RESTRICTED

INTERNATIONAL COMMISSION FOR THE NORTHWEST ATLANTIC FISHERIES

Serial No.2028
(B.g.14)

ICES/ICNAF Salmon Doc.68/9
(also ICNAF Res.Doc.68/46)

ANNUAL MEETING - JUNE 1968

Studies on the Parasites of Atlantic Salmon (Salmo salar)

by

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INTRODUCTION

Studies on the parasites of Atlantic salmon to determine which parasitic species, if any, might be useful to ascertain the continental origin of salmon caught on the high seas began in 1966 (Pippy, 1967). A total of 1629 smolts* from 60 European and North American rivers and 154 adult salmon from Europe, North America and Greenland have been examined and the findings tabulated (Tables 1, 2 and 3). Morphological and quantitative analyses of some of the more promising parasites have been made. Discussion is confined to species with distinct differences in geographic distribution or abundance. These are: Diplostomulum sp., Eubothrium salvelini, Pomphorhynchus laevis, Anisakis sp., Contracaecum aduncum, and Salmincola sp.

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*Several samples undoubtedly consisted of both smolts and parr. In the absence of reliable criteria to separate smolts from parr in preserved samples, all juvenile salmon for each sample were considered to be smolts. There were no consistent differences between parasitic fauna of the larger and smaller juvenile salmon. Therefore, the lumping of data from both sizes of fish most likely provides a reasonable estimate of the incidence of each parasite in smolts from each area sampled

RESULTS

Diplostomulum sp.

Diplostomulum sp. is a larval trematode of freshwater origin found in the humors of the fish's eye and sometimes in the lens and retina. Earlier larval stages occur in freshwater snails and the adult parasite occurs in fish-eating birds.

The eyes of 32% of 1026 North American smolts were infected with Diplostomulum, as opposed to only 6% of 603 smolts from the British Isles. The mean number of larvae per infected wild smolt from North America (6.5) was similar to that of British smolts (5.0). In North America, the only adult salmon in fresh water found to harbour the larvae were those from the Margaree River (Table 3). Also, 8 (17%) of 47 adults taken from the sea near the Margaree River in June 1967, harboured a mean of 6 larvae each. The presence of Diplostomulum larvae in adult salmon in the Margaree area is probably associated with a high incidence of the larvae in smolts from the Margaree River system. Nevertheless, the incidence is below that found in smolts from the hatchery. Whether there is a decrease in the number of larvae per host at sea, or the more heavily infected fish die, is not known. Margolis (1963) made similar observations on the Pacific Coast and concluded that the larvae did not live long enough after the fish had migrated to sea to be of any value as a natural tag. This also seems to be the case on the Atlantic Coast.

Several morphological differences between Diplostomulum larvae from eyes of salmon smolts, Arctic char (Salvelinus alpinus), and sticklebacks (Gasterosteus aculeatus) from Kapisigdlit River, Greenland, and Diplostomulum larvae from 15% of 91 salmon caught near Godthaab, Greenland in 1966 indicate that the infected adult salmon did not originate in Kapisigdlit River. Neilsen (1961) indicates that Kapisigdlit River is the only river in Greenland in which salmon are known to spawn. The parasitic fauna of Kapisigdlit River is presumably similar to fauna of other rivers in West Greenland. Diplostomulum matures

In birds which may range widely. Therefore, it seems unlikely that the salmon examined from Godthaab in 1966 were representative of salmon originating in Greenland. The larvae in the adult salmon from Greenland could not be distinguished from specimens in smolts from North America and the British Isles and their presence therefore seems to indicate that the salmon originated in either of these two areas.

Eubothrium crassum

Eubothrium crassum is a marine tapeworm found primarily in the pyloric caecae of salmon. In heavy infections the caecae are expanded and the lighter colour of the tapeworms within can be seen.

E. crassum was found in 93% of a total of 278 North American salmon examined by Hoar (1939), Sandeman and Pippy (1967), and the writer (Table 3). Templeman (1967) found it in 79% of 29 salmon on and near the Grand Banks. In contrast, Heitz (1917) found it in only 58% of 170 salmon in the Rhine River, Germany, and Kane (1966) found it in 46% of 13 salmon in Ireland. Each of 4 Canadian tagged salmon taken in Greenland was infected with E. crassum. This 100% incidence contrasts with the overall Greenland rate of 46% (Table 4) infected. These data support Templeman's (1967) suggestion that E. crassum may be less abundant in European salmon.

The data obtained from 102 Greenland salmon collected in 1966 (Table 4) support the view (Templeman, 1967) that the amounts of tapeworms increase with a longer period of river life. This is probably related to different feeding habits of the various groups of fish once they enter the sea.

