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Summary of salmon parasite investigations 1970-71

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Introduction

Studies have continued on two species of parasites to determine if they might be useful in ascertaining the continental origin of salmon caught on the high seas. Earlier studies (Pippy, 1970 and Nyman and Pippy, 1971) suggested that the parasitic nematode Anisakis simplex was more abundant in European salmon than in North American salmon and that the tapeworm Eubothrium crassum was more prevalent among salmon of North American origin. Since these earlier reports, more salmon from a wider geographic range have been examined and age determinations of these and most of the previous samples have been made, and previous age determinations checked. Results of the parasitological examinations have now been arranged according to the sea-ages (sea-winters) of the host (Appendices I-IV).

Discussion in this report will be confined to data obtained from 1-sea-winter salmon caught near West Greenland and 2-sea-winter salmon caught near the east coast of Canada or in or near rivers of the British Isles. Age determinations for some of the salmon caught in 1970 have not yet been collated with the parasitological data and the studies on salmon caught in 1971 are as yet incomplete. Statistical comparisons of the abundance of A. simplex in different samples are based on transformed data as described by Nyman and Pippy (1971). Determination of the continental origin of untagged salmon caught in Greenland was performed by O.L. Nyman using the techniques described by Nyman and Pippy, 1971. At this state of our research it seems practicable to emphasize only those differences in parasite abundance as they relate to concurrent studies, such as tagging studies and electrophoretic analyses on the host salmon.

Results

Studies on larval Anisakis simplex

Random samples of Atlantic salmon taken off West Greenland in 1968, 1969, and 1970 consistently had higher mean numbers of A. simplex larvae than those samples in Canadian waters in the following years (Table 1). Both the abundance of larvae in Canadian tagged salmon (4.35/host) and in electrophoretically identified Canadian salmon taken in Greenland in 1969 (4.53/host) had a level of infestation which was similar ($P < .9$) to that in salmon caught in Canadian waters the following year (4.04/host). Also, the mean number of larvae in salmon taken in the British Isles in 1970 (9.27/ host) appears to be higher than that observed in Canadian salmon during the same period (Table 1) (although a large proportion of the British value may be due to a sampling in favour of Scotland (Appendix I)). Thus, a comparison of data on the abundance of A. simplex larvae in salmon taken in home waters (North America and Europe) in 1970 agrees with Pippy's (1970) and Nyman and Pippy's (1971) suggestion (based on studies on salmon from West Greenland) that this parasite is more abundant in European salmon.

Data obtained from A. simplex samples off West Greenland in 1970 did not yield results as definitive as did those of 1969. The tagged North American salmon had less larvae ($.02 < P < .05$) than electrophoretically identified North American salmon. Similarly, the tagged European salmon had less larvae ($P = .05$) than electrophoretically identified European salmon. Furthermore, there was no statistically significant difference in larval abundance between the tagged North American and European salmon ($.3 < P < .4$) and between the electrophoretically identified North American and European salmon ($.1 < P < .2$). The reasons for these apparent discrepancies over results of the previous year are not yet

clear. Data analyses on the 1971 samples have not yet been completed. However, there are indications that the mean number of A. simplex larvae in Canadian salmon in 1971 is higher than it was in 1969 and 1970 (Table 1).

Studies carried out in West Greenland in 1970 suggest there may be difficulties in using data on abundance of parasites in tagged fish as representative of groups of fish of unknown origin (Table 1). Results from tagged fish are biased in that the fish come from restricted geographic localities and these may harbour atypical quantities of parasites (Appendix I). This is especially evident from examination of data from the 46 European tagged salmon presented in Appendix II. The relative proportions of recaptured fish from diverse localities may greatly influence the final calculated mean numbers of larvae per host in any wide geographic locality (e.g. North America or Europe). Most Canadian tagged salmon examined from Greenland in 1970 originated in New Brunswick and none came from Newfoundland. Thus the value cited for tagged North American salmon in Table 1 may not necessarily be representative of Canadian salmon from provinces other than New Brunswick.

