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Studies on the parasites of Atlantic salmon (*Salmo salar*) in 1968

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Introduction

Studies on the parasites of Atlantic salmon to determine which parasitic species might be useful to ascertain the continental origin of salmon caught on the high seas (Pippy, 1967 and 1968) continued in 1968. Results of examinations of smolts received in 1968 conformed with those of previous years, namely, that freshwater parasites are of little value in separating stocks in West Greenland. Preliminary observations indicate that some marine parasites may be of value as biological tags. Studies on the abundance of the marine larval nematode *Anisakis* in salmon from North America and England suggested that not a very high proportion of the salmon in the samples collected in 1966 and 1967 had been to Greenland (Pippy, 1968). The possibility that some stocks of salmon frequent Greenland waters while others do not was investigated in 1968. This knowledge, and the identification of the parasite fauna of the stocks involved, is prerequisite to stock separation in Greenland.

Emphasis was placed on certain marine parasites of adult salmon. These were the larval cestodes *Hepatoxylon trichiuri* and *Tentacularia coryphaenae* and the larval nematode *Anisakis* sp. Each of these are considered to be permanent parasites in salmon, that is, once in their host, they remain for the duration of its life. The adult nematode, *Contracaecum aduncum*, formerly thought to be of use as an indicator of migration to Greenland (Pippy, 1968), was also studied.

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Characterization of Canadian stocks by body cavity parasites

A summary of parasite data on adult Atlantic salmon examined to date is presented in Table 1 and a comparison of the abundance of several species in various Canadian stocks is given in Table 2.

Both the incidence and intensity of infestation of *Anisakis* sp., *T. coryphaenae*, and *H. trichiuri* in the body cavity of 2-sea-year salmon from Chaleur Bay and the Miramichi drift-net fishing area are the same (P = .01) (Table 2). However, the incidence and intensity of infestation of *Anisakis* sp. in 2-sea-year salmon from the Saint John area of the Bay of Fundy (55% and 2.0 per host) is lower (P = .01) than for salmon from Chaleur Bay and the Miramichi drift-net fishing area (99% and 6.3). Also, the incidence of *T. coryphaenae* is lower in the Bay of Fundy salmon (4%) than in salmon from Chaleur Bay and the Miramichi area (about 24%). Thus, 2-sea-year salmon stocks from the Saint John area of the Bay of Fundy may be distinguished from stocks in the Chaleur Bay and Miramichi drift-net fishing area by their lower abundance of *T. coryphaenae* and *Anisakis* larvae.

T. coryphaenae is abundant (14% and 0.3 per host) in 3-sea-year salmon from the Miramichi drift-net fishing area but absent in those from Chaleur Bay. Also, both *Anisakis* sp. and *H. trichiuri* are more abundant (P = .01) in the 3-sea-year salmon from the Miramichi area than in those from Chaleur Bay. Thus, 3-sea-year salmon stocks returning to Chaleur Bay are distinguishable from 3-sea-year salmon caught in the Miramichi drift-net fishery by the absence of *T. coryphaenae* and the lower incidence of *Anisakis* and *H. trichiuri*

Atlantic salmon returning to the Chaleur Bay may be divided into two parasitologically distinct groups (Fig. 1). The first group has a high intensity of infestation of *Anisakis* sp. (6.9 per host) and a high incidence of *T. coryphaenae* (27%). The second group has a low intensity of infestation of *Anisakis* sp. (4.3), and no *T. coryphaenae*. In samples examined, the largest salmon in the first group weighed 14.5 pounds and was 84 cm long (fork length), whereas the smallest salmon in the second group weighed 16.3 pounds and was 87 cm long. These two groups can also be separated on the basis of their sea ages, the group of larger fish having spent three years at sea and the smaller fish two years.

Similarities between Canadian stocks and Greenland salmon

The intensity of infestation of Anisakis sp. in 2-sea-year salmon from the Saint John area of the Bay of Fundy (2.0) is less than that found in salmon from West Greenland (4.4) nine months earlier ($P = .01$). If Anisakis sp. is not lost from salmon at sea, salmon caught in the Saint John area of the Bay of Fundy are not representative of salmon caught in Greenland.