Pomphorhynchus laevis

This acanthocephalan of freshwater origin was not found in any smolts from North America but only in smolts from the British Isles. The specimens collected were from 3-11 mm long, up to 1.5 mm in diameter, and most often found with the

bulbous neck embedded in the wall of the intestine so that the proboscis protruded into the abdominal cavity. None of the female specimens examined from the smolts contained eggs.

McIntosh (1863), Tosh (1905), Heitz (1917), and Lane (1966) found P. laevis in adult European salmon (sea ages not specified) returning to fresh water. P. laevis was found in about 24% of smolts from the British Isles, but it was not found in any of 102 salmon (1 + sea winters) examined in Greenland in 1966. If P. laevis is present in salmon in Greenland, it appears to be rare (less than 1% infected) and will therefore be of little use as a biological tag to distinguish eastern from western Atlantic salmon stocks.

P. laevis was found in about 50% of the smolts from Ireland, 3% of those from England, and was absent in smolts from Scotland (Fig. 1). If similar differences in abundance can be demonstrated in adults returning to these areas, P. laevis may be of use as a biological tag for Irish salmon in the sea surrounding the British Isles.

Anisakis sp.

Larvae of the marine nematode, Anisakis occur in the viscera and musculature of many marine fishes. The adult form occurs in marine mammals and sea birds. Salmon serve as intermediate hosts following ingestion of infected planktonic invertebrate hosts.

A comparison of mean intensities of infestation by Anisakis in salmon from England and North America indicate there is no difference ($P = .05$) in the abundance of this larval nematode in salmon from these two areas.

Heitz (1917) showed that the incidence of infestation of Ascaris capsularia (= Anisakis) did not decrease during the salmon's 9 months in the Rhine River, Germany. Observations on Anisakis larvae in herring (Clupea pallasi) by Bishop and Margolis (1955) indicate the occurrence of these larvae in fish is

cumulative, the intensity of infestation increasing with the number of years spent in the sea.

If the occurrence of Anisakis is cumulative with time spent by Atlantic salmon in the sea, salmon in Greenland should have more Anisakis larvae than they had before leaving home waters. Also, salmon which have been to Greenland should have more when they reach home waters. However, the mean number of Anisakis per 1966 Greenland salmon (1 + sea years) was 11.9 (Table 5), which is higher (P = .01) than the mean of 3.8 for older salmon (2 + sea years) collected off the southwest coast of England in 1967. Similarly, the Greenland mean was significantly higher than the mean of 5.5 for older salmon (2 + sea years) caught in North American waters (Table 5). The data suggest that either (1) numbers of Anisakis present decrease with time, contrary to the findings of Bishop and Margolis (1955), or (2) not a very high proportion of the salmon in the samples taken in North America and England had been to Greenland. These trends will be investigated further by increasing sample sizes and geographic distribution of the sampling stations during 1968. Large numbers of Anisakis in salmon may possibly be indicative of migration to Greenland.

Studies are now under way to determine whether there are morphological differences in Anisakis larvae from the British Isles and Canada.

Contracaecum aduncum

The marine nematode, Contracaecum aduncum was found in 98% of 91 adult salmon from Greenland but was absent in 56 returning salmon taken in North American fresh waters. Heitz (1917) reported it as being rare in returning salmon taken in the Rhine River, Germany. C. aduncum may possibly be of use as an index of migration of salmon to Greenland. However, it is not inconceivable that our sample of salmon and Heitz's had contained C. aduncum while at sea but had lost the nematodes shortly after entering fresh water. Further sampling is needed to clarify the status of C. aduncum as a potential biological tag.

Salmincola sp.

Salmincola sp. is a parasitic copepod of freshwater origin. It is yellowish white, about 3.3 mm long, and found on the gills and gill opercula of parr, smolts and adult salmon. It can survive on the gills of salmon in salt water.

In the samples collected during 1966 and 1967, Salmincola sp. was found on 7.1% of the smolts from Newfoundland and Labrador (see Fig. 2) i.e. 3.5% of all the Canadian smolts examined. It was not found on any of the 545 smolts from Prince Edward Island, Nova Scotia and New Brunswick nor on any of the 603 smolts examined from the British Isles. There is no published information on this form of Salmincola found on juvenile salmon in the eastern Atlantic.

Templeman (1967) reports a single specimen of Salmincola on the gills of a 1-sea-year salmon. This fish was taken at 50°58'00"N, 49°00'W (Templeman, personal communication). The parasite has been examined by the writer and found to be very similar to those found on Newfoundland smolts. The fish may have originated in a Newfoundland or Labrador river.

