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Determination of lethal concentration (LC50-96 hr) of lambda cyhalothrin for a fish, *Anabas testudineus* (Bloch)

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Abstract
The study was conducted to determine the 96-hour LC_{50} of Lambda-cyhalothrin, a synthetic pyrethroid pesticide, in *Anabas testudineus*, a freshwater fish species of ecological and commercial significance. Fish were exposed to various concentrations of the pesticide (0.004, 0.005, 0.015, 0.025, 0.035, and 0.045 mg/20L), and mortality was recorded. A clear dose-dependent response was observed. Using probit analysis, the 96-hour LC_{50} value was calculated to be 0.020 mg/20L. Behavioral changes such as erratic swimming and surfacing were also noted. These findings highlight the high sensitivity of *A. testudineus* to Lambda-cyhalothrin and emphasize the need for cautious pesticide use near aquatic ecosystems.

Keywords: LC_{50}, *Anabas testudineus*, lambda-cyhalothrin, synthetic pyrethroid

1. Introduction

The widespread use of pesticides in modern agriculture has undoubtedly enhanced crop yields, but it has also introduced serious environmental consequences. One of the most alarming impacts is the contamination of aquatic ecosystems due to pesticide runoff from agricultural fields. Among the many pollutants entering water bodies, synthetic pyrethroids are particularly noteworthy due to their extensive use and high efficacy against a broad spectrum of pests (He *et al.*, 2008) [5]. Lambda-cyhalothrin (LCT), a type II synthetic pyrethroid, has been widely adopted in farming practices owing to its potent insecticidal action and relatively low persistence in terrestrial environments. However, its lipophilic nature and high toxicity make it especially harmful to aquatic organisms, even at low concentrations (Srivastava *et al.*, 2004) [9].

Once LCT enters aquatic systems, it poses a direct threat to non-target species, especially fish. These chemicals interfere with the nervous systems of aquatic organisms, often leading to severe physiological disruptions and death (Werner & Moran, 2008) [12]. Unlike terrestrial organisms, fish are continuously exposed to dissolved toxicants, which can bioaccumulate in their tissues over time, making them valuable bioindicators of environmental health. Acute toxicity studies, such as LC_{50} (lethal concentration for 50% mortality), are crucial in understanding the immediate effects of such contaminants and serve as the basis for environmental safety regulations (Bownik *et al.*, 2019) [1].

Anabas testudineus, commonly referred to as the climbing perch, is a freshwater fish species widely distributed in India, Bangladesh, and Southeast Asia. This species is of considerable ecological and commercial importance, as it is both resilient and capable of surviving in low-oxygen environments. Due to its adaptability, it is frequently used in toxicological research. Its physiological and behavioral responses to toxic substances provide insight into the harmful effects of pollutants on freshwater biota (Vikas & Subramannian, 2022) [10].

Monitoring the toxicity of LCT in fish species like *Anabas testudineus* is essential not only for ecological assessments but also for guiding policy and pesticide usage in agriculture. Toxicity levels can vary depending on species, environmental conditions, and duration of exposure. Therefore, establishing standardized data such as the LC_{50} over a defined period, such as 96 hours, helps in assessing risk more accurately. This also aids in comparative toxicology and helps inform stakeholders, including policymakers, farmers, and environmentalists, about the potential dangers associated with pesticide misuse (Saha & Kaviraj, 2008) [8].

This study focuses on determining the 96-hour LC_{50} value of LCT on *Anabas testudineus* under controlled laboratory conditions. By examining mortality rates at various concentrations, the research aims to assess the acute toxicological effects of this pesticide on the target species. The findings are expected to contribute to a deeper understanding of pesticide impacts on freshwater fish and support efforts in establishing environmentally sustainable pest control practices.

2. Materials and Methods

Experimental Animal

Tests on pesticide toxicity were carried out in the Department of Zoology, Bio Endocrinology lab at T. M. Bhagalpur University Bhagalpur. The experiment involved the selection of healthy freshwater *A. testudineous*, weighing 25 ± 1g and measuring 8-10 ± 0.5 cm in length. The fish were obtained from the natural pond located in the Bhagalpur area. To check for any dangerous illnesses, fish were checked. Glass aquariums were sun-dried after being cleaned with 1% $KMnO_4$ to prevent fungal infestation. After that, healthy fish were moved into glass aquariums measuring 22 x 10 x 10 inches that held dechlorinated tap water (pH 8.2 ± 0.04; temperature 26 ± 2 °C; total hardness 514 ± 23 mg/l; dissolved oxygen 6.1 ± 0.2 mg/l; salinity 1.3 ± 0.13 ppt). Before research, fish had a 15-day acclimation period to laboratory conditions. They were given commercial food daily, and the medium (tap water) was changed every day to get rid of food scraps and faeces. Each aquarium (holding 20 litres) was initially filled with 20 litres of tap water.

