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Toxicity Bioassay and Bioaccumulation Studies of Lambda Cyhalothrin on Various Tissues of *Channa striatus* (Bloch, 1793)

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Abstract: The fresh water fish *Channa striatus*, were exposed to various concentrations of lambda cyhalothrin to evaluate the 96 h lethal concentration (LC_{50} and LC_{100}) and its bioaccumulation levels and rates on various tissues. The results obtained from the current study revealed that the pesticides had ill effects on the overall functioning of the fish and found to be highly toxic to the test organisms. *Channa striatus* after continuous exposure to pyrethroid pesticide lambda cyhalothrin exhibited changes in morphological and behavioral responses when compared to control. The bioaccumulation and bioconcentration of pyrethroid insecticides and subsequent biomagnification are capable to raise many unpredictable issues at different trophic levels even to humans.

Keywords: *Channa striatus*, *Lambda cyhalothrin*, Lethal concentration, Pesticide, Bioassay, LC_{50}

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Introduction

Environmental pollution by toxic chemicals has become one of the most important emerging problems in the world (Chandran *et al*., 2005). Unscientific application of pesticides can disturb the ecological equilibrium through the addition of toxic residues in the environment (Thomas, 2022). Pesticides are regarded as the worst enemy of many organisms on this planet and it adversely affect the life of aquatic fauna which are manifested as change in physiology, biochemistry and activity levels of many enzymes (Balamurali, 2013). Long lasting exposure to different pesticides can cause acute and chronic poisoning in aquatic animals directly or indirectly through food chain (Misha and Verma, 2016).

According to Sanchez-Fortun and Barahona (2005), synthetic pyrethroids are insecticides that have been introduced over the past two decades for agricultural and domestic purposes. Lambda cyhalothrin is a synthetic pyrethroid pesticide, widely used in agriculture for human welfare and cause toxic effects on neuro-muscular system in

humans (Maiti, 2019). These insecticides act by disrupting the gate mechanism of sodium channels which take part in the generation and transmission of neuronal impulses.

Fishes are highly sensitive bio-monitors of aquatic ecosystem stability and health. Sinha *et al.* (2022) reported that significant changes in biochemical features, tissue integrity, immune status and blood parameters of fish serve as best indicators of stress, toxicant exposure, disease onset or any harmful change in water quality. Numerous studies were previously conducted in this line on many fish species but pyrethroid pesticide investigation in fresh water fishes are still scanty. But the scope of this type of investigation is never ending because of the infinite number of aquatic number of organisms and the generation of novel chemicals every day from various chemical industries. The selected species, *Channa striatus* is a sturdy fish with accessory respiratory organs and are able to overcome drought situations. The fish is commonly found in paddy fields, ponds, tributaries and rivers in Kuttanad. Moreover, *C. striatus* are the most popular, highly nutritional and delicious fish food in the study area. With this background, the present study was focused to determine the toxic effects of commonly used pyrethroid pesticide, lambda cyhalothrin on various tissues of fresh water fish, *Channa striatus* under laboratory conditions.

Materials and Methods

Collection and acclimatization of fish:

The live and healthy specimens of *Channa striatus* were collected with the help of local fishermen from a pond. Uninjured healthy fishes of almost similar length (15-20 cm) and weight (100-120 g) were collected from the stock pond and transferred to the laboratory in closed water filled bucket and acclimatized to the ambient laboratory temperature of 28 ± 0.20ºC in a large stock tank. 25% fresh water was added once in every two days after removing the same amount of water from the tank. The fish were fed with rice flour mixed with fish meal in the ratio 1:1. After seven days of acclimatization, twenty healthy fishes were captured from the stock tank and ten each were introduced into the experimental tanks. Fish were starved for two days prior to the actual experiment. The temperature, pH and dissolved oxygen of the water were noted at regular intervals (Temp 28 ±1ºC, pH 6.5 ± 0.5, and DO 7 ± 0.5 mg/l).