Present knowledge of Salmincola sp. indicates that it may be of use for distinguishing some salmon originating in Newfoundland, Labrador and perhaps Quebec. However, it will probably be of little use for distinguishing Canadian from European stocks. Factors to be considered are:

(1) The proportion of Newfoundland salmon which are infected (about 0.07);

(2) The proportion of Newfoundland salmon in Canadian stocks (arbitrarily suggested to be 0.50);

(3) The proportion of salmon in Greenland originating in Canada. Allen (1967) suggested a proportion of 0.56 based on smolt ages and from 0.31-0.76 based on tagging data.

Assuming that all Salmincola specimens survive on salmon at sea, the probability of finding one on a salmon in Greenland is only 0.02 (0.07 x 0.50 x 0.56). Such a low incidence precludes effective use of this parasite as a biological tag for separating eastern from western stocks in Greenland.

Pippy (1967) outlined the problem of determining the specific identity of Salmincola in Newfoundland. Since then, the growth characteristics of 29 specimens have been compared with 79 specimens of Salmincola salmonea from New Brunswick and Scotland. Indications are that Salmincola sp. (? = S. gordoni) is closely related to S. salmonea, but larger specimens, such as the one found by Templeman (1967), will be required before Salmincola gordoni can be established as a definite species.

DISCUSSION

No parasite of fresh water origin has yet been found which would seem to be reliable in a large-scale program for distinguishing European from American stocks of Atlantic salmon near Greenland. Available evidence indicates that the copepod Salmincola sp. and the acanthocephalan Pomphorhynchus laevis may be of use as a biological tag within Canada (Salmincola in Newfoundland) and the British Isles (P. laevis being more abundant in Ireland). But certain aspects of their abundance, and perhaps longevity, preclude their effective use as biological tags in waters off Greenland.

With the possible exception of E. crassum, which appears to be more abundant in North American salmon than in European salmon, none of the marine parasites yet show particular promise as biological tags to indicate continental origin.

There are indications that certain marine nematodes (Anisakis sp. and Contracaecum aduncum) may be of some use in determining whether or not salmon in North American coastal waters have been to Greenland. These species may be useful for estimating the proportion of salmon in home waters which have returned from Greenland.

ACKNOWLEDGMENTS

Samples of adult salmon and smolts used in this investigation were supplied by personnel of the Fisheries Research Board of Canada, the Department of Fisheries of Canada, the Department of Tourism, Fish and Game of Quebec, the Atlantic Sea Run Salmon Commission of Maine, U. S. A., the Department of Agriculture and Fisheries of Ireland, the Department of Agriculture and Fisheries for Scotland, Salmon and Freshwater Fisheries of England, and the Greenland Research Board in Denmark.

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Table 1. Incidence and abundance of parasites of smolts, by species and area of origin, 1966
The first figure represents the per cent of sample infected and the figure in parenthesis indicates the mean number of parasites per infected fish.

