The Effect of Size on the Uptake of DDT from Water by Fish

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Macek and Korn (1) maintain that direct uptake of DDT from water by six inch brook trout is so slow as to be of minor importance in accounting for the DDT residues found in commercial and sport fish taken from water containing a few parts per trillion (ppt) DDT. In their experiments six inch trout required 20 days to acquire a DDT-C^{14} concentration two thousand times that of the water, while mosquito fish have been reported to achieve this concentration in 24 hours (2).

Assuming that the difference in DDT uptake between trout and mosquito fish is related to their difference in size, one might expect an intra-specific relationship between size and DDT uptake. This study attempts to evaluate that relationship in the mosquito fish (Gambusia affinis).

MATERIALS AND METHODS

Female fish were collected from a perennial pond on a golf course at Salinas, California. Immediately after capture the DDT residues (DDE, DDD and DDT) from thirteen groups and six individual fish were extracted and estimated by gas liquid chromatography (3).

After a week of acclimatization to laboratory conditions, 23 fish of five weight classes were placed in a 22 liter glass bottle containing 16 liters of aged tap water with a p,p'DDT-C^{14} concentration of 41 ppt. The aquarium was sealed; slight stirring was provided by a magnetic stirrer; the fish were not fed during the experiment, and the temperature ranged between 19.5° and 21.0°C. After 48 hours the fish were each dissolved in 2 ml of an acid mixture consisting of equal parts of glacial acetic acid and 60% perchloric acid (4), and the DDT-C^{14} was extracted with three 3 ml washes of hexane. The lipids were removed by passing the extract through a silica gel microcolumn (3); the eluent was evaporated to 1 ml, and mixed with 10 ml of toluene scintillation fluid. The radioactivity was measured by liquid scintillation counting using the channels ratio

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method of quench correction.

RESULTS

The results of the residue analyses on freshly caught mosquito fish (figure 1) suggest that the fish have acquired a DDT concentration in equilibrium with the DDT concentration of their native pond by the time their weight has reached about 150 mg. The large variation in DDT concentrations might be due to DDT dilution associated with reproduction. Since there is no great difference in DDT concentrations between weight classes, it seems unlikely that these initial levels gave a significant bias to the DDT-C^{14} uptake experiment.

The accumulation of DDT-C^{14} from water by fish of different sizes is shown in figure 2. It is evident that the smallest fish were the most efficient at removing DDT from water with the efficiency diminishing rapidly as the fish increased in weight past 200 mg. The smallest fish tested acquired a mean DDT-C^{14} concentration which was four times the mean concentration acquired by the largest fish tested, but even these large mosquito fish were much more efficient at removing DDT from water than were the approximately 100 gram trout discussed above. During the 48 hour experiment the fish removed 21% of the DDT-C^{14} from the water.

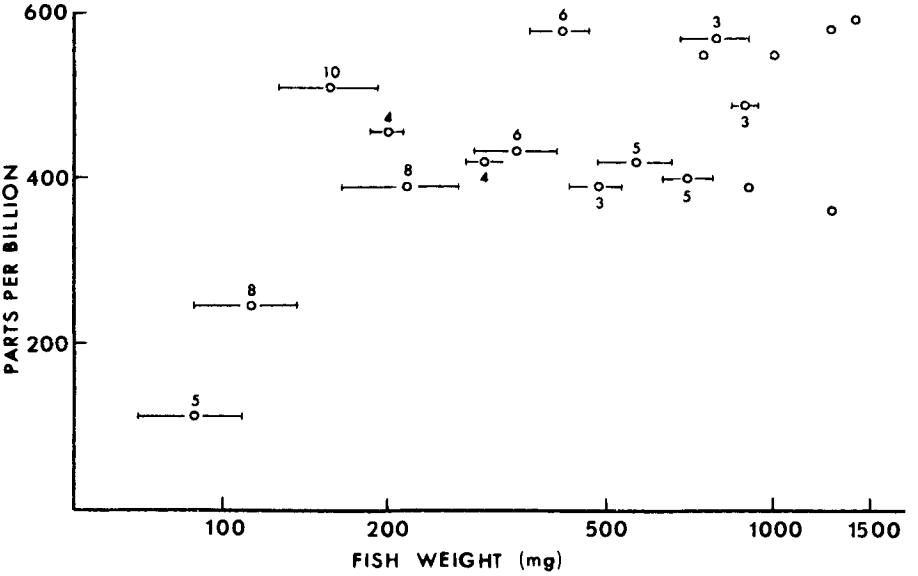

Figure 1. Total DDT residue concentrations in mosquito fish of different sizes taken from a pond at Salinas, California. Numerals indicate the number of fish pooled for each analysis.