The incidence of infestation of Anisakis sp., and H. trichiuri in 2-sea-year salmon from Chaleur Bay and the Miramichi drift-net fishing area were higher ($P = .01$) than those found in 1-sea-year salmon in Greenland the previous fall. This conforms with conclusions by other workers that larval parasites accumulate in their hosts and indicates that 2-sea-year salmon from Chaleur Bay and the Miramichi area are parasitologically similar to those caught in Greenland the previous fall. This similarity, and the dissimilarity of the Bay of Fundy salmon, is presented graphically in Fig. 2 and 3. Because of the relatively high abundance of Anisakis larvae in grilse and the relatively low abundance in 3-sea-year salmon (Table 1), it is unlikely that the observed similarity between Chaleur and Miramichi salmon and Greenland salmon is simply indicative of time spent at sea. A more plausible explanation is that the salmon from these areas, in general, have had similar feeding habits with respect to infested intermediate hosts of the parasites. Most likely these 2-sea-year salmon have returned from Greenland.

Since no 2-sea-year salmon have yet been examined from Greenland, it is not possible to make similar comparisons for 3-sea-year salmon in Canadian waters.

Pippy (1968) observed Contracaecum aduncum in adult salmon in Greenland but not in those in Canadian waters and speculated on its use as an index of migration to Greenland. More recent data (Table 1) show that C. aduncum is indeed present (94% infested in Miramichi area) in Canadian adult salmon. C. aduncum is apparently lost from salmon shortly after they enter fresh water. This species may not, therefore, be used as an indicator of migration to Greenland.

Identification of Canadian and European salmon in Greenland

General studies on the intestinal parasites of adult salmon suggest that few, if any, of these parasites will be of value in determining the continental origin of salmon caught on the high seas. *Eubothrium crassum*, which appears to be more abundant in Canadian than European salmon (Templeman, 1967; Pippy, 1968), requires further investigation. The body cavity parasites *Hepatoxylon trichiuri* and *Tentacularia coryphaenae* are apparently too rare to be of much use. In view of these findings, emphasis has been placed on the study of the abundance and specific characters of *Anisakis* larvae.

The abundance of *Anisakis* in both Canadian and European salmon appears to be the same (Pippy, 1968). Studies in 1968 indicate there are no morphometric differences in *Anisakis* larvae from the British Isles and Canada. However a characteristic pattern of fluorescence (when illuminated by ultraviolet light) has been found in many Canadian larvae but not yet in any from the British Isles. More intense sampling in the British Isles and Greenland is necessary before this attribute can be seriously considered as characteristic of larvae of Canadian origin. Another possible method of identifying *Anisakis* larvae from different areas of the north Atlantic is based on observed genetically determined polymorphisms in certain enzymes. This research is discussed by Nyman (1969).

Summary and Conclusions

Evidence based on the abundance of the three body cavity parasites, *Anisakis* sp., *Hepatoxylon trichiuri* and *Tentacularia coryphaenae*, in salmon in Greenland and Canada suggests that not all Canadian stocks of salmon are represented in Greenland. Two-sea-year salmon returning to the Miramichi and Chaleur Bay areas of Canada are parasitologically similar to those caught in Greenland the previous fall. Salmon caught in the Saint John area of the Bay of Fundy are not representative of salmon caught in Greenland. This finding complicates the search for a biological tag. Identification of the major Canadian stocks which migrate to Greenland and documentation of their parasite fauna will be necessary before data on occurrence of certain parasites in Greenland salmon can be effectively used as indicators of continental origin.

There is little hope for the use of freshwater parasites as biological tags in salmon in Greenland. Of the marine parasites, the nematode *Anisakis* sp., and the cestode *Eubothrium crassum* show promise. Further study on the occurrence and classification of these parasites is necessary before they can be used as biological tags in Greenland salmon.

