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Assessment of piscicidal effect of five toxicants for the eradication of weed fish Nile tilapia (*Oreochromis niloticus*)

S. Aman[1], B. Aftab[2], S. Ahmad[3*]

[1]Department of Zoology, University of the Punjab, Lahore, Pakistan

[2]Department of Biological Sciences, Faculty of Fisheries and Wildlife, University of Veterinary and Animal Sciences, Lahore, Pakistan

[3]Department of Poultry Production, Faculty of Animal Production and Technology, University of Veterinary and Animal Sciences, Lahore, Pakistan

ABSTRACT: Unwanted or weed fish in aquaculture pond may affect the growth and development of cultured fish species. The current investigation aimed to assess the piscicidal effect of five commercial toxicants on weed fish, Nile tilapia (Oreochromis niloticus) for a short period. The fish was exposed to four concentrations (0.5, 1.0, 1.5, and 2.0 ppm) of dimethoate, pyrethroid lambda-cyhalothrin, cypermethrin, malathion, and Chillas along with control (without any toxicants) during a 48-hour static bioassay. Fish mortality and physicochemical parameters i.e., pH and dissolved oxygen (DO) of water were checked after every 8 hours. The pH of water varied from 3.46to 6.5 and DO range 2.70-5.66 during all experiments. After 48 hours of exposure, the maximum fish mortality was achieved by dimethoate (4.15, 8.30%), cypermethrin (4.16, 8.32%), malathion (4.0, 8.00%), and Chillas (4.0, 8.00%) at the highest applied concentration (2.0 ppm). While pyrethroid lambda-cyhalothrin showed the highest mortality at 1.5 ppm (4.16) with 8.32% as well as on 2.0 ppm (4.16, 8.32%). In conclusion, pyrethroid lambda-cyhalothrin was observed as the best toxicant as piscicide causing overall higher mortality on all applied concentrations. However, the long-term experiment is further needed to clarify the mortality trend and optimization of toxicants in a long-term experiment.

Keywords: Fish mortality;*O. niloticus*;Physicochemical; Piscicide;Weed fish

Corresponding Author:
S. Ahmad, Department of Poultry Production, Faculty of Animal Production and Technology, University of Veterinary and Animal Sciences, Lahore, Pakistan, 54000
E-mail address: sohail.ahmad@uvas.edu.pk

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INTRODUCTION

Unwanted or weed fish may enter the aquaculture farm accidentally or naturally along with carp spawn (Rath, 2018; Bocek and Gray, 2019). This weed fish competes with cultured species for food, dissolved oxygen as well as space in the pond (Chakroff, 1884; Rath, 2018)and also ripen speedily with high fecundity. So, eradication of such unwanted fish from aquaculture ponds is an important practice in pre-stocking management (Chatterjee and Ganguli, 1993). Several customary practices such as hook and line with bait repeated drag netting and screens on water inlet have been used to remove or reduce the entry of weed fishes in the pond (Lee, 1991; Pillay and Kutty, 2005),but these approaches have been found uneconomical and incomplete(Rath, 2018). Therefore, the use of selective toxicants for limited poisoning of the pond became popular gradually for this purpose (Das et al., 2017).

There are several herbals as well as chemical toxicants that can be used as piscicides to eradicate unwanted fishes (Das et al., 2017). Piscicide is a cost-effective and reliable tool, sometimes the only applicable method for managing aquatic communities (Helfrich et al., 2009; Donnelly, 2018; Fried et al., 2018). A suitable piscicide is one that (i) kills only the target organism at a pretty lower dose without injuring other organisms (ii) shows no adverse effects on fish pond, (iii) gets nullified in water quickly, and (iv) easily economical available (Ghatak and Konar, 1993; Comfort and Re, 2017; Kuo et al., 2017). Similarly, organochlorines also work as neurotoxins (Bonnineau et al., 2016).The chemical piscicides are usually classified as organophosphates or organochlorines. These chemicals act on a biochemical and physiological level which eventually result in fish kill. Specifically, Organophosphates generally act as neurotoxins that inhibit the enzymatic pathway (Ghatak and Konar, 1993; Comfort and Re, 2017; Kuo et al., 2017). Similarly, organochlorines also work as neurotoxins (Bonnineauet al., 2016).

