DET NORSKE VIDENSKAPS-AKADEMI I OSLO

RESULTATER
AV DE NORSKE STATSUNDERSTØTTEDE SPITSBERGENEKSPEDITIONER

BIND I

Nr. 7

KNUT DAHL:
CONTRIBUTIONS TO THE BIOLOGY OF THE SPITSBERGEN CHAR

UTGITT PÅ
DEN NORSKE STATS BEKOSTNING
VED SPITSBERGENKOMITEEN

REDAKTØR: ADOLF HOEL

OSLO
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CONTRIBUTIONS TO THE BIOLOGY OF THE SPITSBERGEN CHAR

BY

KNUT DAHL

Introduction.

During the summer of 1923, Mr. THOR IVERSEN, Adviser to the Norwegian Board of Fisheries, went on a fishing expedition to Spitsbergen in the motor cutter "Blaafjell". Mr. EINAR KOEFOED, M. Sc., accompanied him in the capacity of scientific observer.

During this expedition a number of experiments were made by means of gill nets and bag nets, for the purpose of capturing the Arctic sea char — the so-called "Spitsbergen salmon" (*Salmo umbla*, Lin. subsp. *stagnalis*, Fabr. var. *Vide*. LÖNNBERG [4] pp. 28—30). From the char thus captured Mr. KOEFOED collected material for the elucidation of age, growth, and other biological features of this fish.

This material consisted partly of dried samples of scales with corresponding details as to the length, weight, and sexual organs in the fish examined. A few fish were also preserved whole in formaline. Part of the material consisted of fish from which the intestines had been removed and which had been preserved in salt. Also a few stomachs were preserved with their food contents, and length measurements of the majority of the fish taken had also been recorded.

The material had mainly been derived from two localities: The mouth of the river from Lake Dieset, 8 kilometres to the north of Cape Mitra, in the following called Dieset River. It is situated at 79° 10′ N. Lat. and 11 12′ Long. E. o. Gr., and also from Cape Starostin, on the south side of the entrance to Ice Fjord at 78° 6′ N. Lat. and 13° 51′ Long. E. o. Gr., where the great majority of the fish were taken in the sea, and a few being captured in the adjacent Russe-elv.

The catch from the Dieset River was made in the first half of August, and at Cape Starostin during the last half of the same month.

The material has kindly been turned over to me for examination and further treatment, and I will here record my results.

Age, Growth, and Composition of Stock.

The material suitable for age determinations consisted of the scales from 84 fishes varying from 20 cm. to 72 cm. in length.

It will easily be understood that this comparatively small sample, at least in regard to many questions, does not possess a great representative

value. It can only serve the purpose of rendering a first and rough survey of the main features of age, growth, and age-distribution in that part of the stock which is subject to capture.

The reading of the scales presented, as is the case with all char, certain difficulties mainly due to the minute size of the scales. By care and patience however these difficulties were surmounted. The various summer and winter zones could, as a rule, be read with fair accuracy, except in the case of some of the largest and oldest fish. In these few specimens some of the last winters cannot be read with absolute accuracy.

All the scales exhibited a striking record of a sudden change of growth, similar to what we find in the scales of other *andromous salmonidae* such as the salmon, the sea trout, and the sea char of northern Norway.

In the central parts of the scale we find a varying number of narrow summer and winter zones, denoting a juvenile river stage with very slow growth. After these follow a series of years with broad growth zones and more widely separated winter zones, obviously caused by the transition from fresh water to the sea and to the rich and abundant food presented by the latter.

In this way it is easy to tell how many winters each fish has lived prior to migration to the sea, and how many winters it has spent after this migration.

In the appended table, p. 11, the results from the scale reading of the 84 char have been recorded. From this table we may see how many individuals of each length class (divisions of 3 centimetres) have been examined, and how long these individuals have lived before and after migration.

From this table the following survey has been compiled.

Life before Migration.

Total number of fish examined	Number (and percentage) of fish of different ages at migration		
	2 winters	3 winters	4 winters
84	35 (43 %)	42 (50 %)	6 (7 %)

The majority of the young char thus appear to leave the river after 2 or 3 winters. Only a few prove to have spent 4 winters in the river.

As regards growth during this period, the material does not allow us to draw safe conclusions. On account of the minute size of the scales I have not deemed it advisable to employ the method of measuring

and calculating the length of the fish in each winter of its life, which Mr. E. LEA and myself have adopted in the case of other fish (K. DAHL [1], p. 22). Nor does the material contain any fish taken in the river before its first migration to the sea.