CANADA

		TREMATODA								CESTODA					ACANTHOCEPHALA		NEMATODA				COPEPODA
	No. Hosts Examined	Crepidostomun farionis	Apophallus brevis	Phyllodistomum limnosa	Tetracotyle sp.	Discocotyle sagittata	Azygia longa	Diplostomulum sp.	Phyllodistomum sp.	Eubothrium salvelini	Diphyllobthrium sp.	Cyathocephalus truncatus	Diplocotyle olrikii	Ligula sp.	Echinorhynchus sp.	Pomphorhynchus laevis	Metabronema salvelini	Capillaria salvelini	Contracaecum sp.	Raphidascaris sp.	Salmincola sp.
	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U
NEWFOUNDLAND																					
Deadmans Bay	25	100(34)	28(14)	-	-	48(7)	-	-	-	-	-	-	-	-	100(14)	-	88(28)	16(3)	-	-	-
Exploits River	23	70(8)	57(33)	8(7)	4(7)	26(4)	-	70(4)	-	4(3)	4(3)	-	-	-	57(5)	-	87(26)	-	-	-	-
Gander River	24	58(8)	-	4(4)	29(11)	16(1)	-	63(22)	-	8(2)	-	-	-	-	58(4)	-	92(10)	-	-	-	4(1)
Great Codroy R.	25	76(18)	-	-	8(1)	8(3)	-	68(7)	-	-	-	-	12(2)	-	44(11)	-	96(18)	4(1)	-	-	8(1)
Indian River	20	2(2)	44(18)	25(3)	30(7)	30(7)	-	95(14)	-	5(1)	-	-	-	-	25(18)	-	90(14)	-	-	-	-
North Harbour River	25	88(12)	-	-	-	-	-	4(1)	-	-	-	-	-	-	12(5)	-	100(5)	-	-	-	-
Steady Brk(Humber)	17	100(12)	18(3)	-	18(2)	68(3)	-	64(6)	-	-	-	-	-	-	24(18)	-	24(5)	-	-	-	23(1)
Garnish River	24	67(13)	58(26)	-	8(1)	50(2)	-	58(7)	-	8(1)	-	4(1)	-	-	83(48)	-	95(23)	-	-	-	8(1)
Peters River	25	72(6)	24(65)	-	-	-	-	84(15)	-	-	-	-	-	-	44(3)	-	60(14)	-	-	-	8(2)
Harbour Main	25	28(3)	4(44)	-	-	-	-	76(4)	-	-	-	-	-	-	56(2)	-	96(41)	-	-	-	16(2)
Long Harbour	25	76(6)	72(34)	-	20(3)	28(1)	-	88(7)	-	-	-	-	-	-	88(7)	-	36(4)	4(1)	-	-	24(1)
Salmonier River	20	85(9)	15(10)	-	-	10(3)	-	50(4)	-	15(3)	-	-	5(1)	-	75(13)	-	55(7)	15(2)	-	-	-
Salmon Cove River	24	67(11)	-	-	-	2(4)	-	66(3)	-	-	-	-	-	-	88(12)	-	8(3)	8(6)	-	-	-
LABRADOR																					
Eagle River	12	67(8)	8(1)	-	-	8(1)	-	66(18)	-	-	-	-	-	-	33(6)	-	58(9)	-	-	-	17(1)
PRINCE EDWARD ISLAND																					
Cains Stream	24	29(3)	-	-	-	-	-	-	-	-	-	-	-	-	86(10)	-	46(12)	-	4(1)	-	-
NOVA SCOTIA																					
Margaree R. Hatchery	27	-	-	-	-	-	-	100(148)	-	-	-	-	-	-	8(1)	-	-	-	-	-	-
NEW BRUNSWICK																					
Big Salmon River	25	32(1)	12(2)	-	-	-	-	-	-	-	-	-	-	-	-	-	96(22)	-	-	-	-
Millbank	23	78(4)	9(2)	-	-	9(1)	13(4)	-	-	-	-	-	-	-	-	-	78(37)	-	-	9(1)	-
Saint John River	24	17(2)	-	-	-	-	-	13(1)	-	4(1)	-	-	-	-	4(1)	-	54(5)	4(1)	-	4(1)	-
South Esk Hatchery	24	-	-	-	-	-	-	-	-	-	-	-	-	-	4(1)	-	-	-	-	-	-

Table 1(Cont'd.) BRITISH ISLES

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U
ENGLAND																					
R. Esk	25	44(4)	-	-	-	-	-	-	-	-	-	-	-	-	44(2)	-	64(10)	-	-	-	-
R. Axe	25	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	8(1)	-	-	-	-
R. Dee	22	9(1)	-	-	-	-	-	-	-	-	-	-	-	-	1(1)	-	1(1)	-	-	-	-
Coquet R.	4	50(2)	-	-	-	50(2)	-	-	-	-	-	-	-	-	100(3)	-	25(2)	50(2)	-	-	-
IRELAND																					
Burrishodler R.	25	20(4)	-	-	12(2)	20(3)	-	16(6)	8(3)	8(1)	-	-	-	-	40(10)	48(1)	60(6)	8(5)	-	-	-
Owenea R.	25	60(5)	-	-	12(3)	12(5)	-	-	4(3)	-	-	-	-	-	4(3)	16(1)	76(7)	-	-	-	-
Corrib R.	27	70(21)	-	-	-	7(5)	-	4(3)	-	-	4(6)	-	4(1)	-	56(3)	64(9)	70(9)	-	-	-	-
SCOTLAND																					
R. Bran	26	46(7)	-	-	8(3)	4(2)	-	8(2)	-	-	-	-	-	-	-	-	65(14)	-	-	-	-
Tweed R.	15	53(4)	-	-	33(4)	67(4)	-	13(6)	-	7(1)	-	23(4)	-	7(1)	73(5)	-	93(6)	-	-	-	-
North Esk R.	26	59(2)	-	-	38(6)	39(2)	-	38(4)	-	-	-	-	-	-	-	-	62(3)	-	-	4(1)	-
Tay River	25	16(2)	-	-	8(2)	4(3)	-	4(1)	-	-	-	-	-	-	60(5)	-	40(6)	-	-	-	-

Table 2. Incidence and abundance of parasites of smolts, by species and area of origin, 1967.
The first figure represents the per cent of sample infected and the figure in parenthesis indicates the mean number of parasites per infected fish.