Pippy (1970) suggested that the salmon stocks from the Miramichi and Chaleur Bay areas of Canada were, with respect to the abundance of A. simplex larvae, similar to the stocks of salmon found in West Greenland. In 1968 the mean number of larvae in 8 tagged Canadian salmon caught in West Greenland was 4.5 and the mean for 165 salmon caught in the Miramichi and Chaleur Bay areas a year later was 4.3. Except for the sample of salmon from the Bay of Fundy, the 1969 Miramichi and Chaleur Bay samples were the only ones with mean numbers of larvae above 4. Of 222 North American salmon caught in Greenland in 1969 the mean number of larvae per host was 4.4; this value is close to the mean of 4.3 in 413 salmon taken a year later (1970) in Miramichi and Chaleur Bay areas. Many of the tagged salmon taken in Greenland originated in this area of Canada and, since the means for tagged salmon were lower than for untagged salmon they may have influenced the results somewhat. However, in 1970 the value of 4.3 larvae per host does not appear to be atypical for Canadian samples. Apparently, there may be considerable annual variation in the

abundance of A. simplex in different samples of salmon (Appendix I). Until the nature of this variation is understood it is not yet possible to say that the Miramichi and Chaleur Bay salmon, or any other stocks of Canadian salmon, contribute significantly greater proportions to the Greenland fishery than any other canadian stocks.

Studies on Eubothrium crassum

During each year from 1967 to 1970 the proportion of Atlantic salmon infected with E. crassum in Canadian waters was higher than that recorded in random samples taken during the previous fall off West Greenland (Table 3). This repetition of results over a four year period supports the suggestion that E. crassum might be more abundant in salmon caught in Canadian waters than in European waters. This is supported by the fact that of the 263 tagged Canadian salmon caught in Greenland in 1969 and 1970, 22.4% were infected with E. crassum while only 4.5% of 67 European tagged salmon taken in the same general locality and period were infected. Similarly, in both 1969 and 1970, salmon identified electrophoretically as being of North American origin had a higher prevalence of E. crassum than did those identified as being of European origin. Generally, the prevalence of E. crassum in fish identified from tagging procedures was comparable to data obtained from salmon identified using electrophoresis (Table 3).

The presence of E. crassum in 3.1% of the 193 salmon taken from the British Isles in 1970 contrasts with a prevalence of 32% of 670 salmon taken in Canadian waters in the same year. The observed low prevalence of E. crassum in salmon from the British Isles in 1970 may be misleading because Atlantic salmon are known to lose their tapeworm fauna shortly before or after they move into fresh water and practically all UK salmon used here were taken from fresh water or in or near estuaries.

Summary and conclusions

(1) Data on the abundance of the parasitic nematode Anisakis simplex and on the prevalence of the tapeworm Eubothrium crassum have been updated and compiled according to the sea-age of the hosts (Appendices I-IV).

(2) Figures on the abundance of A. simplex larvae in North American salmon in West Greenland and in home waters have been consistently lower than those from European salmon. The 1970 data from Greenland are complicated somewhat by differences between tagged and untagged salmon. The data from the 1971 collection, currently being studied, should help clarify this problem.

(3) Data collected in 1970 yielded little evidence to support any proposal that some North American stocks of salmon contribute more or less than other North American stocks to the Greenland salmon fishery. However, the data do not preclude the possibility of differences.

(4) Studies on the tapeworm Eubothrium crassum support earlier findings that, in West Greenland, this parasite is more prevalent in North American than in European salmon.

(5) Differences observed in the abundance of A. simplex and in the prevalence of E. crassum may be used to support results obtained from electrophoretic determinations (and possibly other techniques currently under investigation) of continental origins of salmon caught off West Greenland. A more complete analysis of the available data and at least one more season's study will be necessary to determine if these parasites per se can be used to arrive at a reasonable estimate of the proportion of North American salmon in catches on the high seas.

References

Nyman, O.L. and J.H.C. Pippy. 1971. Techniques to identify continental origin of Atlantic salmon caught at sea. ICNAF Res. Doc. 71/3; 21 p.

Pippy, J.H.C. 1970. Summary of salmon parasite investigations, 1969. ICNAF Res. Doc. 70/8; 10 p.

Table 1. Mean numbers of *Anisakis* larvae in 1-sea-winter salmon caught off West Greenland compared with those in 2-sea-winter salmon from home waters the next year. Data from Appendices I and II.