The only statement as to the size of the young char at migration that may be safely made at present is that the smallest fish in the material was 20 cm. long. And the scales of this fish exhibited 3 winters of river life, with a subsequent broad belt of sea growth during the last summer.

The rest of the material — see appended table — also tends to show that the young char probably leave the river before they reach a length of 20 cm.

As regards the food during river life, the material affords no information, as no young fish have been taken or preserved.

From Professor HOLTEDAHL's expedition to Novaya Semlya in 1921, however, there is available a small number of char from "Lommevand" at Matoshkin Shar, collected by Dr. F. ØKLAND. This collection has kindly been turned over to me for examination.

Two of these char were very small young taken on July 16, 1921. Their length being 5,4 and 5,8 cm. respectively. The smallest of them had no recognisable scales, and the largest had very small scales exhibiting 2—3 growth ridges. The stomachs of these contained a number of insect remains, which Mr. T. H. SCHØYEN, State Entomologist, has been kind enough to classify as follows:

15 *Larvae* of *Chironomidae.*
6 *Pupae* - —
1 *Larva* - *Nemura sp.* (*Plecoptera*).

A larger char 20 cm. long, from the same locality, which had never left fresh water, contained the following organisms according to Mr. SCHØYEN'S analysis:

1 *Ichneumonid* (*imago*).
1 *Tipulid larva*, belonging to the group of *Limnophiliformes.*
8 *Larvae* of *Chironomidae*, besides a great number of digested remains of *larvae* and *pupae* of *Chironomidae.*

As far as this material shows, the food of the young Arctic char during river life appears to consist mainly of insects.

Life after Migration.

Upon closer examination of the appended table we find age after migration to be distributed as follows. (0 winter = first summer in sea).

Number of fish examined	No. (and percentage) of fish having lived the following winters after migration								
	0	1	2	3	4	5	6	7	8 winters
84	1	1	22 (26%)	24 (29%)	13 (15%)	12 (14%)	6 (7%)	4 (4%)	1
Average Length	20 cm.	29 cm.	34,9 cm.	38,7 cm.	45,2 cm.	52,9 cm.	60 cm.	69 cm.	70 cm.

The youngest age groups are very poorly represented, obviously because the gear employed has had too large a mesh to catch them in larger numbers. It is only after 2—3 winters of sea life that the fish are large enough to appear in the catch. The subsequent age-distribution is similar to that of the sea trout of Norway. The larger and older fish become comparatively scarce, and when this rapid decrease is found in these primitive surroundings, where practically no fishing is carried on, it may reasonably be concluded, that the rapid disappearance of the older fish indicates the natural death rate of the fish. The maximum age appears to be about 7 or 8 winters after migration, or an aggregate age — including parr life — of 10—11 winters. But the majority do not apparently attain anything like this age.

Growth is indicated by the averages seen in the table above. At all events, for the classes 2, 3, 4 and 5 winters the averages appear to present fairly reliable figures. Apparently it takes about 4 winters after migration for a char to become 45 cm. long, or to attain to a weight of about 1 kg.

The relations of length to weight may to some extent be illustrated by some records of length and weight for the same fish registered during the cruise by Mr. EINAR KOEFOED.

Mr. KOEFOED'S notes may be tabulated as follows:

38 cm., 0,7 kg.
39 „ 0,7 „
40 „ 0,7 „
41 „ 0,9 „
46 „ 1,1 „
49 „ 1,4, 1,4 kg.
50 „ 1,5 kg.
51 „ 1,4 „
52 „ 1,75, 1,5 kg.
54 cm., 1,5 kg.
56 „ 2,3 „
57 „ 1,9 „
59 „ 2,15, 2,2, 2,3 kg.
61 „ 2,6, 2,5 kg.
62 „ 2,5 kg.
71 „ 3,3, 4,0 kg.
72 „ 4,7 kg.

As to growth, it may further be remarked that the analysis quite distinctly confirms a rule which I have previously demonstrated in the case of salmon and trout (K. DAHL [1], p. 46). In examining salmon and trout I found that fishes which had lived for an equally long time in the sea, exhibited a growth which corresponded in a marked degree with their age at migration. The rapidity of growth after migration proved to be conspicuously dependent upon the number of winters spent before migration. A short parr life tended to retard growth in the sea and a long parr life appeared to have the opposite effect.

This was demonstrated in the case of salmon and sea trout, as well as in large inland trout, which exhibit a great change of growth.

The analysis of the Spitsbergen char also shows the same peculiarity.

Taking the most representative part of the material in the appended table (quod vide) we may compile the following review.

