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Seasonal Lethality of Pentachlorophenol to Juvenile Atlantic Salmon

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Various factors have been shown to affect response of fish to toxicants. These include environmental factors such as photoperiod, pH, temperature and temperature of acclimation (Sprague 1970). Zitko and Carson (1977) have shown that juvenile Atlantic salmon show seasonal variation in their response to zinc. Their data show a seven-fold difference in lethality of zinc depending on the time of year. To our knowledge, no work has been published indicating if similar seasonality is evident with this species and organic compounds.

Pentachlorophenol (PCP) is a broad spectrum biocide. It has been suggested that pentachlorophenol and its sodium salt, sodium pentachlorophenate, be used as a reference toxicant for fish studies (Davis and Hoos 1975). This would facilitate valid interlab, interspecies and intercompound comparisons of toxicity.

In this paper we report the results of a 2-yr study in which juvenile Atlantic salmon (*Salmo salar*) were exposed to PCP in a series of lethality tests to determine if the lethality of this compound is affected by the time of year of exposure.

MATERIALS AND METHODS

Juvenile Atlantic salmon (0+ parr) were received in August in each of two successive years from the Saint John Fish Culture Station, Saint John, New Brunswick, Canada. The fish were held for 1 mon prior to the beginning of testing in running fresh water at a temperature of 10°C ± 1°C under artificial lighting and simulated natural photoperiod. The fish were fed dry pellets (Corey #1C-3C) at 2% body weight per day. Prior to testing each month, fish were transferred to test tanks and acclimated for several days. The fish were starved 72 hr before testing.

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A single lethality test was performed each month by exposing five fish in 10 L of water. There were five test concentrations and a solvent (ethanol) control (0.1 mL/L) in each test. Pentachlorophenol (Chem Service, West Chester, PA) solutions were changed after 48 hr. All tests were performed using dechlorinated St. Andrews municipal water of pH = 6.8 and hardness of 12-14 mg/L as $CaCO_3$. All fish (mortalities and survivors) were weighed and measured for length. The tests were performed at 10°C ± 1°C under simulated natural photoperiod. The fish were not fed during the experiment.

The 96-hr LC50 and confidence limits (where practical) were calculated according to Stephan (1977). In tests where all or none of the fish died in each concentration (no partial deaths), a binomial calculation of LC50 with 93.8% confidence limits was performed. In cases where one or more concentrations resulted in partial deaths (>0%; <100% mortality), the moving average method of Thompson (1947) or Weil (1952) was used to determine the LC50 and its 95% confidence interval. In most of these cases, only one concentration produced partial death. Confidence limits are not reported for these cases.

Several problems were encountered in measuring the pentachlorophenol concentration in water. Therefore, concentrations are reported on a nominal basis. To confirm the presence of toxicant, 14C-pentachlorophenol (UL labeled, California Nuclear) was added to exposure tanks and its concentration monitored for 48 hr. Water samples (1 mL) were placed in scintillation vials with 15 mL Aquasol added. Counting was performed on a Beckman LS 100C liquid scintilation counter.

RESULTS AND DISCUSSION

The test carried out to ensure that pentachlorophenol was present in near nominal concentrations showed greater than 90% of the radioactivity was still in the water after 48 hr. It was assumed that the radioactivity was due to pentachlorophenol since the water solubility of pentachlorophenol is unusually high for organic pesticides (up to 4000 mg/L as sodium salt at pH = 8) (Dominiguez and Chapman 1984). Oikari (1987) reports random checks of pentachlorophenol concentration in water during static bioassays revealed 85% or greater of the calculated level present at the end of the tests (48 or 96 hr).