Sample	West Greenland				Home Waters	
	Year	Tagged	Electro-phoresis	Random	Year	Mean
North American	1968	4.50			1969	3.00
Random				5.77		
North American	1969	4.35	4.53		1970	4.04
European		7.20	7.16			9.27
Random				6.17		
North American	1970	4.03	5.91		1971	5.75 *
European		5.00	6.78			
Random				6.34		

* analyses incomplete; 333 examined; all ages combined.

Table 2. Transformed data on abundance of *Anisakis* larvae in 1-sea-winter salmon caught off West Greenland and in home waters based on the transformations $y = \log(x+1)$ when K is ≤ 2 and $y = \log(x+\frac{1}{2}K)$ when $2 < K < 5$ where $K = \bar{x}^2/S^2-\bar{x}$.

Sample	Year	West Greenland						Home waters		
		Tagged		Electrophoresis		Random		Year		
		$\bar{x}$	S^2	$\bar{x}$	S^2	$\bar{x}$	S^2		$\bar{x}$	S^2
North American	1968	1.408	.658					1969	1.291	.527
Random						1.702	.517			
North American	1969	1.464	.508	1.321	.757			1970	1.468	.446
European		1.683	.929	1.780	.670				-	-
Random						1.611	.745			
North American	1970	1.431	.384	1.652	.585			1971	-	
European		1.536	.632	1.806	.537					
Random						1.728	.565			

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Table 3. Percentages of 1-sea-winter Atlantic salmon infested with *E. crassum* off West Greenland compared with samples of 2-sea-winter salmon examined in home waters during the next year. Electro. = continent of origin identified by O. L. Nyman using electrophoresis. Most data are from Appendices III and IV. * indicates data not found in appendices; in these the bracketed figure represents the number of salmon in each sample.

Sample	West Greenland				Home waters	
	Year	Tagged	Electro.	Random	Year	
North American	1966	100(4)*			1967	59(72)*
Random				55(97)*		
North American	1967	100(1)*			1968	68(286)*
Random				32(88)*		
North American	1968	62.5			1969	73.4
Random				52.9		
North American	1969	20.5	22.4		1970	31.5
European		0	11.6			3.1
Random				17.6		
North American	1970	24.8	18.7			
European		6.4	7.0			
Random				12.3		

Appendix I. Number (N), mean number ($\bar{x}$) and standard deviation (S) of *Anisakis* larvae found in Atlantic salmon from sampling stations in the North Atlantic Ocean, arranged according to host's sea-winters.