Age after migration	Average length of char migrating at the following ages		
	2 winters	3 winters	4 winters
2 winters	34,0 cm.	36,1 cm.	39,0 cm.
3 —	-	37,7 -	40,3 -
4 —	44,0 cm.	45,0 -	48,7 -
5 —	51,0 -	53,8 -	57,0 -
6 —	59,0 -	60,3 -	61,0 -

It will be seen that the average length of the fishes belonging to each age group shows after migration a regular rise corresponding to the age before migration. The fish which have the longest parr life, and consequently are largest at migration, have obviously an advantage in their increased size, which gives them a greater faculty for growth, than the younger and smaller migrants. V. K. DAHL [2], Chap. V, p. 46.

As previously mentioned, the growth change on transition from parr to sea life is easily observed in the scales of the Spitsbergen char.

Judging from the stomach contents of the young char from Novaya Semlya, it would seem probable that the young Spitsbergen char, during parr life, also have to depend to a great extent on insect food.

As soon as the young char reaches the sea, this frugal fare is altered, and the varied profusion of organisms found in the Arctic Sea is at their disposal. The preserved stomachs, which proved full of the organisms of the sea, plainly demonstrate that the char greedily avails itself of this food.

An examination of the contents of the preserved stomachs yields the following list of organisms eaten by the char[1].

Capelan (*Mallotus villosus*).

Young *Cettidae*: *Cottus scorpius*, *Triglops Pingellii* and *Icelus hamatus*.

Young *Liparids*: *Liparis Reinhardti* and others.

Gammarus locusta.

Mysis oculata.

Amathilla homari.

Rhoda inermis.

Nereis pelagica.

Especially the large *Gammaride*, the *Gammarus locusta* (up to 4 cm. long), besides the *Mysis oculata*, appeared to form the main food, several stomachs being largely filled with these organisms. But also the other groups were profusely represented. The small young of cottidae and liparids were thus very commonly found in the stomachs. On the whole, the Spitsbergen char appears to eat organisms from the bottom and from the shore belt, as well as the more detached and pelagic organisms such as the pelagic schizopod (*Rhoda inermis*), the capelin, and the nereide, which latter, at all events during certain stages of life, leads a pelagic existence.

The relation of sexual maturity to age and size cannot be determined with any great degree of accuracy, as only a small number of fishes have been examined in regard to the development of sexual organs.

Mr. KOEFOED examined the sexual organs of 22 char from the Dieset River, classifying them according to maturity in stages from I to VII, where I and II denote sexual organs so small that it might safely be said that the fish would not spawn that year, while III—VI denote sexual organs more or less approaching spawning, (stage VI), stage VII denoting spent fish.

During August Mr. KOEFOED did not however find any sexual organs further developed than stage V. Scales from the fish thus examined were also preserved by Mr. KOEFOED. These were 15 female fish and 7 males.

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[1] Mr. J. A. GRIEG mentioned in his treatise on the evertebrates from Spitsbergen, [3], p. 10, an examination of the stomach of a single Spitsbergen char, where he found: 1 *Cottus scorpius* 24 mm., 1 *Triglops pingellii* 22 mm., 2 *Nereis pelagica* and *Amathilla homari*. Mr. GRIEG has also done me the service of verifying some of the above organisms determined by me.

The analysis gives the following results in the case of

Female Fish.

Length in cm.	Number of fish which after migration had completed							
	3 winters		4 winters		5 winters		6 winters	
	ripe	unripe	ripe	unripe	ripe	unripe	ripe	unripe
36—40	2	1						
41—45		2						
46—50			1		1			
51—55					2			
56—60					1		2	
61—65							3	

"Ripe" denotes fish with ovaries in stage III and upwards, "unripe" stands for fish with ovaries in stages I and II and which would certainly not spawn that year. From this table it will be seen that all female fish longer than 46 cm. and older than 3 winters after migration were sexually mature. Among the fish below 46 cm., and among the fish that had lived 3 winters after migration, there was a comparatively large number of immature fish. The smallest ripe female was 38 cm. long, and showed 2 winters of parr life, 3 winters after migration.

Among the male fish examined, of which the smallest was 49 cm. long, and showed 4 winters of parr life and 4 winters after migration, only 2 were ripe and fit to spawn that season (above stage II), viz: the two largest fish, both 71 cm. long and showing respectively 2 and 3 winters of parr life and 7 winters after migration.

Owing to the insufficient material no very great importance can be attached to this result in the case of the male fish.