Nile tilapia (*Oreochromis niloticus*) is native fish to Africa and has the ability to resist a large range of environmental conditions, fast growth, reproductive strategies, flexible habitat requirements as well as omnivorous and aggressive feeding habits (Canonico et al., 2005; Martin et al., 2010). Due to these traits, this fish has become one of the successful invasive species (De Silva, 2004; Attayde et al. 2011). So, the current investigation was carried for the assessment of five easily available commercial pesticides/insecticides as piscicides for Nile Tilapia (*O. niloticus*). The appropriate dosage for the eradication of this highly resistant fish was selected and the effects of all toxicants on the water quality of the fish pond were determined during their applications in a short term (48 hours) experiment.

MATERIALS AND METHODS

Chemicals

Five commercial pesticides/insecticides chemicals, dimethoate, pyrethroid lambda-cyhalothrin, cypermethrin, malathion, and Chillas were purchased from the local market of Pattoki, District Kasur, Pakistan. Dimethoate, cypermethrin, malathion, and Chillas were in liquid form while pyrethroid lambda-cyhalothrin was solid.

Pyrethroid 1-cyhalothrin:

The pyrethroid is used as an insecticide worldwide. The exposure of fish to CL induced a high change in the enzymaticprofiles of *P. lineatus*, with the alterations in biotransformation enzymes and antioxidant defense indifferent tissues. It was also observed that an increase in sodium-potassium ATPase activity was observed in the gills of fish exposed to the highest-CL concentration, probably in order to compensate a reduction in plasma sodium. So, because of thelow CL concentrations and the short period of time, this pyrethroid causedoxidative stress, hematological adjustments, osmoregulatory disorders.

Cypermethrin:

Effect of cypermethrin on fingerlings of common edible freshwater culture carp *(Labeo rohita)* laboratory evaluation were made to check the toxicological and biochemical effect of cypermethrin. LC_{50} values decreased from 0.323 μg/L (6 h)to >0.278 μg/L (12 h),>0.240 μg/L (18 h) and >0.205 μg/L (24 h) so the significant negative values ($P < 0.05$) were correlation was observed. Thus, cypermethrin has potential piscicidal activity against fingerlings of fish *Labeo rohita* and can easily change their behavioral patterns and also constraining energy production by suppressing ATP synthesis.

Effects of dimethoate:

The acute toxicity was monitored with different concentrations at different interval of time. After adding this physico-chemical parameters were also checked.The glycogen and protein levels were decreased in sub lethal and lethal exposure, The protein was percentage was depleted (22.21%) in kidney and maximum percentage was (49.80%), in liver were observed, the depletion of glycogen content minimum in kidney (18.73%),and maximum in liver (80.14%), the fish was exposed to sub lethal and lethal concentrations for 8 days.

Malathion toxicity:

Malathion is one of the most widely studied pesticides, may induce many significant changes in fish and many studies were aimed to review the toxicological effects on haematological parameters, physical parameters, respiratory responses, biochemical parameters, neurotoxic, histopathological changes, respiratory responses, bioaccumulation and chromosomal changeswhen they were exposed with malathion.

Test organism

One hundred and fifty (150) active and healthy having the weight of 8-10grams specimens of Nile tilapia (*O. niloticus*) were taken randomly from ponds of the University of Veterinary and Animal Sciences (UVAS), Ravi Campus, Pattoki, Kasur, Pakistan. No sex determination was done of fish samples. Fish specimens were first acclimatized in circular ponds for two days then shifted to six rectangular glass aquariums having 20-liter water in each (five experimental, one control).

Water physicochemical parameters

Physiochemical parameters i.e., pH and dissolved oxygen (DO) of water were monitored using pH meter (LT-Luton pH-207, Tiwan) and DO meter (YSI 55 Incorporated. Yellow Spring, Ohio,4387, USA) throughout the experiment on a daily basis.