References

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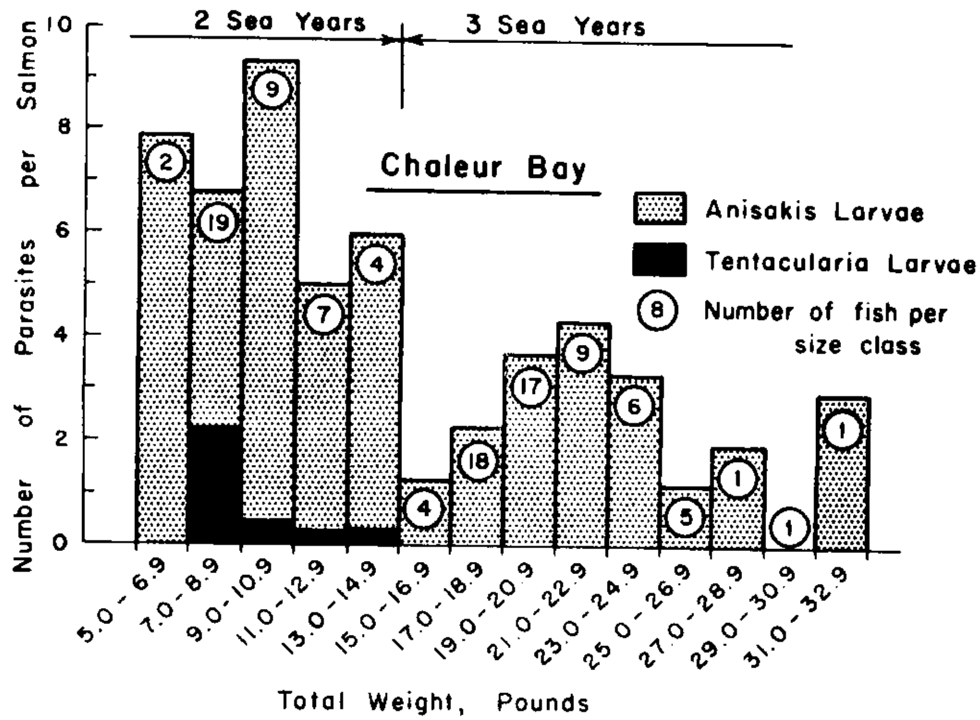

Fig. 1. Abundance of Anisakis larvae and Tentacularia coryphaenae larvae in salmon of different sea ages and various size classes in Chaleur Bay, 1968.

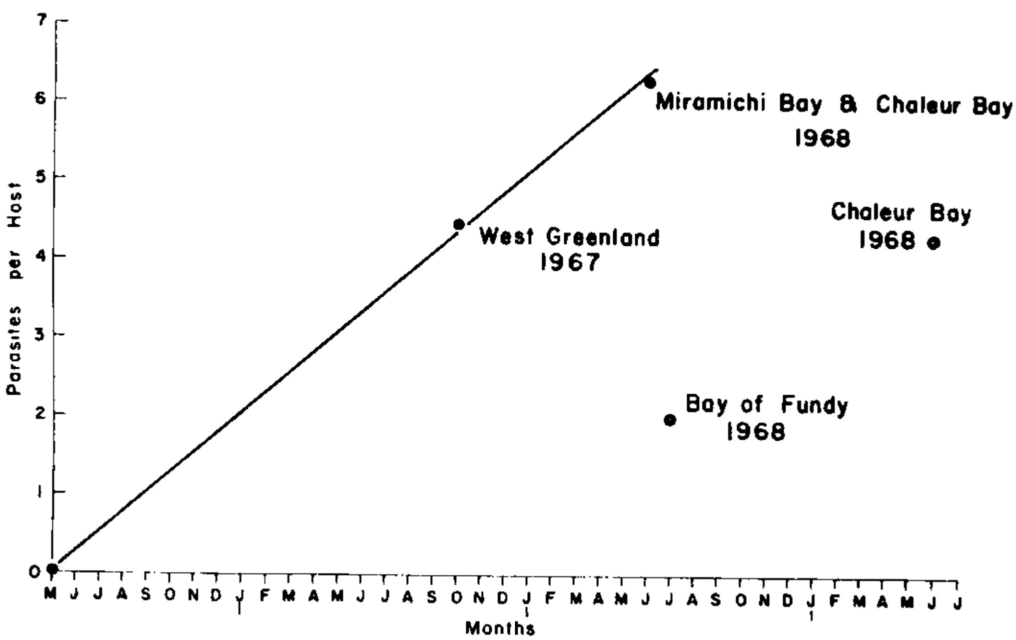

Fig. 2. Relation of mean number Anisakis larvae (from body cavity) per salmon to time spent at sea in salmon. Note that salmon returning to Miramichi Bay and Chaleur Bay appear to be more closely related to West Greenland salmon than Bay of Fundy salmon and 3-sea-year salmon in Chaleur Bay.