An examination of 6 preserved fish 20 cm. ♀, 29 cm. ♀, 30 cm. ♂ 40 cm. ♀ 40 cm. ♂ and 41 cm. ♂ shows that all were in stages I and II, and were doubtlessly unfit to spawn that year. The specimens were taken during the middle and latter half of August, and have been personally examined by me.

These facts undoubtedly indicate that the Spitsbergen char must attain a considerable age as well as size before spawning sets in.

This fact is also illustrated by a series of measurements which were made by fishermen in the Dieset River and in the sea by Cape Starostin.

These measurements comprised 81 char from the Dieset River and 111 char from Cape Starostin.

The size of the fish and the distribution of sizes will appear from the following table.

Sizes	Dieset River		Cape Starostin	
	Number	Per cent.	Number	Per cent.
Below . . . 30 cm.	-		3	3
31— 40 -	-		53	48
41— 50 -	11	14	35	32
51—60 -	31	38	9	8
61— 70 -	38	47	5	4
Above . . . 70 -	1	1	6	5

It will easily be seen that the smaller and younger fish predominate in the sea; there are just as many under as over 40 cm. in length. In the river, however, we obviously have to deal with a segregated stock of fish, mainly spawning fish, or fish above the sizes at which we have previously seen that sexual maturity sets in.

In the expedition journal, Mr. KOEFOED has characterized the catches in the two localities in the following words: 19/8 23. Dieset River.

"A great number of the char taken in the Dieset River during the first half of August are female fish with ovaries approaching maturity."

31/8. Cape Starostin.

"The char in this locality during the last half of August are small fish from about 40 cm., fat and with small roe and milt."

From the latter locality Mr. KOEFOED notes some few large fish as being sexually mature.

According to this the majority of the Spitsbergen char appear to have to spend several winters after migration — probably at least 3 winters — before sexual maturity is attained. Nothing definite can be gathered from the present material as to whether char occurs in Spitsbergen attaining sexual maturity before it finishes its parr life in fresh water, or even char that spends its entire life in fresh water. This material does not contain a single fish that has not spent some time in the sea.

As mentioned before, Professor HOLTEDAHL'S expedition to Novaya Semlya 1921 brought home a small collection of char.

Besides the exceedingly young char from Lommevand, previously mentioned the collection contained 3 larger young fish, also taken in Lommevand at Matoschkin Shar on July 14, 1921. The fish were taken in gill nets. These three fish were 18, 19 and 20 cm. long, and respectively 4, 4, and 5 winters old, according to the scales. All were female fish with far advanced ovaries (stages III—V) and would doubtlessly have spawned that season. The scales exhibited no sign of sea growth.

Age Distribution in Char.

Locality: Spitsbergen. Date: August 1923.

Winters after migration		0	1	2					3			4				5				6				7			8	
		Winters before migration																										
Length in cm.	Number of fish examd.	3	2	2	3	4	Tot.	2	3	Tot.	2	3	4	Tot.	2	3	4	Tot.	2	3	4	Tot.	2	3	Tot.	3	Tot.
20	1	1																									
-	-																										
30	3		1	2			2																				
33	7			3	4		7																				
36	16			4	5		9	5	2	7																	
39	15				3	1	4	4	7	11																	
42	9							2	2	4	3	2		5													
45	4								2	2	1	1		2													
48	8										1	2	3	6	2			2									
51	4														3	1		4									
54	3															2	1	3									
57	2														1	1		2									
60	7																1	1	2	3	1	6					
63	1																							1	1		
66	-																										
69	1																									1	1
72	3																						1	2	3		
Total	84	1	1	1	9	12	22	11	13	24	5	5	3	13	6	4	1	12	2	3	1	6	1	3	4	1	1
Aver.	Lth. in cm.	20	20	29	29	34,0	36,1	39,0	34,9	37,7	40,3	38,7	44,0	45,0	48,7	45,2	51,0	53,8	57,0	52,9	59,0	60,3	61	60	-	-	69	-	70

The collection also contained one specimen of char taken in the sea at Pomorskaya Bay in Matoschkin Shar, July 7, 1921, 48 cm. long, ♂ stage II. The scales of this fish showed 4 winters of parr life, 2 winters after migration, exhibiting a very marked change of growth after migration to the sea.

This shows that, besides the ordinary migratory type of char, char occur in Novaya Zemlya which can propagate in fresh water, without, or previous to, migrating to the sea.

Whether a similar phenomenon also occurs at Spitsbergen must be decided by future investigations in the fresh waters of that island.

Oslo, May 1925.

Knut Dahl.

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A. W. BRØGGERS BOKTRYKKERI A/S