Assessment of piscicides

The experiment was conducted in Fisheries and Aquaculture Department, UVAS, Ravi Campus, Pattoki. The study was planned in a completely randomized design with five treatments of dimethoate, pyrethroid lambda-cyhalothrin, cypermethrin, malathion, and chillas with a control group without any treatment. Each treatment has three replicates and there were 5 fish in each replicate. The toxicity assessment was performed consecutively for each different pesticide. All the chemicals were used at four dosages (0.5 ppm, 1.0 ppm, 1.5 ppm, 2.0 ppm) for 48 hours. Mortality was checked at time intervals of 8, 16, 24, 32, and 48 hours for every concentration of treatment and control. All experiments were conducted at room temperature without any supplemental aeration. Fish were not fed during the investigation (Reish, 1987).

Statistical Analysis

Collected data collected were subjected to one-way ANOVA using GLM procedures in SAS software considering significance level at $P \leq 0.05$. For comparison of significant treatment means, Duncan's multiple range test was applied. Data were presented as least square mean ± standard deviation. The following mathematical model was applied:

$$Y_{ij} = \mu + \tau_i + \epsilon_{ij}$$

Where,

Y_{ij} = Observation of dependent variable recorded on i^{th} treatment group

μ = Population mean

τ_i = Effect of i^{th} treatment group (i = 1, 2, 3, 4)

ϵ_{ij} = Residual effect of j^{th} observation on i^{th} treatment group, NID ~ 0, σ^2

RESULTS AND DISCUSSION

Water physicochemical parameters

The pH mean values were found significantly different ($P\leq0.05$) during the application of different concentrations of all toxicants (Table 1). The mean maximum and minimum values ranged for dimethoate (3.46-6.10), pyrethroid lambda-cyhalothrin (5.69-6.10), cypermethrin (5.30-6.50), malathion (5.15-5.70), and chillas (4.80-5.55) presented in Table 1. While overall minimum pH value was observed at 3.46 with dimethoate (2.0 ppm) and maximum value 6.50 with cypermethrin (1.0 ppm).

Except for dimethoate, the dissolved oxygen (DO) mean values varied significantly ($P\leq0.05$) for concentrations of all other toxicants (Table 2). The minimum and maximum mean values of DO for each chemical were, dimethoate (2.70-3.89 mg/L), pyrethroid lambda-cyhalothrin (3.95-5.03 mg/L), cypermethrin (3.65-5.66 mg/L), malathion (4.25-5.10 mg/L), and chillas (4.29-5.28 mg/L). Overall maximum DO mean value (5.66 mg/L) was observed at 1.5 ppm of cypermethrin while dimethoate (2.0 ppm) showed the minimum dissolved oxygen (2.70 mg/L). In agreement with our investigation, several studies indicated the increase as

Table 1. pH values (mean± standard deviation) of water during 48 h exposure of toxicants

Piscicides	Concentration (ppm)			
	0.5	1.0	1.5	2.0
Dimethoate	6.10^{b}±0.22	3.80^{e}±0.21	3.59^{e}±0.13	3.46^{d}±0.67
Pyrethroid lambda cyhalothrin	6.10^{b}±0.22	6.18^{b}±0.33	5.76^{a}±0.15	5.69^{a}±0.66
Cypermethrin	6.46^{a}±0.24	6.50^{a}±0.34	5.56^{b}±0.13	5.30^{b}±0.64
Malathion	5.70^{c}±0.23	5.15^{d}±0.23	5.30^{c}±0.03	5.31^{b}±0.64
Chillas	5.30^{d}±0.23	5.55^{c}±0.22	4.94^{d}±0.34	4.80^{c}±0.63

Superscripts on different means within row differ significantly at $P \leq 0.05$

Table 2. Dissolved oxygen values (mean± standard deviation) of water during 48 h exposure of toxicants

