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ATLANTIC SALMON AND TROUT INVESTIGATIONS

1940

No. VI. Predators of salmon fingerlings in Goldmine brook.

By Paul F. Elson

In 1939 Goldmine brook was prepared for planting salmon fingerlings by removing, as thoroughly as possible, certain predators - speckled trout and eels. The trout were apparently removed fairly thoroughly, 132 being taken from the 3000 feet of stream used in the experiment. Eels are more difficult to detect and capture, and judging from the 1940 results, when 251 eels were taken, the 1939 catch of about a dozen eels could not have made much impression on the eel population of the stream. It was thought that the removal of these predators in 1939 would result in rather ideal conditions for the salmon fingerlings, at least in as far as predators were concerned; however, the 1940 results indicate otherwise.

It was found in 1940 that only a small proportion of salmon fingerlings planted in Goldmine brook, Moser River, N. S., survived for more than a few weeks. A large part of the disappearance can be attributed to the action of freshets, with the accompanying condition of the water, which is characterised by low pH value.

Nevertheless losses occurring at other times, especially in the period immediately following planting, were considerable and it is safe to say that some of this loss can be attributed to the depredations of larger fish.

In Goldmine brook fish were apparently the most important predators of young salmon fingerlings. Salmon parr, speckled trout and eels are all involved. Fish-eating birds were seen only along the marsh at the mouth of the brook and were not numerous. There were no indications of birds working any distance up the stream, except on the still-waters, which are not utilized by salmon either as parr or fingerlings. Certain invertebrates, particularly dragonfly nymphs and leeches, also appear to prey on salmon fingerlings to some extent.

Studies on predators in Goldmine brook may be divided into three general groups: (1) feeding of predators under natural conditions, including stomach analysis of parr, trout and eels; (2) experiments in feeding suspected species with salmon fingerlings; (3) consideration of losses not accountable to high water.

Feeding in nature.

Records of fingerlings taken from the stomachs of predators captured in the experimental part of the stream show that salmon parr, trout and eels feed on salmon fingerlings, but hardly indicate the extent to which this may be done. In order to avoid repetition the data for all forms is lumped together in chronological order, and a brief synopsis for each species given near the end of this section.

In the lower section of the stream - lots 1 to 7 - only three of the 168 fingerlings planted were recovered from the stomachs of predators captured. On June 30 a 6-inch eel having one fingerling in its stomach, and July 3 a 7 $\frac{1}{2}$ -inch eel containing two fingerlings, were taken in the down-stream trap. The 6-inch eel was the smallest eel recorded as having eaten salmon fingerlings. It is impossible to say whether these fingerlings were taken by the eels after the latter had entered the trap, or not.

On August 6, 210 fingerlings were planted in lots 9 to 12. Between 9.30 p.m. and 10.30 p.m. that evening the large fish, such as parr, trout and eels, were removed from the section as thoroughly as possible, using a gasoline lamp and hand-seine. Trout and parr were believed to have been completely removed, but one eel escaped and there may well have been more eels in the section than the two seen. Table I. shows the fish taken and fingerlings found in their stomachs.

Table I. Salmon fingerlings found in the stomachs of predator fish removed from 150 feet of stream on the first night after planting 210 fingerlings.

Species	Number Removed	Size range (mm.)	No. of fingerlings in stomachs	Total fingerlings eaten by species	Per cent of planted fingerlings
Trout	1	140	3	3	1.4
Parr	7	100 to 115	2,2,1	5	2.4
Eels	1	230	7	7	3.3
Total	9			15	7.1

The fingerlings remaining in the area at the time the predators were removed were not counted, but the number was estimated to be not over 100. One week later only about half a dozen fingerlings could be found by night counting, and two weeks after planting none could be found. Since there was no freshet in the interval it would seem that most of the fingerlings had been taken by predators, either eels which were not removed from the area on the night of August 6, or possibly trout and parr which migrated into the section from adjacent parts of the stream.

On five occasions fingerlings were planted in upland sections of the stream, at the approximate rate of one fish for each foot of stream length, and the section fished (angling) for possible predators a few hours later. On four occasions the planting (total of 633 fingerlings) was done in the forenoon and parr (5 caught), trout (7 caught) and eels (2 caught) fished for in the afternoon. In no instance were salmon fingerlings found in stomachs of larger fish taken in the daylight hours immediately following the planting of fingerlings. Daylight fishing 24 hours to a week after planting fingerlings also gave negative results in regard to fingerlings being found in the stomachs of larger fish. However, on one occasion (July 29), when the fingerlings were planted in the afternoon and the larger fish removed by seining after dark on the same day, fingerlings were found in some of the stomachs, as indicated below:

Fingerlings planted	Place (lots)	Fish removed			Place (lots)	Fingerlings in stomachs		
		Parr	Trout	Eels		Parr	Trout	Eels
218	47 to 52	24	6	0	58 to 52	3, 1, 1	0	--

Since, one month later, only 5 parr and no trout were found in the section fished, it is safe to say that most of the parr and trout in the section at the time of planting were removed that night. Since eels are not so readily seen, no statement regarding them can be made. One week after planting no fingerlings could be found in the section, nor was there any indication of their having moved either up or down stream. In all cases where fingerlings were planted in the stony, upland portions of the stream they disappeared almost completely within a week, and usually within a day or two.

