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Effect on adult returns of exposure of native wild smolt to sublethal DDT

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Abstract

Atlantic salmon smolt captured during downstream migration were tagged, exposed to sublethal DDT (50 ppb), and then released to continue their development under natural conditions. Two years later, tag returns for DDT-treated fish were 41% less than for control fish. High mortality of the DDT-treated fish, shortly after their release as smolts following experimental treatment, may have been the reason.

Introduction

When administered in sublethal doses, DDT has been shown to induce certain physiological and behavioural responses in fish. These have included changes in selected temperature, standard oxygen consumption, neurophysiological functioning of the lateral line nerve, conditioned learning, reflex action, and lower lethal temperature (Anderson, 1971). However, these results were all obtained from laboratory experiments. For the most part their significance to natural conditions in the field is unknown.

In order to investigate the ecological consequence of subacute DDT poisoning, native smolt of Atlantic salmon, *Salmo salar* Linn., which had been captured during downstream movement, were exposed to DDT at a concentration, and according to experimental treatment, which in the laboratory is known to produce responses of the sort noted above. After exposure the fish were released to continue their seaward migration.

Methods

Stocks were 2-year-old smolts. Capture and release was at the Fisheries Research Board of Canada's counting fence installed at Curventon, 8 miles above the head of tide on the Northwest Miramichi River, New Brunswick. All fish were tagged below the dorsal fin, the day before experimental treatment, with a modified Carlin stainless steel tag. The fish were treated in approximately 80-litre capacity glass aquaria holding 70 litres of water. Thirty fish per aquarium were used. DDT was added in 3.5 ml of acetone to give a final concentration in the test tanks of 50 parts per billion (ppb). In the control tanks acetone alone was added. All exposures were for 24 hours. The treatments were made in eleven 24-hr periods from May 29, 1969, to June 13, 1969. In all, 4,000 fish were treated with DDT; an equal number served as controls.

Results

The Northwest Miramichi is predominantly a grilse river. Therefore, it was expected that most of the returns would be in by the end of 1970. However, at the time of preparing this paper (July 30, 1971), it seems certain that at least a few 2-sea-year returns are still outstanding, since the Northwest Miramichi has a late run (September-October) as well as an early run (June-July) for both 1- and 2-sea-year fish.

To date, the reported adult returns for the control fish are 137. Returns for the DDT-treated fish are 81, a reduction of 41%.

Table 1 gives the returns, expressed as a percentage, for several different ways of grouping the data. Considering the groupings according to Location of Capture and Method of Capture, there appears to be little difference in the percent returns between the DDT and control data. From this it can be concluded that the observed reduction in total returns for the DDT-treated fish cannot be the result of a significant decrease in returns from one or more specific area or type of fishing gear.

A few fish in each group were captured ascending a river other than that of their origin, i.e., were strays. The general agreement between the returns for the two groups of fish indicates that DDT treatment in these experiments does not appear to have interfered with the home-waters migratory mechanism.

There is a suggestion, but no more than that, that compared to the control fish, more of the DDT-treated returns are 2-sea-year, as opposed to 1-sea-year (grilse) -- 19.7% vs 11.7%. There is also a slight indication that a greater percentage of the DDT-treated fish are late-run. However, to date the 2-sea-year returns have come almost entirely from the Newfoundland fishery; the late-run data have represented mostly grilse. By the end of the year the 2-sea-year and late-run trends indicated in Table 1 could be clarified by the 1971 fall angling and Curventon fence returns.

Discussion

From Table 1, it is evident that the marked reduction in returns for DDT-treated fish occurs proportionately throughout the fishery insofar as Method of Capture and Location of Capture are concerned. While there may be an effect of DDT treatment on duration of sea life and time of return-to-river, such effects if real seem unlikely to provide an explanation for the drop in total returns for the DDT fish. Evidently the decrease in these returns is the result of the DDT-treated fish suffering relatively high mortality before their entry into the fishery as tag returns. The most likely time for this would seem to be soon after their release as smolts following experimental treatment.

There are, of course, many possible explanations to account for different rates of mortality between DDT-treated and control fish. Perhaps the simplest would be that the fish treated with DDT were somehow rendered more susceptible to disease. More complex possibilities would involve behavioural impairment. However, it appears that at least one behavioural hypothesis can be ruled out. The earlier work showing that DDT can inhibit learning in fish suggested to us that DDT exposure might cause the salmon parr to be less able to escape predation from such natural predators as brook trout (*Salvelinus fontinalis* Mitch.). Recent work shows that when exposed to the organophosphate insecticide, Fenitrothion,* at 1 ppm, salmon parr are indeed rendered more susceptible to predation by large trout (Hatfield and Anderson, 1971). However, DDT at 70 ppb, was without effect.

All that can be safely concluded from the experiments reported here is that when salmon smolt are exposed to a concentration of DDT which is not immediately lethal, and then allowed to continue their development under natural conditions, there is some evidence which indicates that they suffer higher mortality than would otherwise be the case. The explanation for this remains to be investigated.

*Chemical formula O,O-DIMETHYL O-(4-NITRO-<u>m</u>-TOLYL). PHOSPHOROTHIOATE.

References

Anderson, J. M. 1971. II. Sublethal effects and changes in ecosystems. Assessment of the effects of pollutants on physiology and behaviour. Proc. Roy. Soc. Lond. B. 177: 307-320.

Hatfield, C. T., and J. M. Anderson. 1971. Effects of two insecticides on the vulnerability of Atlantic salmon parr to trout predation. J. Fish. Res. Bd. Canada (in press).

Table 1. Percentage returns of control and DDT-treated fish, as reported up to July 30, 1971. Actual numbers given in brackets.

Total number	Control 100(*137*)	DDT-treated 100(*81*)
Method of capture:		
Angled	24.8(*34*)	21.0(*17*)
Set net	40.1(*55*)	43.2(*35*)
Drift net	7.3(*10*)	6.2(*5*)
Curventon counting fence	21.9(*30*)	23.5(*19*)
Millbank traps	0.7(*1*)	0.0(*0*)
Poached	3.6(*5*)	3.7(*3*)
Unknown	1.6(*2*)	2.5(*2*)
Location of capture:		
Commercial, distant waters:		
West Greenland	12.4(*17*)	13.6(*11*)
Newfoundland	12.4(*17*)	12.3(*10*)
Commercial, home waters:	24.8(*34*)	25.9(*21*)
Other:		
Angled	24.8(*34*)	21.0(*17*)
Poached	3.6(*5*)	3.7(*3*)
Curventon fence	22.0(*30*)	23.5(*19*)
Strays*	7.3(*10*)	6.2(*5*)
Time of return to river:**		
June	31.2(*20*)	25.0(*9*)
July	57.8(*37*)	50.0(*18*)
August	7.8(*5*)	8.3(*3*)
September	1.6(*1*)	16.7(*6*)
October	1.6(*1*)	-
2-sea-winter fish	11.7(*16*)	19.7(*16*)

*Only angling and Curventon fence data used. Poached data discarded.

**Only returns from angling and Curventon fence used here. Poached returns not used because of their unreliability; drift net fishery returns also discarded because of the selectivity of the gear (i.e. grilse excluded by mesh size) and early (August 15) closing date.