Piscicides	Concentration (ppm)			
	0.5	1.0	1.5	2.0
Dimethoate	3.82^{e}±0.12	3.89^{e}±0.12	3.83^{e}±0.22	2.70^{e}±0.21
Pyrethroid lambda cyhalothrin	5.00^{c}±0.22	5.03^{a}±0.11	4.56^{c}±0.23	3.95^{c}±0.23
Cypermethrin	5.25^{b}±0.34	4.40^{d}±0.12	5.66^{a}±0.45	3.65^{d}±0.13
Malathion	4.25^{d}±0.21	4.50^{b}±0.15	5.00^{b}±0.67	5.10^{a}±0.11
Chillas	5.28^{a}±0.32	4.47^{c}±0.13	4.29^{d}±0.65	4.70^{b}±0.12

Superscripts on different means within row differ significantly at $P \leq 0.05$

well as a decrease in oxygen consumption by different fish species on the exposure to different chemicals. Fish species showed these variations at different times and duration of chemical exposure. Dimethoate induced variation in oxygen consumption in *Oreochromis mossambicus* (Shereena et al., 2009). Dimethyl parathion caused a disturbance in oxygen consumption for *Labeo rohita*(Bengeri et al., 1984), DDT in *Lepidocephalichthys thermalis*(Gurusamy and Ramadoss, 2000), and different chemicals in *Puntius ticto*(Magare and Patil, 2000).

Assessment of piscicides

Figures 1 & 2 depicted the weed fish (*O. niloticus*) mortality on the exposure of five different commercial toxicants as piscicide with four different concentrations i.e., 0.5, 1.0, 1.5, and 2.0 ppm during 48 hours experiment. No fish mortality was observed in the control experiment (without any toxicants). Fish mortality increased with the increase of concentration for each toxicant. At the first three concentrations, the pyrethroid lambda-cyhalothrin showed the significantly highest ($P \leq 0.05$) fish mortality (2, 3, and 4) with 4 7 and 8 percentage. However, with further increase in concentration the mortality didn't increase. The cypermethrin had the lowest mortality on all first three levels (0.33, 0.66%; 1.3, 2.60% and 1.66, 3.32%);but on 2.0 ppm, its value for mortality increased significantly (4.16, 8.32%) and it became equal to pyrethroid lambda-cyhalothrin mortality value (4.16, 8.32%). So, in our experiment, the pyrethroid lambda-cyhalothrin has been observed very effective even at lower concentrations to eradicate the weed *O. niloticus*.

In our results of fish (*O. niloticus*), the mortality appeared during a very early time compared to Richterova et al.(2014) who evaluated the effect of gamma-cyhalothrin on the larvae and embryos of *Cyprinus carpio* L. where mortalities appeared on 3rd day of the experiment with a concentration of 5, 25, and 250 $\mu g\,L^{-1}$. The reduced hatching and mortality percentages for these concentrations were 1%, 1%, 6%, 3%, and 14%. In agreement with our investigation, Dey and Saha(2014) also declared that Lambda-cyhalothrin showed more mortality percentage for *Labeo rohita* than Dimethoate. Similarly, de Moraes et al.(2013) tested three toxicants on *Brycon amazonicus*, a freshwater fish. The results indicated the deltamethrin to be the most toxic. Whereas lambda-cyhalothrin was found more toxic than cypermethrin similar to our investigation. Kumar et al.(2007) observed lambda-cyhalothrin to be fifty times more toxic than cypermethrin to *Channa Punctatus*. Kumar et al.(2011) stated the lambda-cyhalothrin very effective at even small concentrations related to *Clarias batrachus*.

Fish are sensitive to the hormone and enzymic disruptors. So, they can be affected with even small exposure to pesticides. Small doses which are not as tox-