Throughout the summer a total of 76 salmon parr were removed from the experimental portion of the stream, and a total of 11 fingerlings were recovered from 5 stomachs; 56 trout had 4 fingerlings in 2 stomachs; and 243 eels had 11 fingerlings in 4 stomachs. A total of 1563 fingerlings were planted in the 3000 feet of stream under observation. In each instance where fingerlings were found in the stomachs of larger fish they formed from 50 to 100 per cent (av. 88%) of the contents, by volume, indicating that such fish as did feed on fingerlings used them to a large extent, when the fingerlings were available.

One reason for the greater number of fingerlings occurring in parr stomachs may be found in the fact that the habitat of the parr more nearly resembles that of the fingerlings than does that of the trout. The latter, particularly the larger individuals, are usually found in large pools, while the parr tend to be in shallower but rougher water, to a greater extent. Possibly the removal of the trout would allow the parr to live in the larger pools where they would be less likely to prey on the fingerlings.

In a small lowland sub-area, where five fingerlings were planted in a pool 7 feet by 3 feet and averaging 3 inches deep, a Boyeria nymph killed and partially ate one fingerling during a three-week period. These insects occur throughout the stream. They apparently lurk under stones and occasionally capture a fingerling which approaches close enough to them. While they do remove some fingerlings their depredations do not appear to be great.

Leeches, (Macrobdella and Haemopsis) which were found to take salmon fingerlings in feeding experiments, apparently catch the fingerlings in somewhat the same manner as the dragon-fly nymphs. Since the distribution of the leeches is confined to the lower 100 feet of the stream, where they are occasional migrants from the lake, they are probably not a serious factor in removing young salmon unless the latter ^{are} carried down to the lake by some such factor as freshets.

Feeding experiments.

Parr.

A yearling parr (about $4\frac{1}{2}$ inches long) was placed in a small, screenebottomed box and salmon fingerlings (about $1\frac{1}{2}$ inches long), added to the box from time to time. During the course of the experiment the organisms placed in the box were the only source of food for the parr. The results are given in table II.

Table II. Salmon fingerlings eaten by a 4 $\frac{1}{2}$ -inch salmon parr.

Date of examination	Fingerlings added to box	Fingerlings in box	Fingerlings eaten	Remarks
Aug. 27	4	4	---	Expt. commenced
28	0	4	0	
29	0	3	1	+ 1 dead with head torn (killed by parr) removed dead fish
30	0	2	0	
31	0	2	0	
Sept. 1	0	2	0	
2	0	2	0	dragon-fly nymph added
3	0	2	0	dragon-fly nymph present
4	0	2	0	" "
5	0	2	0	" "
6	0	1	1	" "
7	0	1	0	" "
8	-	-	-	---
9	0	0	1	" "
10	2	2	0	" "
11	2	2	2	" "
12	0	0	2	" "

In 16 days total eaten and killed is 8 fingerlings.
Dragon-fly nymph not harmed.

It will be noticed that during the first nine days in the box the parr took only one fingerling (on the second day) doubtless owing to being confined. Towards the end of the experiment the fingerlings were taken more frequently, and sometimes, at a greater rate per day, so that the indications are that parr would actually eat more fingerlings, under more natural conditions, than shown by this experiment. The experiment shows that a single salmon parr, of the average size found in Coldaine brook, is capable of killing fingerlings at the approximate rate of one every two days, providing, of course, the fingerlings are sufficiently available. The fingerlings appear to be taken in preference to dragon-fly nymphs.

Trout.

Trout (about 3 inches long) which represented the maximum size found in Goldmine brook, were confined in boxes and supplied with salmon fingerlings in the same manner as the salmon parr. Two sets of data are presented in table III. In case 1, during the nine days that fingerlings were available ^{to} it the trout ate 13 salmon fingerlings and one dragon-fly nymph. In case 2 eight salmon fingerlings, 5 trout fingerlings (2½ inches long) and one dragon-fly nymph were eaten by the trout in ten days. The trout fingerlings were considerably larger than the salmon fingerlings. From these data an estimate of one fingerling per trout per day would seem quite conservative for the possible depredations of such fish, and might apply equally well to trout two or three inches shorter, providing, again, that the fingerlings were available.

Table III. Salmon fingerlings eaten by 9-inch trout.