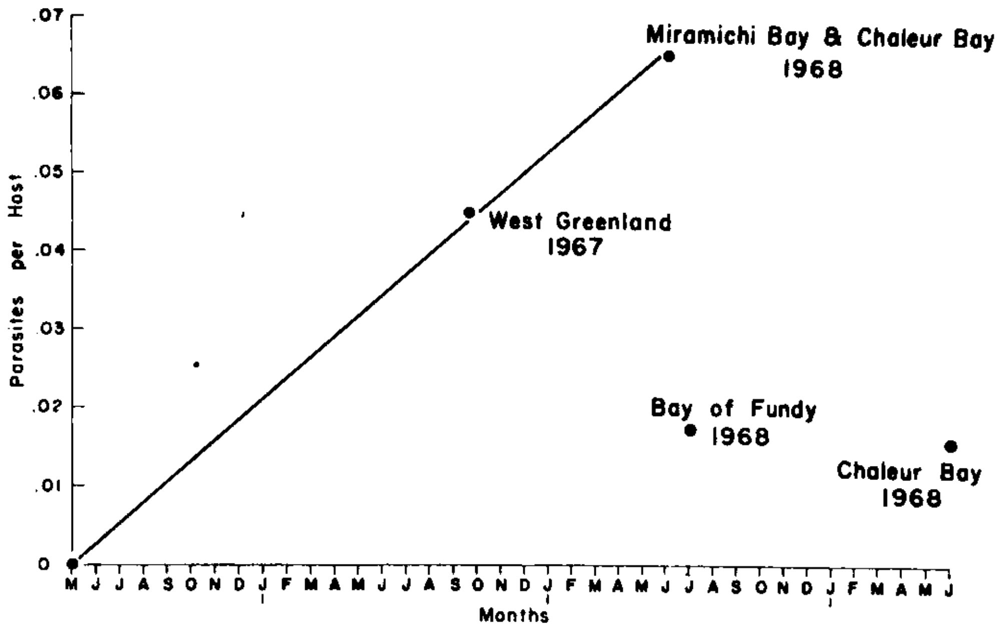

Fig. 3. Relation of mean number Hepatoxylon trichiuri larvae per salmon to time spent at sea in salmon. Note that salmon returning to Miramichi Bay and Chaleur Bay appear to be more closely related to West Greenland salmon than Bay of Fundy salmon and 3-sea-year salmon in Chaleur Bay.

Table 1. Incidence and intensity* of infestation of parasites of adult salmon, by species and area of origin, 1966 to 1968. "Grilse" is a term used for small salmon which spend about a year at sea before returning to fresh water; "salmon" spend two or more years at sea.