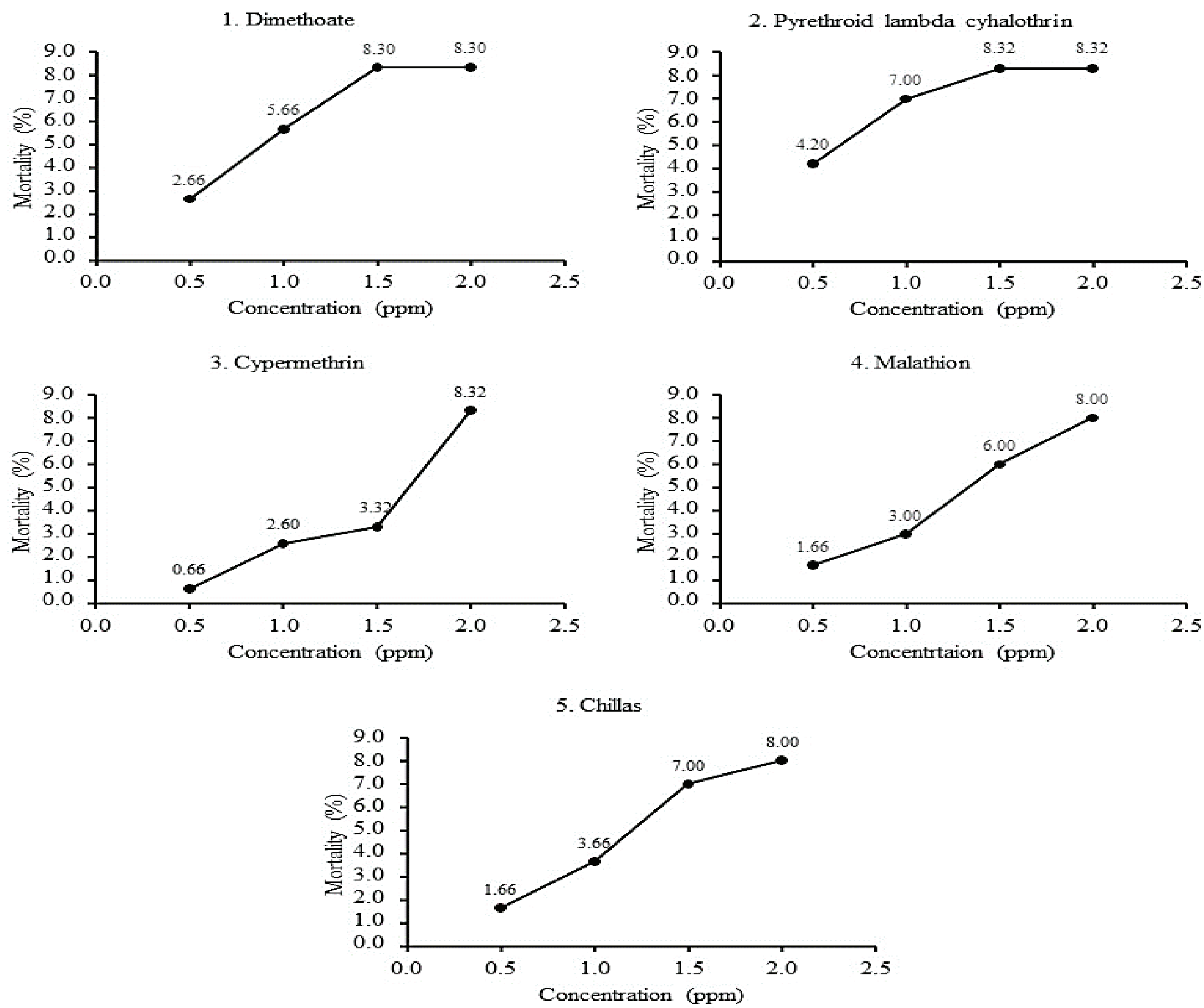

Figure 1. Fish (*O. niloticus*) mortality (%) on the application of five different toxicants during 48 hours

