Duration of a DDT-Induced Shift in the Selected Temperature of Atlantic Salmon (*Salmo salar*)

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Although it is now well known that the thermogradient response of fish can be altered by a variety of chemical compounds (OGILVIE and ANDERSON 1965; OGILVIE and FRYER 1971, and MILLER and OGILVIE 1975), the persistance of such effects is less well documented. GARDINER (1973) reported that the selected temperature of brook trout was significantly decreased following a 24-hour exposure to DDT, and this effect was still evident nine days after exposure. Unfortunately, this report does not indicate whether or not the selected temerature did eventually return to normal. Because of the long half-life and high fat solubility of DDT, this compound has the potential to accumulate in animal tissues and exert long-term effects. This paper presents evidence that a single 24-hour exposure to DDT can significantly alter the thermal preference of young salmon for at least a month.

Methods

Underyearling Atlantic salmon (Salmo salar, Linn.) were provided by the Environment Canada fish culture station at Collingwood, Nova Scotia. They were kept on a 12L:12D photoperiod, and were acclimated at 20 °C for at least two weeks prior to experimental use. Stock solutions of technical grade DDT (Nutritional Biochemical Corporation) were prepared in an acetone carrier.

Prior to temperature gradient tests the fish were fed for 10 minutes and then exposed for 24 hours to either 50 ppb of DDT, or to an identical amount of the acetone carrier. The DDT dosage employed in this experiment was chosen because previous work revealed that a 24-hour exposure to 50 ppb produced a maximum shift in the mean temperature selected by brook trout (MILLER and OGILVIE 1975).

For each exposure, groups of five fish were placed in 2.5 litres of gently aerated water maintained at 20 °C, and containing either 2.5 ml of acetone only (control), or 2.5 ml of acetone containing the appropriate amount of DDT. After 24 hours the control and experimental fish were removed from the exposure tanks and tested simultaneously in a multichannel thermogradient device.

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The temperature gradient apparatus has been described previously (OGILVIE and FRYER 1971), and the procedures used during these experiments with salmon were identical to those employed during our previous study with brook trout (MILLER and OGILVIE 1975). Following their initial test in the temperature gradient, both control and DDT-exposed fish were placed in separate tanks containing clean water where they were held at 20 °C for seven weeks. During this time their response to the thermogradient was redetermined periodically.

Results and Discussion

Control salmon exposed to acetone-containing water for 24 hours had a mean selected temperature of 19.1 °C, whereas fish that had been similarly exposed to 50 ppb DDT had a mean selected temperature of 23.4 °C. This DDT-induced upward shift in selected temperature is highly significant ($P < 0.01$), and similar in direction and magnitude to that reported previously for the same species (OGILVIE and ANDERSON 1965), and for the brook trout (MILLER and OGILVIE 1975).

The time-course for the change in selected temperature following a single 24-hour exposure to DDT is illustrated in Fig. 1. It can be seen that the DDT-induced elevation in selected temperature evident at the beginning of the experiment persisted for at least one month. When the fish were checked at six and seven weeks, there was no longer a difference between the mean temperatures preferred by the DDT-exposed and the control fish.

In what appears to be the only other study that has examined the time-course of change in selected temperature following an acute exposure to DDT, GARDINER (1973) found that the mean temperature selected by brook trout exposed to 20 ppb DDT remained significantly lower than the control values for at least nine days after exposure to the insecticide. On the ninth day of observation, the mean temperature selected by experimental fish was still significantly lower than that selected by control fish, however, as was the case in the present study, the experimental value was beginning to approach that for the control fish.

It should be noted that Gardner's exposure of 20 ppb decreased the selected temperature whereas our exposure of 50 ppb increased it. This is not necessarily a contradiction, but rather is probably a reflection of the fact that the relationship between DDT dosage and alteration of selected temperature is biphasic in nature. Thus in our previous work with brook trout (MILLER and OGILVIE 1975), a 24-hour exposure to 10 ppb DDT shifted the animals' response towards the cold end of the gradient, while 50 ppb significantly increased the selected temperature.

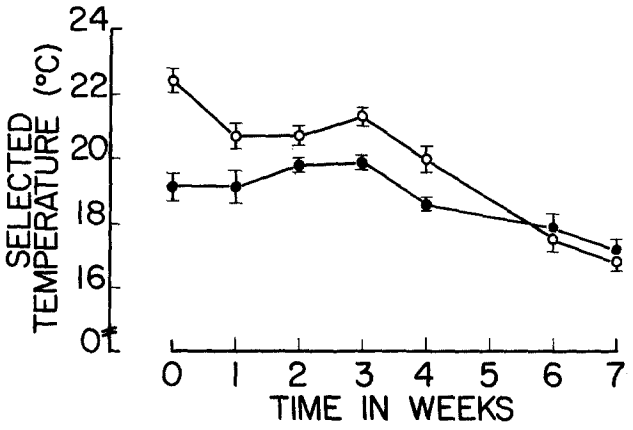

Fig. 1. Mean temperatures selected by underyearling salmon repeatedly tested in a thermogradient device following a single 24-hour exposure to 50 ppb DDT (open circles), or acetone carrier only (closed circles). Each point represents the mean temperature selected by seven to 20 fish. (In the case of the DDT-exposed fish, 25% mortality occurred during the exposure period, and only seven of the original group of 20 fish lived to the end of the experiment.) Vertical bars denote ± 2 S.E.M.

It is well established that fish are able to detoxify DDT (PREMDAS and ANDERSON 1963; GREER and PAIM 1968). In an attempt to explain the gradual return to control levels following exposure to DDT, one might hypothesize that the DDT stored in the fish was depleted due to detoxification, thereby reducing the internal concentration of the agent responsible for inducing the shift in thermal preference. Such a suggestion is of course highly speculative, however, some data describing the time-course of DDT-detoxification in fish may be of interest in this respect. For example, the average half-life of DDT in goldfish tissues was reported to be 29 days (GRZENDA et al. 1970). Similarly, the whole body concentration of DDT in the bluegill sunfish and the goldfish declined rapidly for three to four days after exposure, and then more slowly to reach a steady state after approximately 16 days in the bluegill and 32 days in the goldfish (GAKSTETTER and WEISS 1967). Thus although it is not possible to relate the rate of DDT elimination in the salmon to changes in its

level of selected temperature, there is in general a rough agreement between the time required to achieve a significant reduction in the level of DDT in other species of fish following a single acute exposure, and the time required for temperature selection in DDT-exposed salmon to return to normal. Obviously further work is necessary to determine if this hypothesis is sound.

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