Sampling station	Date of capture	Environment (S = sea; R = river)	Number examined	Years at sea or stage	TREMATODA: Gyrodactyloides bychowskii	TREMATODA: Derogenes varicus	TREMATODA: Hemiurus levinseni	TREMATODA: Hemiurus sp.	TREMATODA: Brachyphallus crenatus	TREMATODA: Lecithaster gibbosus	TREMATODA: Lampritrema nipponicum	TREMATODA: Azygia sp.	TREMATODA: Discocotyle sagittata	TREMATODA: Diplostomulum sp.	TREMATODA: Tetracotyle sp.	CESTODA: Eubothrium crassum	CESTODA: Hepatoxylon trichiuri	CESTODA: Tentacularia coryphaenae	CESTODA: Pelichnibothrium sp.	NEMATODA: Anisakis sp. (body cavity)	NEMATODA: Anisakis sp. (muscles)	NEMATODA: Contracaecum aduncum	ACANT.: Echinorhynchus gadi	COPEPODA: Lepeophtheirus salmonis	COPEPODA: Salmincola salmoneus
					A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U
S.W. England, near R. Axe	7/67	S	32	2	0	100(119)	10(2)	3(12)	0	72(32)	0	3(1)	0	0	0	28(+)	13(2)	0	-	91(3)	16(2)	0	0	0	0
Greenland (Godthaab area)	9/66	S	97	1	19(19)	93(31)	20(3)	0	14(3)	40(15)	0	0	2(3)	13(2)	1(2)	55(+)	7(1)	0	78(79)	94(7)	87(6)	96(19)	24(2)	47(+)	0
West Greenland	9/67	S	88	post-grilse	-	87(26)	6(6)	0	11(1)	15(5)	1(1)	0	0	-	0	32(+)	5(1)	3(1)	-	87(5)	89(5)	91(13)	6(1)	-	0
North America																									
Big Salmon R., N.B.	16/11/66	R	7	grilse	0	100(52)	0	0	0	43(7)	0	0	0	0	0	100(+)	0	-	-	43(2)	14(1)	0	0	0	86(19)
Margaree R., N.S.	11/66	R	3	grilse	0	33(4)	0	0	0	33(3)	0	0	0	33(3)	0	100(+)	0	-	-	100(9)	100(3)	0	0	0	0
Miramichi R., N.B.	11/66	R	5	grilse	0	80(26)	0	0	0	40(3)	0	0	0	0	0	80(+)	0	-	-	100(6)	100(6)	0	0	20(1)	20(1)
Miramichi R., N.B.	6 to 7/68	R	6	grilse	-	100(35)	0	0	100(5)	50(9)	0	0	0	0	0	67(+)	17(1)	17(1)	-	100(4)	-	0	0	-	0
Miramichi R., N.B.	6 to 7/68	R	9	grilse	-	-	-	-	-	-	-	-	-	-	0	67(+)	0	0	-	100(4)	100(7)	-	-	-	-
Nepisiguit R., N.B.	11/66	R	1	grilse	0	0	0	0	0	0	0	0	0	0	0	100(+)	0	-	-	100(3)	100(1)	0	0	0	0
River Philip, N.S.	11/66	R	5	grilse	0	60(15)	0	0	0	20(2)	0	0	0	0	0	100(+)	0	-	-	80(6)	80(6)	0	0	0	0
St. Jean R., Que.	11/66	R	5	grilse	0	20(2)	0	0	0	0	0	0	0	0	0	100(+)	0	-	-	80(13)	80(9)	0	0	0	20(2)
Big Salmon R., N.B.	16/11/66	R	3	salmon	0	100(79)	0	0	33(3)	67(44)	0	0	0	0	0	100(+)	0	0	-	33(1)	0	0	0	0	67(14)
Machias R., Maine	16/5/66	R	10	salmon	0	90(155)	0	0	40(85)	10(130)	0	0	0	0	0	50(+)	0	-	10(3)	100(4)	10(2)	0	0	0	0
Machias R., Maine	10/11/67	R	9	salmon	-	11(25)	0	0	0	0	0	0	0	0	0	66(+)	0	0	-	100(5)	44(8)	0	0	-	0
Margaree R., N.S.	11/66	R	8	salmon	0	75(158)	0	0	38(6)	75(19)	0	0	0	38(7)	0	100(+)	0	-	-	100(5)	38(3)	0	0	0	0
Margaree R., N.S.	11/67	R	12	salmon	-	50(96)	0	0	25(11)	17(18)	0	0	0	0	0	75(+)	16(1)	0	-	75(6)	58(4)	8(2)	8(1)	-	0
Miramichi R., N.B.	11/66	R	4	salmon	0	100(217)	0	0	75(34)	100(47)	0	0	0	0	0	100(+)	0	0	50(5)	100(4)	50(1)	0	0	0	25(1)
Miramichi R., N.B.	2/11/67	R	15	salmon	-	-	-	-	-	-	-	-	-	-	-	50(+)	10(1)	0	-	-	-	-	-	-	10(4)
Narraguagus R., Me.	22/11/67	R	8	salmon	-	50(45)	0	0	13(1)	13(2)	0	0	0	0	0	63(+)	0	0	-	100(5)	-	0	0	-	0
Orland R., Maine	11/67	R	1	salmon	-	100(285)	0	0	0	0	0	0	0	0	0	0	0	0	0	100(6)	0	0	0	0	0
Petitcodiac R., N.B.	11/67	R	7	salmon	-	-	-	-	-	-	-	-	-	-	-	86(+)	0	0	-	43(1)	-	-	-	-	0
River Philip, N.S.	11/66	R	5	salmon	-	100(187)	0	0	100(7)	100(15)	0	0	0	0	0	80(+)	0	-	-	100(7)	80(4)	0	0	0	0

Table 1. (cont'd.)