Sampling station	Year	1			2			3			4			5		
		N	$\bar{x}$	S	N	$\bar{x}$	S	N	$\bar{x}$	S	N	$\bar{x}$	S	N	$\bar{x}$	S
West Greenland	1968	155	5.77	4.49	10	9.00	6.00	-	-	-	-	-	-	-	-	-
Canadian (by tagging)	1968	8	4.50	4.60	6	4.00	3.41	2	3.00	1.41	-	-	-	-	-	-
Canada	1969	126	2.48	3.04	531	3.77	3.71	152	6.90	7.68	11	5.00	4.40	2	2.50	0.71
Packs Harbour, Labrador	1969	5	8.20	5.98	8	3.00	2.65	-	-	-	-	-	-	-	-	-
St. Anthony, Newfoundland	1969	19	3.95	2.74	28	3.00	2.38	2	2.50	0.50	1	2.00	0	-	-	-
Bonavista, Newfoundland	1969	40	1.65	1.17	61	3.12	2.75	23	5.13	3.25	1	6.00	0	-	-	-
Cape Spear, Newfoundland	1969	11	5.64	4.58	72	3.33	4.01	16	12.69	20.36	-	-	-	-	-	-
Port aux Basques, Newfoundland	1969	1	0	0	71	2.99	3.02	13	5.85	4.07	1	1	0	-	-	-
Loggieville, New Brunswick	1969	-	-	-	95	4.19	3.89	11	5.91	4.72	-	-	-	-	-	-
Carleton, Quebec	1969	-	-	-	70	4.57	3.58	81	7.84	9.72	6	6.50	4.92	2	2.50	0.71
East shore Bay of Fundy	1969	49	1.39	1.65	57	3.63	4.15	6	4.67	3.20	1	5.00	0	-	-	-
Saint John, New Brunswick	1969	1	0	0	69	4.12	4.95	-	-	-	1	2.00	0	-	-	-
West Greenland (untagged)	1969	205	6.17	6.57	15	6.00	8.18	-	-	-	-	-	-	-	-	-
European (by electrophoresis)	1969	103	7.16	7.12	8	6.86	1̣.09	-	-				-	-	-	-
American (by electrophoresis)	1969	76	4.53	5.68	4	6.75	2.99	-	-	-	-	-	-	-	-	-
European (by tagging)	1969	2(	7.20	8.09	4	9.75	4.79	-	-	-	-	-	-	-	-	-
Canadian (by tagging)	1969	146	4.35	3.64	5	6.00	3.0^	-	-	-	1	6.00	0	-	-	-
Labrador Sea	1970	-	-	-	23	3.70	5.89	2	2.50	3.54	-	-	-	-	-	-
Canada (excluding unag·d fish (*))	1970	85	2.80	2.14	670	4.04	3.26	110	4.90	4.49	9	3.40	3.50	-	-	-
Packs Harbour	1970	82*	4.24	4.92												
St Anthony	1970	103*	3.53	3.56												
Bonavista	1̣970	44	2.71	2.27	46	5.09	3.64	7	2.86	2.34	-	-	-	-	-	-
Rose Blanche (near Port aux Basques)	1970	-	-	-	87	3.94	3.29	3	3.00	1.73	-	-	-	-	-	-
Loggieville	1970	35	3.03	1.99	238	4.09	3.33	19	4.90	3.91	1	10.00	0	-	-	-
Carleton	1970	-	-	-	175	4.55	3.09	71	5.56	4.80	5	2.13	0.41	-	-	-
Saint John	1970	6	2.17	1.17	124	2.92	2.50	10	2.20	1.75	3	3.33	4.04	-	-	-
..sh Isles	1970	6	4.16	-	193	9.27	-	17	2.59	-	-	-	-	-	-	-
Scotland	1970	4	4.50	2.65	107	14.20	13.02	-	-	-	-	-	-	-	-	-
England	1970	-	-	-	45	6.00	7.57	6	2.33	1.63	-	-	-	-	-	-
Ireland	1970	2	3.50	0.71	41	6.12	8.86	11	2.73	2.37	1	1	0	-	-	-

Appendix II. Number (N), mean number ($\bar{x}$) and standard deviation (S) of *Anisakis* larvae found in Atlantic salmon from off West Greenland, Fall, 1970.

Sample	1			2			3			4		
	N	$\bar{x}$	S	N	$\bar{x}$	S	N	$\bar{x}$	S	N	$\bar{x}$	S
Random	162	6.34	5.50	9	9.89	7.04	1	4	0	1	14	0
European (by electrophoresis)	86	6.78	5.50	5	14.40	2.71	1	4	0	-	-	-
North American (by electrophoresis)	75	5.91	5.50	4	4.25	2.63	-	-	-	1	14	0
European (by tagging) (see below)	47	5.51	6.38	2	9.50	3.54	-	-	-	-	-	-
North American (by tagging)	117	4.03	3.08	8	8.88	5.72	1	8	0	-	-	-
European tagged salmon												
England	21	3.57	3.30	1	7.00	0	-	-	-	-	-	-
Scotland	17	6.88	8.36	1	12.00	0	-	-	-	-	-	-
France	4	2.25	1.89	-	-	-	-	-	-	-	-	-
Norway	4	7.25	3.59	-	-	-	-	-	-	-	-	-

Appendix III. Number salmon examined (Ex'd), number infested (Inf'd) and percent infested (%) with *A. simplex* in sampling stations in the North Atlantic region, arranged according to host's sea-winters.