Date	Case 1.			Case 2.		
	Food added	Food in box	Food eaten	Food added	Food in box	Food eaten
Aug. 27	2 salmon	2 salmon	---	4 salmon 4 trout	4 salmon 4 trout	---
28	dragon-fly nymph 1 salmon	2 salmon dragon-fly	1 salmon	---	4 salmon 4 trout	
29	1 salmon	2 salmon dragon-fly	1 salmon	---	4 salmon 4 trout	
30	---	2 salmon dragon-fly	---	---	3 salmon 4 trout	1 salmon
31	---	1 salmon dragon-fly	1 salmon	---	1 salmon 4 trout	2 salmon
Sept. 1	3 salmon	3 salmon dragon-fly	1 salmon	----	3 trout	1 salmon 1 trout
2	---	2 salmon	1 salmon dragon-fly	---	2 trout	1 trout
3	2 salmon	2 salmon	2 salmon	2 salmon	2 salmon 1 trout	1 trout
4	4 salmon	4 salmon	2 salmon	3 salmon 1 trout	3 salmon 1 trout	2 salmon 1 trout
5	dragon-fly	dragon-fly	4 salmon	dragon-fly	1 salmon dragon-fly	2 salmon 1 trout
6	---	---	dragonfly	---	1 salmon	dragonfly

Total eaten in 10 days --- 13 salmon
2 dragonflies

Total eaten in 10 days --
8 salmon
5 trout
1 dragonfly

Note: Salmon fingerlings about 1½ inches long; trout about 2½ inches.

Eels.

Feeding experiments with eels, similar to those described for trout and salmon parr, were attempted after the middle of October. During the ten days of the experiment one 10-inch eel, and one 14-inch eel, both in the same box with 10 salmon fingerlings, did not eat any salmon fingerlings, apparently having ceased feeding at this time of year.

Invertebrates.

Dragon-fly nymphs of the genus Boyeria occur throughout the stream. Feeding experiments resulted in 3 salmon fingerlings being killed by 3 nymphs during a period of one month. Single specimens of two species of leeches (Macrobdella sp. and Haemopsis sp.) when kept in captivity for 2 to 4 days, killed and ate one fingerling each.

Losses not accountable to high water.

On June 10, 144 fingerlings were planted in lots 1 to 7 and by June 17 a large number, estimated to be about 93, of these fingerlings had disappeared. It is known that they did not pass down through the down-stream trap and there was no freshet during the interval. The only indication of movement was a concentration of the remaining fingerlings in the lower 50 to 100 feet of the section. Disappearance must have been the result of mortality resulting from predators and other causes. There was an unknown number of eels up to 14 inches in length in the section; a count on August 30 showed 16 parr in the section and at least 2 trout over 8 inches long; previous to

this, but after the planting of June 10, 9 parr and 17 trout had been removed from the section; hence an estimated population of 40 parr and 10 trout, at least 5 of the latter over 8 inches in length, is well within the limits of probability. Now, as has been shown above, a yearling parr is capable of eating one fingerling every two days and a trout of the size found in the section can easily dispose of one fingerling every day, hence the population of parr and trout could conceivably have eaten 130 fingerlings in the week between June 10 and June 17. When to this is added any predation by eels in the section it will be seen that these three species of proven predators could easily have accounted for the disappearance of the 93 fingerlings, or 64 percent of the planted fish within a week's time. On three other occasions during the summer small losses (July 25 - 3 fingerlings, August 15 - 9 fingerlings, September 4 - 8 fingerlings) in lots 1 to 7, occurring during periods of low water, are well within the limits which could be attributed to the three species of larger fish.

Other instances of the removal of fingerlings, presumably by predators, occurred in the three small sub-areas. In the Lowland sub-area (25 feet long by 4 feet wide), out of 28 fingerlings known to have been in the area during the summer only 4 (4%) survived until October 22; 15 (60%) were lost at times of freshet; and the remaining 9 (36%) disappeared during times of low water and were presumably taken by a 9-inch eel seen in the area on several occasions.

As far as is known there were no other fish predators in the area. In a smaller lowland sub-area a dragon-fly nymph (Eogeria sp.) killed one fingerling out of five planted, over a three-week period. In an upland sub-area (25 feet long by 4 feet wide) where 25 fingerlings were planted, 20 had disappeared before any freshet occurred. One 10-inch eel was seen in the area and quite probably there were others, though attempts to catch them failed. In this case it is probable that predators in the form of eels removed the missing 80 percent of the fish.

Summary.

Considering the data obtained from stomach analysis and feeding experiments, and the general losses among planted fingerlings, the following statements seem to be warranted.

1. Trout 9 inches long are capable of eating one $1\frac{1}{2}$ inch salmon fingerling per day, and probably more.
2. A trout as small as 6 inches took 3 fingerlings in one evening, in open stream, the fingerlings having been planted that day.
3. Yearling salmon parr (4 to 5 inches long) are capable of removing fingerlings at the rate of one every two days.
4. Parr do remove some planted fingerlings under natural conditions, and probably more than do trout, since they are more likely to be found in the same habitats as the salmon fingerlings.

5. Eels eat salmon fingerlings. A 10-inch eel was taken with 7 fingerlings in its stomach and had apparently not finished feeding. The smallest eel recorded as having eaten a fingerling was 6 inches long.

6. Dragon-fly nymphs of the genus Boyeria kill and eat some fingerlings.

7. Leeches (Macrobdella sp. and Haemopsis sp.) may kill and eat fingerlings in that part of the stream adjacent to the lake.

8. Fingerlings were found in the stomachs of predators taken on the first night after planting, though not in the stomachs of predator species taken in the daylight hours immediately following planting.

9. A loss of 84 percent of planted fingerlings, in lots 1 to 7, within the first week, was probably largely the result of predators.