

# Acute Toxicity of Deltamethrin on Nile Tilapia (*Oreochromis niloticus* L.1758) Larvae and Fry

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## ABSTRACT

Deltamethrin, a synthetic pyrethroid insecticide and contaminating aquatic ecosystems, was investigated in the present study for acute toxicity. The aim of this study was to evaluate LC<sub>50</sub> values of deltamethrin on Nile tilapia (*Oreochromis niloticus* L.1758) larvae and fry after acute exposure to deltamethrin. The 48 h LC<sub>50</sub> values for Nile tilapia larvae and fry were estimated as 1.17 and 1.70 µg/L, respectively. The bioassay experiments were repeated 3 times using the static test method. Data were evaluated using the U.S. E.P.A. LC<sub>50</sub> computer program based on Finney's Probit Analysis Method. In addition, behavioral changes at each group for deltamethrin concentration were determined. All larvae and fry exposed to deltamethrin showed behavioral effects and the extent of behavioral changes increased with increased deltamethrin concentration. The results are significant for reporting deltamethrin highly toxic to fish early life stages under acute exposure.

**Key Words:** Behavioral effects, Deltamethrin, *Oreochromis niloticus*, Pyrethroid.

## 1. INTRODUCTION

The long-term ecological hazards associated with the use of organochlorine, organophosphate and carbamate pesticides led to the introduction of a new generation of pesticides with a lesser degree of persistence. In this direction, synthetic pyrethroids have emerged as viable substitutes. The synthetic pyrethroids are less persistent and less toxic to mammals and birds. The synthetic pyrethroid, deltamethrin [(S)α-cyano-3-phenoxybenzyl-(1R)-cis-3-(2,2-dibromovinyl)-2-dimethylcyclopropane carboxylate] has found wide acceptability. The pyrethroids are widely used in field pest control, household use, and as veterinary and human pediculicides and are among the most potent insecticides known [1]. The widespread use of these pesticides consequently leads to the exposure of manufacturing workers, field applicators, the ecosystem and finally the public to the possible toxic effects of these pesticides. The environmental fate and toxicology in mammals, birds, amphibians and both terrestrial and aquatic invertebrates of synthetic pyrethroids have been

reviewed [2, 3]. Pyrethroids have been reported to be extremely toxic to fish and some beneficial aquatic arthropods, for example, lobster and shrimp [3, 4].

Toxicity is highly dependent on stereochemical structure. Most products however, are mixtures of isomers. Pyrethroids are especially advantageous for use in northern climate zones, since they exhibit a negative temperature coefficient of toxicity. They are also considered as relatively non-persistent therefore are not expected to biomagnify through the food chain. Maximum bioconcentration factors ranged from 698X for whole fish (deltamethrin) to 6090X (bifenthrin) [5]. Deltamethrin has been classified "immobile" by the U.S. E.P.A. [5]. Therefore in the field most of the affected organisms show rapid recovery.

Acute toxicity data for deltamethrin in fish have been summarized in a report of the World Health Organization [6] and classified as highly toxic to fish, the LC<sub>50</sub> being in the < 1.0 ppb range. The potential hazard to fish is due to its heavy use in many aquatic

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larvicidal programs. The aim of this study is to evaluate acute LC<sub>50</sub> value for deltamethrin and to determine behavioral changes after acute deltamethrin exposure of Nile tilapia (*Oreochromis niloticus* L.1758) larvae and fry. The selected test species is recommended by international institutions and the national regulation (cf. Materials and Methods section) as standard organism [7, 8].

## 2. MATERIALS AND METHODS

The test organisms, Nile tilapia (*Oreochromis niloticus* L.1758) larvae and fry were obtained by artificial reproduction from Ankara University, Fisheries Research Center. Average weights of the larvae (individuals absorbed the yolk-sac, after pre-larva stage) were: 0.054±0.002 g; fry 0.22±0.02 g. Average lengths were: larvae 0.724±0.023 cm; fry 1.51±0.06 cm. The specimens were taken from the tanks (210 L.) where they were usually stocked and put into experimental chamber (5 L.) at least 10 days before the beginning of the experiment. Specimens were selected randomly for each chamber. 10 larvae and 10 fry were put into each chamber separately. During this acclimation period, chambers were continuously aerated. Fry was fed with commercial trout pellets that contain 45% crude protein and feeding was stopped 24 hours prior to the experiment. Animals were not fed during the last 24 hours of adaptation, and throughout the duration of the experiment. Test chambers of about 5 L capacities were filled with 3 L of tap water. Temperature was controlled at 22±1°C by using heater thermostat. Water quality parameters were: dissolved oxygen 7.2±0.16 mg/L, conductivity 0.93–0.96 µS and pH 6.73 – 6.89. Different concentrations of deltamethrin were added to the experimental chambers.

