at low incidence (2.5%) in the Sevogle River.

Crepidostomum farionis, *Capillaria salvelini*, *S. tenuissima*, and *Raphidascaris* sp. were widely distributed, and *Echinorhynchus lateralis* and the glochidium were found sporadically throughout the river system (Table 1).

The incidences of infection of parasites of smolts in the Northwest Miramichi were not reduced by host migration and residency in the estuary for up to 5–10 days, except for *C. farionis*. The percentages of these smolts infected in the river (125 fish) and in the estuary (23 fish) were:

	River	Estuary
D. sagittata	50.4	60.9
C. farionis	31.2	17.4
C. salvelini	4.8	8.7
Raphidascaris sp.	4.8	17.4
S. tenuissima	100	100
Glochidium	14.4	17.4

Discussion

On the basis of their locally restricted distributions, *Discocotyle sagittata*, *Diplostomum spathaceum*, and *N. rutili* may be useful as biological tags to identify the tributary of origin of smolts in the Miramichi River system. Presence of *Discocotyle sagittata* on smolts collected in the Miramichi estuary would identify smolts that originated in the Main Northwest Miramichi, thus allowing for a separation of smolts from this tributary and the Main Southwest Miramichi. Although there was low incidence (1.5%) of *D. sagittata* on smolts in the Southwest Miramichi, the dilution by smolts from the other four tributaries draining into the Main Southwest Miramichi makes it unlikely that the parasite would be detected on smolts of Main Southwest Miramichi origin in the estuary. *Discocotyle sagittata* was not recorded on the 1970 smolts from the Sevogle River, tributary to the Main Northwest Miramichi but was present on 18.5% of the 1971 sample. The absence of this parasite in 1970 was probably due to the method of capture, i.e. electrofishing smolts from a small area of the river. *Discocotyle sagittata* was present on salmon parr collected in the headwaters of the Sevogle in 1970 (G. M. Hare unpublished data). Presence of *Diplostomum spathaceum* in smolts collected in the Main Southwest Miramichi or in the Miramichi estuary would identify smolts that originated in the Southwest Miramichi. Presence of *N. rutili* in smolts collected in the Main Southwest Miramichi would identify smolts of Bartholomew origin. If smolts were collected concurrently from the Main Northwest Miramichi, the Main Southwest Miramichi, and the Miramichi estuary, presence of *Discocotyle sagittata* could be used to estimate the proportion of smolts in the estuary contributed from the Main Northwest Miramichi. Likewise, if smolts were collected concurrently from the Southwest Miramichi, the Main Southwest Miramichi, and the estuary, presence of *Diplostomum spathaceum* could be used to estimate the proportion of smolts in the Main Southwest Miramichi or in the estuary that were contributed from the Southwest Miramichi. The presence of *N. rutili* in smolts collected concurrently from the Bartholomew and the Main Southwest Miramichi could be used to estimate the proportion of smolts in the Main Southwest Miramichi that originated in the Bartholomew.

The use of the above parasites as biological tags is contingent upon their survival with host migration into estuarine water. Because the incidence of infection of *Discocotyle sagittata* on smolts of Northwest Miramichi origin was not reduced by host migration and residency in the estuary, it could be used to estimate the proportion of smolts originating in the Main Northwest Miramichi. Although the effect of host migration on the incidences of infection of *Diplostomum spathaceum* and *N. rutili* are unknown, these parasites are probably retained with the migration of infected hosts into estuarine water because of their host sites. *Diplostomum spathaceum* was found in the vitreous humor and retina of the eye, and *N. rutili* was embedded in the intestinal mucosa or in the intestinal wall.

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