Sampling station	Year	1			2			3			4			5		
		Ex'd	Inf'd	%	Ex'd	Inf'd	%	Ex'd	Inf'd	%	Ex'd	Inf'd	%	Ex'd	Inf'd	%
West Greenland	1968	155	82	52.90	10	7	70.00	-	-	-	-	-	-	-	-	-
Canadian (by tagging)	1968	8	5	62.50	6	3	50.00	2	2	100.00	-	-	-	-	-	-
Canada	1969	126	60	47.61	531	390	73.44	152	81	53.28	11	10	90.90	2	2	100.00
Packs Harbour, Labrador	1969	5	3	60.00	8	8	100.00	-	-	-	-	-	-	-	-	-
St. Anthony, Newfoundland	1969	19	9	47.36	28	23	82.14	2	0	0	1	1	100.00	-	-	-
Bonavista, Newfoundland	1969	40	12	30.00	61	51	83.60	23	14	60.86	1	1	100.00	-	-	-
Cape Spear, Newfoundland	1969	11	4	36.36	72	59	81.94	16	10	62.50	-	-	-	-	-	-
Port aux Basques, Newfoundland	1969	1	1	100.00	71	53	74.64	13	10	76.92	1	1	100.00	-	-	-
Loggieville, New Brunswick	1969	-	-	-	95	49	51.57	11	7	63.63	-	-	-	-	-	-
Carleton, Quebec	1969	-	-	-	70	39	55.71	81	37	45.67	6	5	-	2	2	100.00
East Shore Bay of Fundy	1969	49	30	61.22	57	45	78.94	6	3	50.00	1	1	100.00	-	-	-
Saint John, New Brunswick	1969	1	1	100.00	69	63	91.30	-	-	-	1	1	100.00	-	-	-
West Greenland (untagged)	1969	205	36	17.56	15	4	26.66	-	-	-	-	-	-	-	-	-
European (by electrophoresis)	1969	103	12	11.65	8	2	25.00	-	-	-	-	-	-	-	-	-
American (by electrophoresis)	1969	76	17	22.36	4	2	50.00	-	-	-	-	-	-	-	-	-
European (by tagging)	1969	20	0	0	4	0	0	-	-	-	-	-	-	-	-	-
Canadian (by tagging)	1969	146	30	20.54	5	4	80.00	-	-	-	1	1	100.00	-	-	-
Labrador Sea	1970	-	-	-	23	15	65.21	1	0	0	-	-	-	-	-	-
Canada (excluding unaged fish (*))	1970	85	9	10.58	670	211	31.49	110	85	77.27	9	8	88.88	-	-	-
Packs Harbour	1970	82*	66	80.48												
St. Anthony	1970	103*	56	54.36												
Bonavista	1970	44	5	11.36	46	10	21.73	7	5	71.42	-	-	-	-	-	-
Rose Blanche (near Port aux Basques)	1970	-	-	-	87	50	57.47	3	3	100.00	-	-	-	-	-	-
Loggieville	1970	35	3	8.57	238	45	18.14	19	13	68.42	1	1	100	-	-	-
Carleton	1970	-	-	-	175	44	25.14	71	55	77.46	5	4	80.00	-	-	-
Saint John	1970	6	1	16.66	124	62	50.00	10	9	90.00	3	3	100.00	-	-	-
ish Isles	1970	6	0	0	193	6	3.11	17	1	5.88	-	-	-	-	-	-
cotland	1970	4	0	0	107	5	4.67	-	-	-	-	-	-	-	-	-
England	1970	-	-	-	45	1	2.22	6	1	16.67	-	-	-	-	-	-
Ireland	1970	2	0	0	41	0	0	11	0	0	1	0	0	-	-	-

Appendix IV. Number salmon examined (Ex'd), number infested (Inf'd) and percent infested (%) with *B. crassum* in samples from off West Greenland, Fall, 1970, arranged according to host's sea-winters.

	1			2			3			4		
	Ex'd	Inf'd	%	Ex'd	Inf'd	%	Ex'd	Inf'd	%	Ex'd	Inf'd	%
Random	162	20	12.34	9	2	22.22	1	1	100	1	1	100
European (by electrophoresis)	86	6	6.97	5	1	20.00	1	1	100	-	-	-
North American (by electrophoresis)	75	14	18.66	4	1	25.00	-	-	-	1	1	100
European (by tagging) (see below)	47	3	6.38	2	0	0	-	-	-	-	-	-
North American (by tagging)	117	29	24.78	8	3	37.50	1	0	0	-	-	-
European tagged salmon												
England	21	2	9.52	1	0	0	-	-	-	-	-	-
Scotland	17	0	0	1	0	0	-	-	-	-	-	-
France	4	1	25.00	-	-	-	-	-	-	-	-	-
Norway	4	0	0	-	-	-	-	-	-	-	-	-