Following the preliminary experiment, all acute toxicity determinations for LC<sub>50</sub> values were repeated three times. Mortality was controlled at 24, 48, 72 and 96 hours from the beginning of the tests. Dead individuals were removed immediately, and behavioral changes were observed closely.

Technical grade (98%) deltamethrin was from the Insecticide Testing Laboratory of Hacettepe University, Ankara (Source: Chanzhou Kangmei Chemical Industry Co. Ltd., China). Deltamethrin stock solution was prepared in acetone by weighing a certain amount stored at +4°C. Dosing solutions were prepared from this stock by diluting with acetone to give the dosing concentrations of 0.25, 0.50, 1.00, 1.50, 2.00 and 2.50 µg/L for the larvae LC<sub>50</sub> experiments and 1.00, 1.50, 2.00, 2.50 and 3.00 µg/L for the fry bioassays.

The dosing volume never exceeded 0.2 ml. Control group received acetone at the maximum acetone volume used in the dilution of the dosing concentrations. The bioassay system was as described in standardized methods [7, 8] and the national regulation [9]. LC<sub>50</sub> and 95% confidence limits were calculated by a computer program [10] based on Finney's Probit Analysis.

## 3. RESULTS AND DISCUSSION

The calculated 48 h acute LC<sub>50</sub> value (95% confidence limits) of technical deltamethrin, dissolved in acetone, using a static bioassay system to Nile tilapia (*Oreochromis niloticus* L. 1758) larvae was 1.17 µg/L (0.85 – 1.52); to fry was 1.70 µg/L (1.42 – 1.96). Control mortality was zero. The results show that deltamethrin is highly toxic to both larvae and fry life stages of Nile tilapia and larvae is more sensitive than fry to this synthetic pyrethroid. The selected species is the standard test organism as recommended by the reference/standard methods [7, 8] and the Turkish national regulation [9] and findings are shown in Tables 1 and 2.

Table 1. Acute 48 h toxicity of technical deltamethrin to Nile tilapia (*Oreochromis niloticus* L.1758) larvae.

Point	Concentration (µg/L)	95% Confidence Limits	Slope ± SE	Intercept ± SE
LC 1.00	0.26	0.07 - 0.45	3.56 ± 0.82	4.76 ± 0.22
LC 5.00	0.40	0.15 - 0.61		
LC 10.00	0.51	0.22 - 0.73		
LC 15.00	0.60	0.29 - 0.82		
LC 50.00	1.17	0.85 - 1.52		
LC 85.00	2.28	1.71 - 4.09		
LC 90.00	2.67	1.95 - 5.37		
LC 95.00	3.38	2.33 - 8.09		
LC 99.00	5.25	3.22 - 17.73		

Note. Control group (theoretical spontaneous response rate) = 0.0000.

Table 2. Acute 48 h toxicity of technical deltamethrin to Nile tilapia (*Oreochromis niloticus* L.1758) fry.

Point	Concentration (µg/L)	95% Confidence Limits	Slope ± SE	Intercept ± SE
LC 1.00	0.84	0.43 – 1.10	7.57 ± 1.75	3.25 ± 0.52
LC 5.00	1.03	0.62 – 1.28		
LC 10.00	1.15	0.75 – 1.39		
LC 15.00	1.24	0.86 – 1.47		
LC 50.00	1.70	1.42 – 1.96		
LC 85.00	2.33	2.02 – 3.05		
LC 90.00	2.51	2.15 – 3.45		
LC 95.00	2.80	2.35 – 4.17		
LC 99.00	3.45	2.74 – 6.01		

Note. Control group (theoretical spontaneous response rate) = 0.0000.

