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Acute Toxicity of the Synthetic Pyrethroid Deltamethrin to Freshwater Catfish *Clarias gariepinus*

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Synthetic pyrethroids are rapidly replacing conventional pesticides like organochlorines, organophosphates and carbamates because of world wide concern about their use.. Deltamethrin, (S)-alpha-cyano-3-phenoxybenzyl (1R, 3R)-3-(2,2-dibromovinyl) 2,2-dimethyl-cyclopropane carboxylate, which is the active ingredient of K-Obiol®, belongs to the most recent group (4^{th}-generation) of synthetic pyrethroids. The pesticide (K-Obiol®) is commonly used in India mostly to control stored-grain pests, because of its high effectiveness at a low application rate. The recommended dose of the pesticide for stored-grain pests is 30 mg active ingredient (a.i.) per square meter of the surfaces of each layer of bag. The pesticide is considered environmentally safe because it works rapidly on insects, has low solubility in water and is quickly degraded. However, little is known about its safety level for environment disposal. Reports that documented acute toxicity of deltamethrin for a few species of fish (Mittal et al. 1991, Nemcsok et al. 1999) are inadequate. The purpose of this paper is to determine time-dependent acute toxicity of deltamethrin (K-Obiol®) to fry of the freshwater catfish, *Clarias gariepinus*, under both water soluble and organic solvent (acetone) conditions.

MATERIALS AND METHODS

The test fish were procured from a local hatchery and acclimatized to the test condition for 96-192 hours before use. Length and weight of the fish used in the experiments are given in Table 1.

The synthetic pyrethroid (K-Obiol®: 2.5WP: Aventis Crop Science India Ltd, Mumbai), with deltamethrin as the active ingredient, was used as the test chemical. Static bioassays following the method of APHA (1995) were conducted in 15L glass aquaria each containing 3L of unchlorinated tap water (pH: 8.23 ± 0.04, free CO_2: 5.1 ± 0.3, DO: 5.9 ± 0.2, alkalinity: 70.75 ± 3.77 as $CaCO_3$, hardness: 249.33 ± 11.01 as $CaCO_3$) and three fish. Three replicates were maintained for each of the concentrations tested (Table 1). Two different stock solutions of deltamethrin (K-Obiol®) were prepared, one by dissolving K-Obiol® in water and another in acetone. The concentrations used for both solvents are given in Table 1. Mortality of the test animals were recorded every 24 hr, and

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dead animals were then removed. The median lethal concentration (LC_{50}) with 95% confidence limit for deltamethrin was estimated for 24, 48, 72 and 96 hr by probit analysis (Finney 1971). A temperature of 28 ± 0.2 ^{0}C was maintained in the test medium during the experiments. For each concentration of deltamethrin tested, a control (either dilution water or 0.5 ml / L acetone) with three replicates was conducted simultaneously.

Table 1. Concentrations of deltamethrin using water and acetone as solvents, and the length and weight of fish used to determine LC_{50} values.

Solvent	Deltamethrin Concentration (mg/L)	Length (cm)	Weight (g)
Water	30, 35, 40, 50, 55, 60, 70, 80, 90, 100.	4.54 ± 0.349	1.13 ± 0.134
Acetone (0.5 ml/L)	0.003, 0.01, 0.033, 0.053, 0.066	5.07 ± 0.438	1.27 ± 0.136

Duncan's multiple range test (DMRT) was employed for comparing mean mortality values, after estimating the residual variance by repeated measures ANOVA (Winner 1971) for arc sine transformed mortality data (dead individuals / initial number of individuals). Time of exposure was the repeated measure factor while treatment (concentrations and controls) was the second factor. In addition, LC_{50} values were compared by the method of APHA (1995).

RESULTS AND DISCUSSION

LC_{50} values of water-soluble and acetone soluble deltamethrin (K-Obiol®) for *C. gariepinus* have been summarized in Table 2. The results indicate that there are considerable differences in toxicity of deltamethrin between water-soluble and acetone soluble conditions. Toxicity is reduced when it is dissolved in water. Under water-soluble conditions, there are also no significant differences in LC_{50} values of deltamethrin after different hours of exposure. Acetone-soluble deltamethrin is not only more acutely toxic to *C. gariepinus* than water-soluble deltamethrin but also the toxicity increases with increasing exposure time. While there was no significant variation of LC_{50} values for acetone-soluble deltamethrin between 72 hr and 96 hr, 24 hr and 48 hr LC_{50} values varied significantly from each other and from the 72 hr and 96 hr LC_{50} values.

Pyrethroids are generally least soluble in water, but they are soluble in mineral and vegetable oils. When dissolved in an organic solvent, K-Obiol® becomes highly toxic to fish. Even the lowest concentration of deltamethrin (K-Obiol®) used under acetone-soluble conditions produced significant mortality over the control (Table 3). However, the present results show that toxicity of deltamethrin to fish under such condition is time dependent. Pyrethroids adhere to suspended

organic matter in water. Thus the half-life of pyrethroid pesticides in water depends on the quality of water (Agnihotri 1986).

Table 2. LC_{50} values with 95% confidence limits (in parentheses) of deltamethrin (K-Obiol®) used in water and acetone.

Exposure time (in hours)	LC_{50} of deltamethrin (mg/L)	
	(K-Obiol® in water)	(K-Obiol® in acetone)
24	39.03 (29.41-51.79)	0.015 (0.012-0.019)
48	40.01 (37.208-43.022)	0.008 (0.004-0.015)
72	40.01 (37.208-43.022)	0.004 (0.001-0.012)
96	40.01 (37.208-43.022)	0.004 (0.001-0.012)

Table 3. Comparison of the results of 96 hr mean mortality by DMRT among different concentrations of deltamethrin used.

Water soluble deltamethrin (mg/L)	Acetone soluble deltamethrin (mg/L)
Water control^{a}, 30^{a}, 35^{b}, 40^{b}, 45^{c}, 50^{c}, 55^{c}, 60^{c}, 70^{c}, 80^{cd}, 90^{d}, 100^{d}	Solvent control (0.5 ml / L)^{a}, 0.003^{b}, 0.01^{c}, 0.033^{d}, 0.053^{de}, 0.066^{e}

Common superscript letters among concentrations indicate no significant difference ($P > 0.05$).

K-Obiol® is generally used against stored-grain pests. In practice aqueous solution of the pesticide is sprayed over gunny bags. Although it has been claimed that deltamethrin sprayed at the rate 10-20 mg a.i./m^2 leaves no detectable level of residue (Agnihotri and Yadav 1991), its high toxicity to fish when dissolved in an organic solvent renders it most dangerous for use near aquatic habitats. The present results confirm that an aqueous solution of the pesticide is relatively non-toxic to fish. However, the rate at which it is sprayed may create hazards to aquatic animals if the residue is mixed with any organic solvent and discharged into water. Therefore, it may be safe for terrestrial animals but requires caution for use as far as aquatic animals are concerned.

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