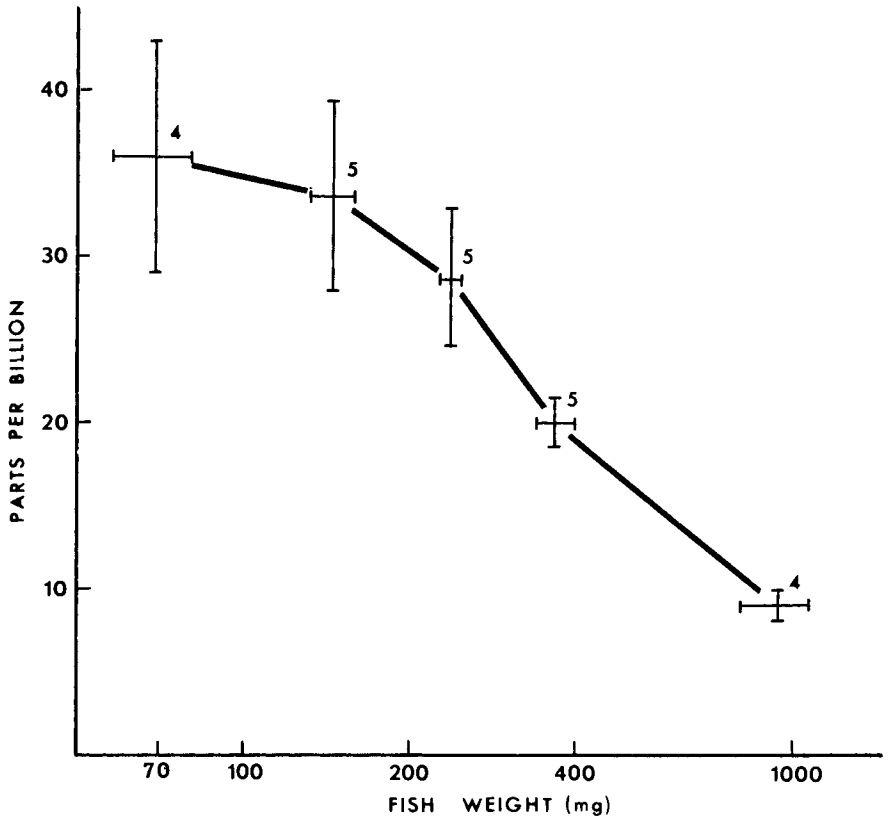

Figure 2. Concentration of DDT-C^{14} in mosquito fish after 48 hours in water with an initial concentration of 41 ppt. Numerals indicate the number of fish in each weight class.

DISCUSSION

Macek and Korn conclude that the food chain is the major source of DDT contamination in fish. They base their conclusion on experiments with six inch trout which indicate that fish are ten times more efficient at removing DDT from food than they are at removing it from water (1). However, if trout fry of one gram or less can remove DDT from water as efficiently as mosquito fish it means that at the time when they are feeding lower on the food chain, and thus ingesting less DDT, they are removing DDT from the water much more efficiently than do larger fish. Therefore, if the relationship between size and DDT uptake reported here is of general application, direct DDT uptake from water may be of considerable importance to fish populations,

especially in light of the report that coho salmon weighing less than seven grams are more sensitive than larger fish to DDT poisoning (5).

It is of further interest that guppies remove dieldrin more efficiently from water than from their diet (6), while trout, as discussed above, remove DDT more efficiently from their diet than from water. On the basis of our results it is conceivable that these opposite findings are due to the difference in the size of the test fish rather than to differences in the characteristics of the insecticides involved.

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