Observations of behavioral response of tilapia larvae and fry were conducted at 1-8 and every 12 h during the acute toxicity tests. The control groups (tap water and tap water with acetone) showed normal behavior during the test period. In the larvae bioassays, changes in behavioral response started at 30 minutes after dosing in the 2.50 µg/L (the highest) concentration chamber. Contrary to control group; fast swimming and swimming with head shaking were observed. After 2 h, fish were constantly swimming sideways and lost balance. First mortality was recorded at 70 minutes. In the 2.00 µg/L concentration, the larvae were swimming sideways, shaking their head and had a spiral twist in the tail region. Similar behavioral responses were observed in the fry exposed to deltamethrin. In the highest concentration of 3.00 µg/L, the fry turned around their vertical axis and tried to “gulp” air from the water surface. The first mortalities recorded were 2 fry at 1.50 and 6 fry at the highest 3.00 µg/L concentrations. The lowest concentration of 1.00 µg/L, the fry had similar behavior with the control group. During the range finding tests, 5.00 and 10.00 µg/L concentrations were tried. However 2 fry died at 10 µg/L within the first hour after dosing.

The 48 h LC<sub>50</sub> value of deltamethrin in Nile tilapia larvae and fry were found as 1.17 and 1.70 µg/L, respectively, in the present work and here we report deltamethrin to be highly toxic to early life stages of fish. The effect of deltamethrin on the sensitive early life stages of zebra fish (*Brachydanio rerio* Hamilton, 1822), were examined by Görgе and Nagel [11]. The development of larvae was influenced by deltamethrin. Ontogenesis was also impaired. Embryo hatchability was reduced in a dramatic way at 0.80 µg/L and higher. The calculated LC<sub>50</sub> values at 35 days (95% confidence

limits) of deltamethrin were 0.52 (0.46-0.58) µg/L. Our results are in agreement with this study.

The U.S.D.A. National Agricultural Pesticide Impact Assessment Program's EXTOWNET document [4] reports deltamethrin acute toxicity to adult fish in laboratory tests, in the average LC<sub>50</sub> range value of 1-10 µg/L. Mittal et al. [12] reported deltamethrin toxicity to *Poecilia reticulata* as the most toxic of the pyrethroids studied: LC<sub>50</sub> = 0.016 mg/L. Viran et al. [13] reported 48 h LC<sub>50</sub> value of deltamethrin on adult male guppies as 5.13 µg/L. Reports of other investigators using adult fish species also lead to deltamethrin being highly toxic [1, 4, 6]. Mestres and Mestres [14] report 96 h fish LC<sub>50</sub> values as: rainbow trout (*Salmo gairdneri*) 0.39 µg/L; common carp (*Cyprinus carpio*) 1.84 µg/L and Mozambique tilapia (*Sarotherodon mossambica*) 3.50 µg/L. Bradbury and Coats [3] have reviewed the toxicology of pyrethroids in mammals, birds, fish, amphibians, and invertebrates (terrestrial and aquatic) and cited deltamethrin toxicity to Atlantic salmon (*Salmo salar*), mosquito fish (*Gambusia affinis*) and rainbow trout as 96 h LC<sub>50</sub> values of between 0.50 and 1.97 µg/L.

U.S. E.P.A. state deltamethrin bioconcentration factor as 698X for whole fish [5]. Although under field conditions deltamethrin is considered to pose less risk due to high adsorption to soil, these data should be considered when assessing possible/potential ecosystem risks.

Although LC<sub>50</sub> values of this synthetic pyrethroid pesticide on fish has been reported by several authors [13-15], no detailed information is available on the aquatic toxicity of deltamethrin on the early life stages of fish.

Deltamethrin is a highly toxic synthetic pyrethroid pesticide widely used in agricultural activities. Here special attention is drawn to its heavy use in mosquito control programs which necessitates in-depth sub-chronic and chronic toxicity tests in residue level determination and histopathological change studies in fish species and in non-target species to be undertaken. In addition, potential risk from deltamethrin metabolites should be investigated to get a more complete picture in terms of toxicity. The early life stages of standard test species are to be included in experimental work to get a better picture of potential toxic effects on fish reproduction and survival. Decrease in sensitivity has been observed with increased size in fishes, although responses varied considerably among the early life stages. Analysis of 96 h LC<sub>50</sub>'s for yolk-sac and swim-up fry exposed to 20 chemicals indicated that each was the most sensitive 50% of the time [16]. To overcome discrepancies and potential synergistic effects from the components of the pyrethroid formulations, toxicity tests with formulations must be included together with active ingredient tests. Using only the pyrethroid active ingredient in the tests is insufficient.

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