NORTH AMERICA

		TREMATODA						CESTODA				ACANTHOCEPHALA		NEMATODA			COPEPODA
	No. Hosts Examined	Crepidostomum farionis	Apophallus brevis	Tetracocotyle sp.	Discocotyle sagittata	Diplostomulum sp.	Phyllodistomum sp.	Eubothrium salvelini	Diphyllobthrium sp.	Cyanthocephalus truncatus	Diplocotyle olrikii	Echinorynchus sp.	Pomphorhynchus laevis	Metabronema salvelini	Capillaria salvelini	Raphidascaris sp.	Salmincola sp.
	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q
NEWFOUNDLAND																	
Exploits R.	18	68(3)	-	-	6(1)	50(7)		-	-	-	-	28(1)	-	83(20)	6(1)	-	-
Lower Gander R.	23	74(17)	4(112)	17(21)	48(1)	70(8)	-	4(8)	-	-	22(4)	70(5)	-	78(14)	13(3)	-	-
Great Codroy R.	17	-	-	-	-	82(4)	-	-	-	-	-	50(2)	-	82(5)	22(1)	-	24(2)
North Harbour R.	23	83(4)	-	-	9(1)	-	-	-	-	-	-	26(2)	-	100(18)	-	-	-
Lower Humber R.	26	58(6)	15(87)	12(5)	12(1)	54(4)	-	-	-	-	-	92(7)	-	31(20)	-	-	31(2)
Indian R.	25	92(28)	4(63)	8(1)	-	68(6)	-	-	-	-	-	32(3)	-	64(18)	-	-	-
Lomond R.	12	33(2)	-	8(1)	-	83(13)	-	-	-	-	-	25(1)	-	100(9)	-	-	-
Terra Nova R.	28	32(7)	7(98)	36(17)	32(2)	71(9)	-	-	-	-	21(13)	68(10)	-	86(19)	7(2)	-	11(1)
Windmill Brk.	25	88(12)	12(40)	-	56(3)	-	-	-	-	4(1)	-	100(6)	-	44(5)	48(7)	-	-
LABRADOR																	
English R.	22*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PRINCE EDWARD ISLAND																	
Cairs Stream	25*	-	-	-	-	44(3)	-	-	-	-	-	-	-	-	-	-	-
Dunk R.	1*	-	-	-	-	100(4)	-	-	-	-	-	-	-	-	-	-	-
NOVA SCOTIA																	
Folly R.	13*	-	-	-	-	100(22)	-	-	-	-	-	-	-	-	-	-	-
Galants Brk.,Marg.R.	25*	-	-	-	-	24(2)	-	-	-	-	-	-	-	-	-	-	-
Margaree R. Hatchery	25*	-	-	-	-	100(115)	-	-	-	-	-	-	-	-	-	-	-
Medway R.	25*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Stewiacke R.	4	25(1)	-	-	-	-	-	-	-	-	-	-	-	75(9)	-	-	-
St. Mary's R.	25	40(3)	-	-	-	-	-	-	-	-	-	-	-	96(12)	-	-	-
Tusket R.	2*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
West R.	25*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
LeHavre R.	6	-	-	-	-	-	-	-	-	-	-	-	-	100(3)	-	-	-

Table 2 (nt'd.)

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q
NEW BRUNSWICK																	
Bartholomew R.	10	20(3)	-	-	-	-	-	-	-	-	-	10(1)	-	10(1)	-	-	-
Big Salmon R.	25*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Little S.W.Miramichi	16*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Main S.W.Miramichi	25*	-	-	-	-	16(4)	-	-	-	-	-	-	-	-	-	-	-
Millbank (Miramichi R.)	27*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
N.W. Miramichi R.	25*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Petitcodiac R.	5*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
St. John R.	25*	-	-	-	-	24(4)	-	-	-	-	-	-	-	-	-	-	-
Tobique R.	24*	-	-	-	-	8(1)	-	-	-	-	-	-	-	-	-	-	-
MAINE																	
Craig Brk. Hatchery	25*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bellington Weir	28*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BRITISH ISLES																	
ENGLAND																	
R. Axe	12	8(1)	-	-	-	-	-	-	-	-	-	25(1)	-	58(12)	-	-	-
R. Coquet	23	52(7)	-	-	35(1)	30(17)	4(3)	-	-	-	-	44(6)	13(3)	48(3)	17(2)	-	-
R. Crake	11	-	-	-	9(1)	-	-	-	-	-	-	82(6)	-	91(10)	-	-	-
R. Lune	6	67(3)	-	-	17(1)	-	-	-	-	-	-	-	-	17(1)	-	-	-
R. Usk	24	33(2)	-	-	-	-	-	-	-	-	-	38(7)	8(2)	33(8)	-	-	-
IRELAND																	
R. Black Water	30	37(2)	-	-	-	-	-	-	-	-	-	-	70(4)	97(34)	-	-	-
R. Boyne	4	-	-	-	-	-	-	-	-	-	-	-	75(2)	25(1)	-	-	-
Burrishode R.	26	23(1)	-	-	15(4)	-	-	-	-	-	-	39(19)	31(3)	85(12)	38(5)	-	-
R. Corrib	23	35(11)	-	5(1)	44(1)	-	-	-	-	-	-	26(10)	87(7)	22(2)	46(1)		
R. Foyle	25	4(1)	-	-	-	-	-	-	-	-	-	-	-	60(3)	-	8(1)	-
R. Lee	37	-	-	-	-	-	-	-	-	-	-	14(2)	68(7)	78(9)	3(5)	-	-
Owenea R.	30	57(3)	-	-	13(2)	-	-	-	-	-	-	-	-	73(7)	-	-	-
R. Slaney	31	55(2)											97(7)	32(2)	-	-	-
SCOTLAND																	
R. Conon	26	80(12)	-	12(1)	35(2)	35(2)	-	-	-	-	-	-	-	81(6)	-	-	-
R. North Esk	25	16(2)	-	-	8(1)	12(1)	-	-	-	-	-	-	-	32(2)	4(1)	-	-
R. Tummel	25	24(1)	-	-	8(2)	-	-	-	4(1)	4(1)	-	36(6)	-	72(13)	-	-	-