				A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U
River Philip, N.S.	5/11/67	R 10	salmon	-	-	-	-	-	-	-	-	-	-	-	50(+)	0	10(2)	-	100(4)	-	-	-	-	0
Saint John R., N.B.	16/11/66	R 1	salmon	0	100(5)	0	0	0	100(2)	0	0	0	0	0	100(+)	0	-	-	100(20)	0	0	0	0	0
Saint John R., N.B.	15/11/67	R 10	salmon	-	-	-	-	-	-	-	-	-	-	-	40(+)	0	20(3)	-	80(3)	-	-	-	-	0
St. Jean R., Que.	8/66	R 4	salmon	0	75(41)	0	0	25(1)	0	0	0	0	0	0	100(+)	0	-	-	100(5)	75(3)	0	0	0	75(3)
Bay of Fundy (Saint John area)	11 to 16 /7/68	S 56	2	-	-	-	-	-	-	-	-	-	-	-	95(+)	56(1)	4(4)	-	45(4)	-	-	-	-	-
Chaleur Bay (Carleton area)	18 to 21 /6/68	S 29	2	-	-	-	-	-	-	-	-	-	-	-	61(+)	10(1)	27(1)	-	100(7)	-	-	-	-	-
Murraree River area	6/67	S 47	2	-	-	-	-	-	-	-	-	-	17(6)	-	-	-	-	-	-	-	-	-	-	-
Miramichi drift net fishing area	25/6/68 to 5/7/68	S 103	2	-	-	-	-	-	-	-	-	-	-	-	43(+)	6(1)	23(1)	-	98(6)	-	-	-	-	-
Miramichi drift net fishing area	5/7/68	S 17	salmon	-	100(183)	12(8)	0	100(30)	24(3)	1(4)	0	0	0	0	94(+)	1(1)	1(1)	-	94(9)	94(13)	94(6)	1(1)	-	-
Nova Scotia coast (Aspy Bay to Scatari)	10 to 14 /6/68	S 10	salmon	-	100(25)	0	0	90(8)	0	0	0	0	0	0	80(+)	0	30(2)	-	100(7)	90(14)	80(7)	0	-	0
Chaleur Bay (Carleton area)	18 to 21 /6/68	S 63	3	-	-	-	-	-	-	-	-	-	-	-	85(+)	2(1)	0	-	87(3)	-	-	-	-	-
Miramichi drift net fishing area	25/6/68 to 5/7/68	S 9	3	-	-	-	-	-	-	-	-	-	-	-	38(+)	13(1)	25(2)	-	100(5)	-	-	-	-	-

*First figure represents percent of each sample infested and figure in parenthesis indicates mean number parasites per infested fish.

Table 2. Incidence and abundance of *Anisakis* sp., *T. coryphaenae*, and *H. trichiuri* in the body cavity of 2- and 3-sea winter Atlantic salmon from the Bay of Fundy, Chaleur Bay, and Miramichi drift-net fishing area, 1968, and post grilse (presumably 1-sea winter) from West Greenland, 1967.

	Anisakis sp.			*T. coryphaenae*			*H. trichiuri*		
Age and area of sample	Hosts exam.	% infested	No./ host	Hosts exam.	% infested	No./ host	Hosts exam.	% infested	No./ host
2-sea-winter salmon									
Bay of Fundy	55	55	2.0	55	4	0.13	55	2	0.02
Chaleur Bay	29	100	6.9	30	27	0.37	30	10	0.10
Miramichi area	103	98	6.3	103	23	0.31	103	6	0.05
3-sea-winter salmon									
Chaleur Bay	63	87	4.3	63	0	0	63	2	0.02
Miramichi area	13	92	5.5	13	14	0.30	13	14	0.14
1-sea-winter salmon									
West Greenland	88	85	4.4	88	3	0.03	88	5	0.05