Pentachlorophenol with its sodium salt, sodium pentachlorophenate, collectively was the second most used pesticide in the United States (Cirelli 1977). Considerable lethality work has been done with salmonids and pentachlorophenol. Mayer and Ellersieck (1986) report 96-hr LC50 values for juvenile rainbow trout (*Oncorhynchus mykiss*) and chinook salmon (*Oncorhynchus tschawytscha*) to be 115 and 68 µg/L, respectively. The 96-hr LC50 for lake trout (*Salmo trutta*) is 54 μg/L (Oikari 1987). The 96-hr LC50 of pentachlorophenol to juvenile Atlantic salmon is approximately 150 μg/L (Zitko, unpublished data).

The 96-hr LC50 values ranged from 59-140 μg/L over the 2 yr of testing. These are comparable with those reported by other investigators for static exposures of salmonids to pentachlorophenol (Mayer and Ellersieck 1986; Dominiguez and Chapman 1984). Oikari suggests that one can have a fairly free choice of test species within narrow taxanomic groups for general screening and basic toxicity mechanisms (Oikari 1987).

There appears to be no difference in lethality of pentachlorophenol to juvenile Atlantic salmon with season. The range of LC50 values shown in Table 1 suggests some difference in sensitivity; however, there is no clear trend. Where confidence intervals are calculated, they are sufficiently wide that there is overlap of intervals between successive months. Zitko and Carson (1977) show a seven-fold increase in lethality of zinc to juvenile Atlantic salmon, the most sensitive time being mid-winter. They suggested that physiological changes that accompany parr-smolt transformation may be responsible for the increased sensitivity of Atlantic salmon to zinc (Zitko and Carson 1977). Our data show no multi-fold difference in sensitivity. The fish used in this study are of similar size as those used by Zitko and Carson and the time frame of exposures (Sept.-Aug.) is also the same. Although

Table 1. Summary of lethality of pentachlorpophenol to juvenile Atlantic salmon and weight of fish during 2-yr study period.

	Year 1		Year 2	
Month	LC50 (μg/L) (Conf. int.)	Weight (g) (Std. dev.)	LC50 (μg/L) (Conf. int.)	Weight (g) (Std. dev.)
Sept.	123 (91-162)	1.3 (0.3)	121 (-)	3.6 (1.5)
Oct.	121 (-)	1.9 (0.6)	59 (42-83)*	2.9 (1.1)
Nov.	65 (46-92)*	2.4 (0.5)	59 (42-83)*	3.7 (1.6)
Dec.	112 (83-148)	4.0 (1.0)	103 (-)	4.4 (1.9)
Jan.	106 (-)	4.0 (1.2)	103 (-)	4.8 (2.2)
Feb.	81 (-)	4.2 (1.0)	103 (-)	4.9 (2.4)
Mar.	108 (76-153)*	3.7 (1.1)	58 (41-81)*	6.0 (2.9)
Apr.	94 (76-115)*	5.8 (2.1)	115 (81-162)*	5.0 (3.3)
May	108 (76-153)*	5.7 (2.0)	115 (81-162)*	8.3 (4.5)
June	94 (76-115)*	7.1 (0.3)	90 (-)	8.4 (3.9)
July	76 (44-129)	9.4 (1.9)	127 (-)	11.5 (4.3)
Aug.	116 (81-162)*	9.8 (2.0)	140 (121-161)*	10.7 (3.4)

*93.8% confidence limits; remainder are 95%.

we did not determine the developmental status of the fish, our data suggest that sensitivity to pentachlorophenol did not vary with physiological changes that were taking place over the time frame of our study.

No significant size effects on lethality are apparent. A linear regression of weight vs LC50 (over the 2-yr period) reveals no significant correlation between these factors ($p > .05$).

In summary, there appears to be no seasonal variation in sensitivity of juvenile Atlantic salmon to the organochlorine biocide pentachlorophenol. This lack of significant variation according to the season suggests the use of pentachlorophenol as a reference toxicant for juvenile salmonids may be appropriate. Any significant differences in lethality measurements would then be attributable to lab or stock differences or indicative of other mitigative factors such as stress.

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