Bio assay studies:

For toxicity bioassay study, the concentration of lambda cyhalothrin 5% EC (manufactured by Segentia India Ltd, Mumbai) used were selected on the basis of trial experiments that causes 0-100% mortality in test animals. The concentration of lambda cyhalothrin used for experiment was 0.072 ppm/l. The fish were fed once in two days for 21 days. The tanks were thoroughly monitored throughout the period of study. Dead fish were removed immediately and precautions were taken to see minimum mortalities in the tanks. 25 liters of water from each tank was removed once in two days and care was taken to maintain the same concentration of pesticides in the medium. After the experimental period, the fish were captured from both tanks, sacrificed and dissected. Tissues such as gills, liver and flesh were removed, cleaned and kept in separate containers, and transported to the laboratory under chilled condition (-20ºC). The analysis was performed with Perkin (model 5890) gas chromatography equipped with Ni 63 electron capture detector following the methods of AOAC (2012). A control set was also run with similar number of fishes but without any pesticides.

Data Analysis:

The data were recorded on the morphological and behavioral changes exhibited by the fish during the period of exposure to the pesticides and also on the mortality responses for different concentrations of pesticides. The mortality of fish was observed every 12 to 96 h. LC_{100}, LC_{50}, Safe and sublethal concentration for each pesticide was done by Probit analysis method (Litchfield and

Table 1: Bioassay studies on *Channa striatus* using Lambda cyhalothrin 5% EC

Concentration (µl/100 L)	12 h (%)	24 h (%)	48 h (%)	72 h (%)	96 h (%)
15	0	0	0	0	10
25	0	0	0	10	15
30	0	10	15	25	40
40	0	15	25	45	50
50	40	50	70	80	85
55	60	70	90	95	100

Table 2: LC_{100}, LC_{50}, safe and sublethal concentrations of Lambda cyhalothrin 5% EC on *Channa striatus*

LC_{100}	12 h	56.65
	24 h	59.85
	48 h	57.41
	72 h	56.78
	96 h	56.87
LC_{50}	12 h	52.18
	24 h	46.47
	48 h	43.39
	72 h	39.50
	96 h	35.79
S-value		1.09
Safe Concentration (µl/l)		0.072
Sub-lethal Concentration (µl /l)		0.089

Wilcoxon, 1949).

Results and Discussion

An assessment of the toxicity levels of pesticide lambda cyhalothrin was carried out and observed that highest mortality at 96 h. 10, 15, 40, 50, 85 and 100% mortality was recorded at 96 h for 15, 25, 30, 40, 50 and 55 µl/100 l concentrations, respectively (Table 1).Control groups showed no mortality. The rice cultivation in various paddy fields of Kuttanad wetland largely depends on pyrethroid pesticides and among them lambda cyhalothrin is extensively used to control various pests. Lambda cyhalothrin was highly toxic since very small concentrations caused death of the fish *C. striatus*. Due to their lipophilicity, pyrethroids have an enormous rate of gill absorption even at very low concentrations in the water and it cannot be metabolized efficiently by fishes (Viran *et al.*, 2003).

The safe concentration and sub-lethal concentration of lambda cyhalothrin was determined as 0.072 µl/l and 0.089 µl/l, respectively. The observed bioassay values (LC_{50} and LC_{100}) for12, 24, 48, 72 and 96 h exposure for this selected pesticide for *Channa striatus* are depicted in the Table 2. According to Capkin *et al*. (2006), lethal concentration 50 of fish Rainbow

Table 3: Bio concentration factors of lambda cyhalothrin in various tissues of *C. striatus*

Tissue	Experimental (mg/kg)	Concentration of exposure (ppm/l)	Bio concentration factor
Gills	0.029	0.072	0.41
Liver	0.021	0.072	0.29
Muscle	0.012	0.072	0.17