*Examinations incomplete; gills and eyes only examined.

Table 3. Incidence and abundance of parasites of adult salmon, by species and area of sampling, 1966. The first figure represents the per cent of sample infected and the figure in parenthesis indicates the mean number of parasites per infected fish.

	No. fish Examined	TREMATODA							CESTODA			NEMATODA			ACANT.	CRUSTACEA	
		Gyrodactyloides bychowskii	Dicrocotyle sanguinata	Diplostomulum sp.	Derogenes varicus	Hemiurus sp.	Brachyphallus crenatus	Lecithaster gibbosus	Eubothrium crassum	Hepatoxylon trichiuri	Pelichnibothrium sp.	Contracaecum aduncum	Anisakis sp. (body cavity)	Anisakis sp. (muscles)	Echinorhynchus gadi	Lepeophtheirus salmonis	Salmincola salmonea
GREENLAND (Salmon)																	
Totals	91	21(13)	2(3)	15(2)	96(28)	+	7(5)	42(16)	46(+)XXX	6(1)	78(79)XX	98(20)	94(7)X	87(6)	22(16)	47(+)	-
NORTH AMERICA(Salmon)																	
Machias R.	10	-	-	-	90(155)	-	40(85)	10(130)	50(+)	-	10(3)	-	100(4)	10(2)	-	-	-
Miramichi R.	4	-	-	-	100(217)	-	75(34)	100(47)	100(+)	-	50(5)	-	100(4)	50(1)	-	-	25(1)
Big Salmon R.	3	-	-	-	100(79)	-	33(3)	67(44)	100(+)	-	-	-	33(1)	-	-	-	67(14)
Margaree R.	8	-	-	38(7)	75(158)	-	38(6)	75(19)	100(+)	-	-	-	100(5)	38(3)	-	-	-
R. Philip	5	-	-	-	100(187)	-	100(7)	100(15)	80(+)	-	-	-	100(7)	80(4)	-	-	-
St. Jean R.	4	-	-	-	75(41)	-	25(1)	-	100(+)	-	-	-	100(5)	75(3)	-	-	75(3)
St. John R.	1	-	-	-	100(5)	-	-	100(2)	100(+)	-	-	-	100(20)	-	-	-	-
TOTALS	35	-	-	9(7)	89(140)	-	49(29)	54(32)	83(+)	-	9(4)	-	94(4)	50(3)	-	-	17(7)
NORTH AMERICA(Grilse)																	
Miramichi R.	5	-	-	-	80(26)	-	-	40(3)	80(+)	-	-	-	100(6)	100(6)	-	20(1)	20(1)
Big Salmon R.	7	-	-	-	100(52)	-	-	43(7)	100(+)	-	-	-	43(2)	14(1)	-	-	86(19)
Margaree R.	3	-	-	33(3)	33(4)	-	-	33(3)	100(+)	-	-	-	100(9)	100(3)	-	-	-
R. Philip	5	-	-	-	60(15)	-	-	20(2)	100(+)	-	-	-	80(6)	80(6)	-	-	-
St. Jean R.	5	-	-	-	20(2)	-	-	-	100(+)	-	-	-	80(13)	80(9)	-	-	20(2)
Nepisiquit R.	1	-	-	-	-	-	-	-	100(+)	-	-	-	100(3)	100(1)	-	-	-
TOTALS	26	-	-	4(1)	39(52)	-	-	27(4)	96(+)	-	-	-	77(7)	69(6)	-	4(1)	31(14)

XIncidence of Anisakis larvae given for 102 Greenland salmon.

XXPelichnibothrium larvae were destroyed by freezing, therefore, final incidence based on 45 fresh specimens examined in Greenland in 1966.

XXXE. crassum not counted, volumes only taken.