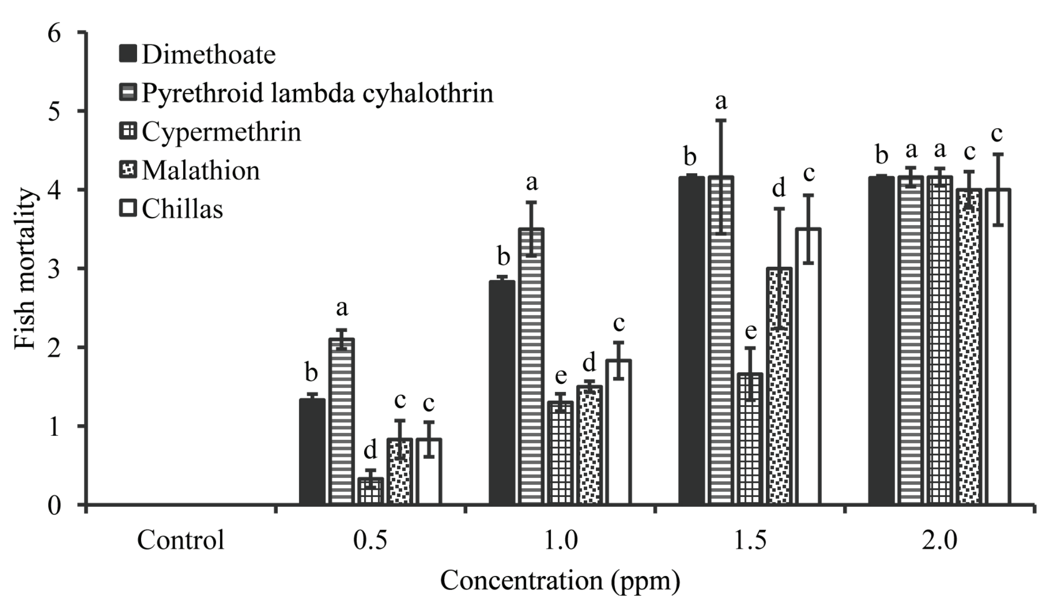

Figure 2. Fish mortality at different concentrations of toxicants (One-way ANOVA, P≤0.05);bars with different superscripts are significantly different

ic may cause physiology and behavioral changes that consequently affect reproduction as well as survival (Kegley, 1999). So, the choice of proper toxicants for the eradication of unwanted is a vital parameter in aquaculture management. Biochemical alterations induced by pesticides cause enzyme inhibition, metabolic disturbance, growth retardation, and fecundity reduction (Murty, 1986). Brain, liver, kidney, and gills are the organs that may be affected the most by exposure to toxicants (Jana and Bandyopadhyaya, 1987). Moreover, several behavioral changes are also caused by these toxicants in the fish species (Haider and Inbaraj, 1986).

Dimethoate is an organophosphate toxicant that inhibits the cholinesterase enzyme. This chemical causes genotoxic effects that were reported to be correlated and invariably accompanied with oxidative stress in the case of fish *Channapunctatus*(Ali et al., 2014). Lambda-cyhalothrin and cypermethrin both affect acetylcholinesterase by decreasing their activity in the brain, gills, and muscle at fish as stated by Kumar et al. (2009)for *Channa punctatus*. In other findings, the lambda-cyhalothrin significantly affected the immunological and hematological indices and growth performance in *O. niloticus*. Moreover, lambda-cyhalothrin also disrupted the transcriptional processes of immune-related genes and induced oxidative injury in immune organs Das et al.(1999) observed the cypermethrin effect on biochemical composition and decrease of glycogen in *Channa punctatus* gills while Rao and Ramaneswari(2002) reported this toxicant caused the decrease of protein in gills of *Mystus vittatus*, *L. rohita,* and *C. punctata*. Whereas malathion toxicity affected the protein content of gills in *C. batrachus* (Khare and Singh, 2002).

CONCLUSIONS

Proper control and eradication of unwanted weed fish in aquaculture ponds is very critical for the growth and development of cultured fish. So, the use of effective piscicide is essential from an economic point of view. In the current investigation, the pyrethroid lambda-cyhalothrin was found to be the most effective at an even lower concentration to eradicate weed fish Nile tilapia (*O. niloticus*) among all five applied toxicants. These piscicides were easily available in the local market in the form of pesticides/insecticides, hence could be accessed without any trouble by local aquaculture ownership. However, future studies are required to evaluate the toxicity with the enhanced time period to clarify the mortality pattern. Furthermore, the experiments should be conducted to optimize the toxic conditions that may only harm the targeted species.

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