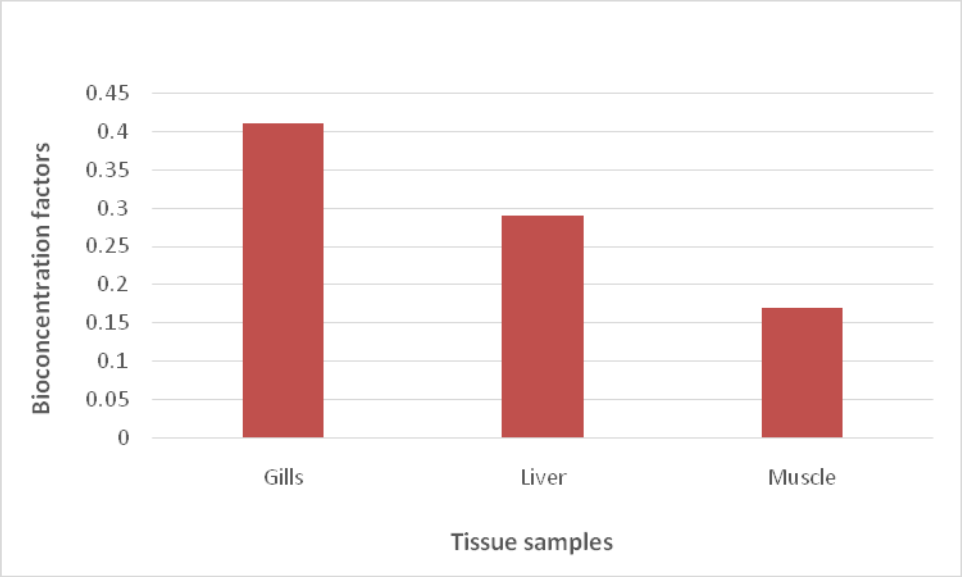

Fig. 1: Bio-concentration factors of lambda cyhalothrin in various tissues of *C. striatus*.

trout depends on fish size, temperature, water quality including pH, alkalinity and hardness.

Table 3 and Figure 1 illustrate the bioconcentration factors of lambda cyhalothrin in various tissues of *Channa striatus.* Pyrethroid insecticide lambda cyhalothrin concentrated in gills (0.029 mg/kg), liver (0.021 mg/kg), and muscles (0.012 mg/kg). The sub-lethal dose introduced was 0.072 ppm /l. The bio-concentration factor values obtained were 0.41 (gills), 0.29 (liver) and 0.17 (muscle), respectively.

Table 3 and Figure 1 illustrate the bioconcentration factors of lambda cyhalothrin in various tissues of *Channa striatus.* Pyrethroid insecticide lambda cyhalothrin concentrated in gills (0.029 mg/kg), liver (0.021 mg/kg), and muscles (0.012 mg/kg). The sub-lethal dose introduced was 0.072 ppm /l. The bio-concentration factor values obtained were 0.41 (gills), 0.29 (liver) and 0.17 (muscle), respectively. The pyrethroid pesticide lambda cyhalothrin, selected for the present study is categorized as restricted use pesticide in Extension Toxicology Network for its toxicity to fishes (Maund *et al.*, 1998). But this pesticide is extensively used in the paddy fields of Kuttanad wetland. The examination of gills, liver and muscle revealed the concentration of lambda cyhalothrin in varying concentrations. In the present study, insecticide lambda cyhalothrin introduced into the medium was 0.072 ppm/l were 0.029 mg/kg (BCF0.41) residue accumulated in the gills. Liver, the major organ of detoxification accumulated 0.021 mg/kg (BCF 0.29) and muscle, the edible portion accumulated 0.012 mg/kg (BCF 0.17). A gradual reduction in concentration of the pesticide was evident in the study (gill >liver>muscle) which

may be due to detoxification in liver. The ADI of lambda cyhalothrin as set by the joint meeting of FAO and WHO (1986) was 0.02 mg/kg. In present study, the concentration of residues in the musclewas below the acceptable daily intake level. The detoxification mechanisms in the body of the fish was able to lessen the concentration to a certain extent.

After pesticidal exposure, major morphological alterations observed were eyes swelling, secretion of excess mucus, formation of dark spots over head and in the tubercles, hemorrhaged areas found in the anterior and posterior dorsal fins of fishes.Marked behavioral changes noted in fish were darting movements, excitations with frequent attempts to jump out the tanks, rapid movements of the buccal and opercular cavities, impaired swimming ability, marked decline in behaviors like chasing and vacating, loss of schooling behavior, head shaking and restlessness before death. Firat *et al*. (2011) reported that alterations in serum parameters of fish *Oreochromis niloticus*, may be the result of target tissues (gills, liver and kidney) damage and dysfunction induced by toxicants, can be used as rapid and sensitive markers of aquatic ecosystem status.

Conclusion

In the present study, mortality was not noticed in control groups while highest mortality were obtained at 96 h in pesticide treated experimental animals. The pyrethroid pesticide, lambda cyhalothrin toxicity effects on *Channa striatus* indicated many morphological and behavioral changes, which may lead to numerous physiological problems, finally resulting in the mortality of fish. Direct spraying of this pesticides by native people in Kuttanad to water bodies for catching fishes and prawns, may contaminate the aquatic ecosystem and could pose high health risks to the consumers of the fish too. Therefore, use of this kind of pesticides in the field may be a huge threat for whole environmental creatures and should be utilized only in minimal concentration level for our survival.

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