Table 4. Abundance of Eubothrium crassum in 102 salmon of different river ages collected in Greenland in 1966. Number of salmon in sample given in parenthesis.

Year River Life	Mean Volume (ml) of E. crassum		Per Cent with Tapeworms
	Mean per Infected Salmon	Mean for all Salmon	
			%
2	41.5(23)	17.7(54)	42.6
3	36.2(20)	17.2(42)	45.5
4	35.8(4)	23.8(6)	66.7
Total 2-4	38.8(47)	17.9(102)	46.0

Table 5. Geographic distribution and abundance of Anisakis larvae in 174 adult salmon from three different areas of the North Atlantic.

Locality	Grilse (one winter only at sea)			Salmon (more than one winter at sea)		
	Sample Size	Mean No. Larvae host	Standard Deviation	Sample Size	Mean No. Larvae host	Standard Deviation
NORTH AMERICA (Summer and fall, 1966.)	26	9.192	10.182	26	5.500	4.852
GREENLAND* (Fall, 1966)	0	-	-	91	11.846	9.393
ENGLAND** (Summer, 1967)	0	-	-	31	3.774	3.703

*One salmon (bearing a Canadian tag) with 53 larvae was omitted because the high infestation was atypical and only the musculature was examined. The musculature of 10 other salmon was not examined and the data on the Anisakis in the body cavity of these fish have been omitted.

**One salmon with 127 larvae was omitted because the high infestation was considered to be atypical.

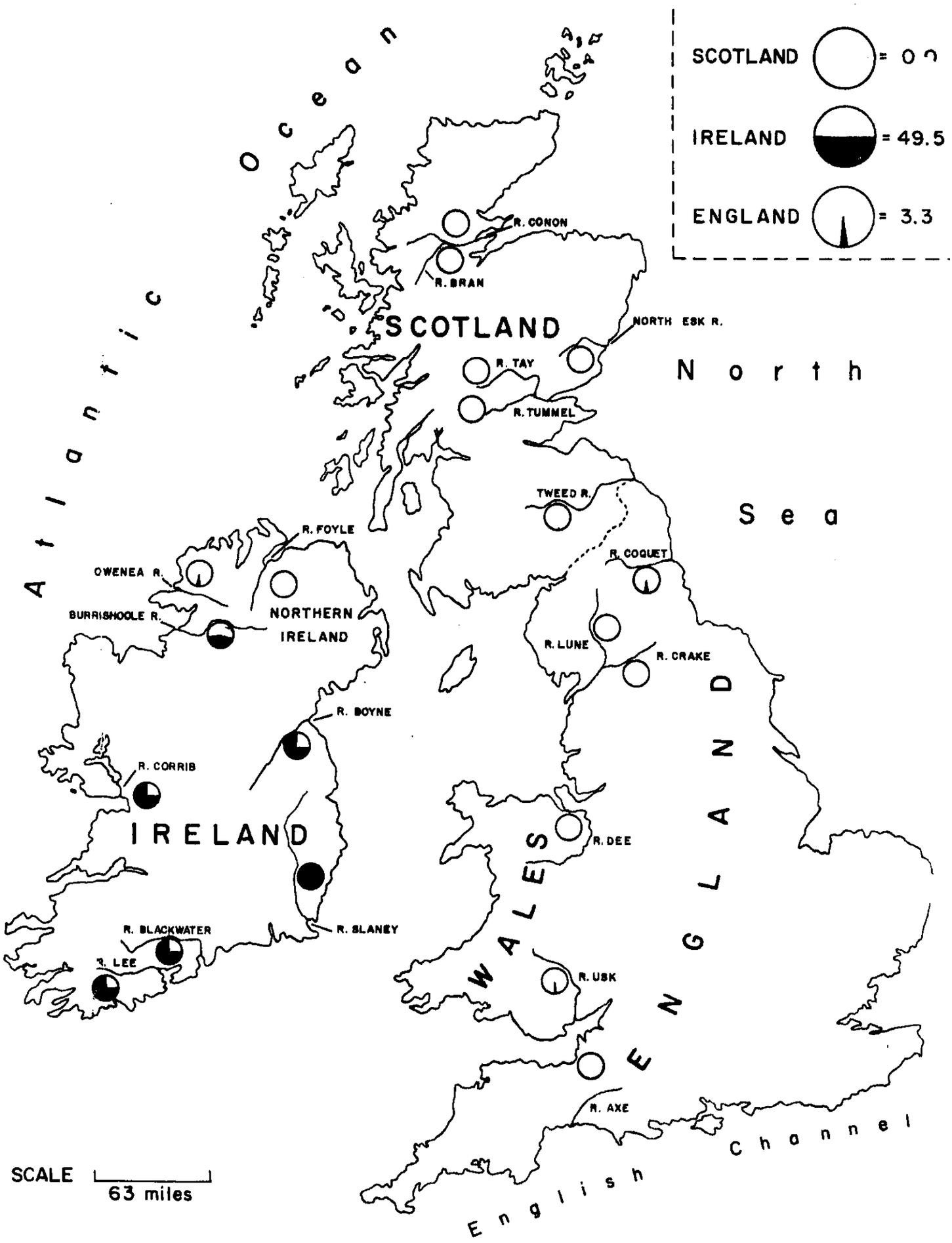

Fig. 1. Distribution and abundance of Pomphorhynchus laevis in British Isles (1966 and 1967 data combined). Black areas indicate percentage of samples infected.

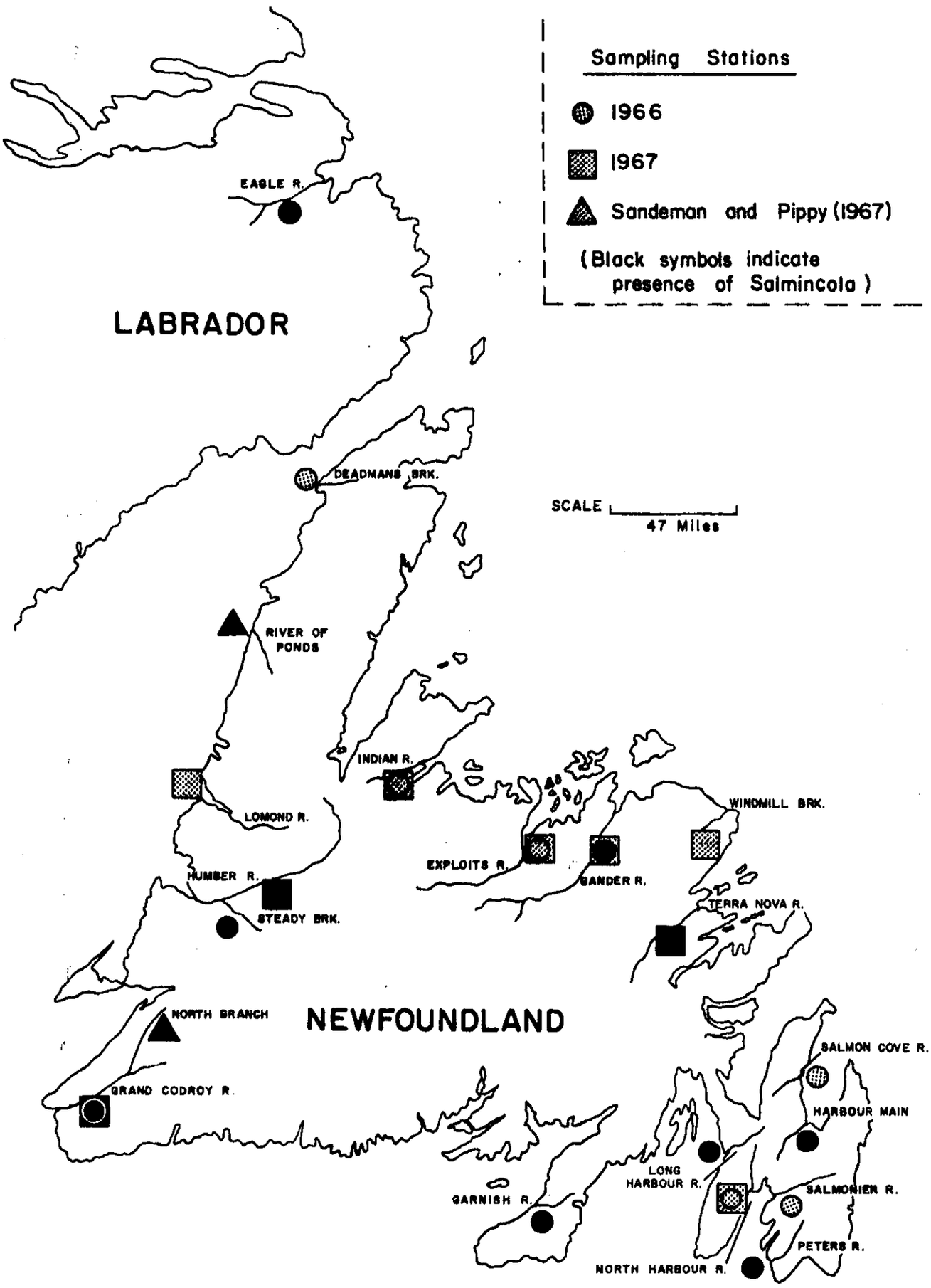

Fig. 2. Distribution of Salmincola sp. on smolts from Newfoundland and Labrador, 1966 and 1967.