Pesticide Solution

Commercial grade lambda-cyhalothrin (5% EC) containing pesticide was purchased from the local market, and LCT concentration was calculated based on the active ingredient reported by the manufacturer, 5% active ingredient. The stock solution was prepared and used for the preparation of different concentrations of 0.005, 0.015, 0.025, 0.035 and 0.045 mg/20L of pesticide for acute toxicity tests. No food was given at the time of the toxicity test.

Data Recording

Mortality was observed every 24 hours for 96 hours. Behavioral responses were also recorded.

Data Analysis

Mortality data were used to compute LC_{50} using probit analysis. Log-dose vs. probit regression was performed using statistical software (e.g., SPSS, R).

3. Results and Discussion

3.1. Results

Table 1 shows the number of fish that died in different concentration groups after 96 hours of exposure. As seen in Figure 1, the linear mortality-concentration relationship with higher concentrations of the insecticide. The LC_{50} value of LCT at 96 hours was calculated to be 0.020 mg per 20 liters. The first signs of mortality were noticed at 72 hours in fish exposed to the concentration used in Tank B. By the end of the 96 hours, all fish in Tank F had died, indicating 100% mortality of *Anabas testudineus* at the highest concentration. As shown in Figure 2, mortality percent varied across tanks in response to different concentrations. Now, interpolate LC_{50} from the linear segment around 50% mortality (between 0.015 and 0.025).

Probit regression analysis (Table 2) showed a linear relationship between log-transformed dose and mortality.

Behavioral abnormalities included:

- Erratic and rapid swimming
- Frequent surfacing
- Loss of balance
- Lethargy before death

Table 1: Mortality of *Anabas testudineus* exposed to Lambda-cyhalothrin

Periods	No. of fishes	Concentration & mortality in every Tank (mg/20L)					
		TANK A (0.004)	TANK B 0.005	TANK C 0.015	TANK D 0.025	TANK E 0.035	TANK F 0.045
24 hr	10	-	-			2	2
48 hr	10	-	-	1	2	1	2
72 hr	10	-	02	1	3	3	2
96 hr	10	-	-	2	2	2	4
Total Mortality		0	2	4	6	8	10

Table 2: Fish Mortality & Probit Analysis at Different Concentrations of Test Substance

Concentration (mg/20L)	No. of Fish	Mortality	% Mortality	log10(Conc.)	Probit
0.004 (Tank A)	10	0	0%	-2.3979	-
0.005 (Tank B)	10	2	20%	-2.3010	4.16
0.015 (Tank C)	10	4	40%	-1.8239	4.75
0.025 (Tank D)	10	6	60%	-1.6021	5.25
0.035 (Tank E)	10	8	80%	-1.4559	5.84
0.045 (Tank F)	10	10	100%	-1.3468	-

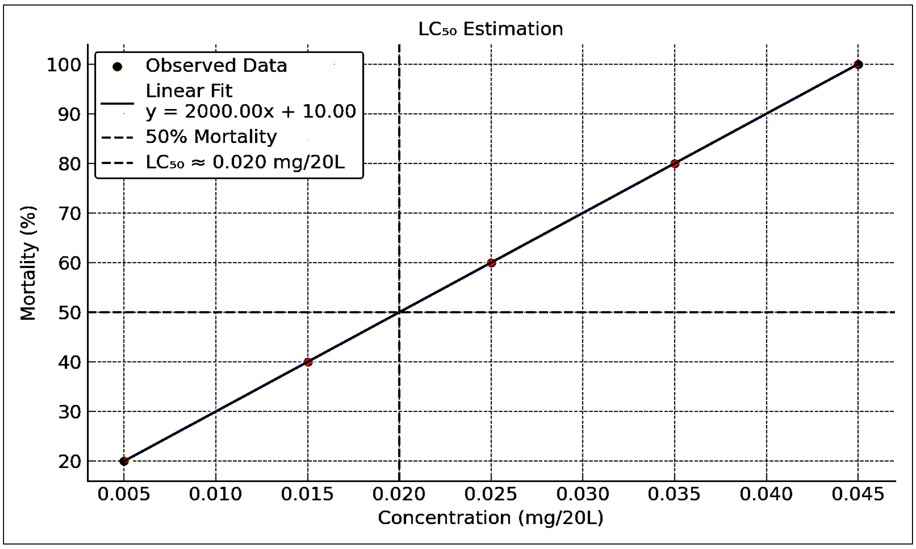

Fig 1: Graph showing estimation of LC_{50} based on Linear Mortality-Concentration Relationship

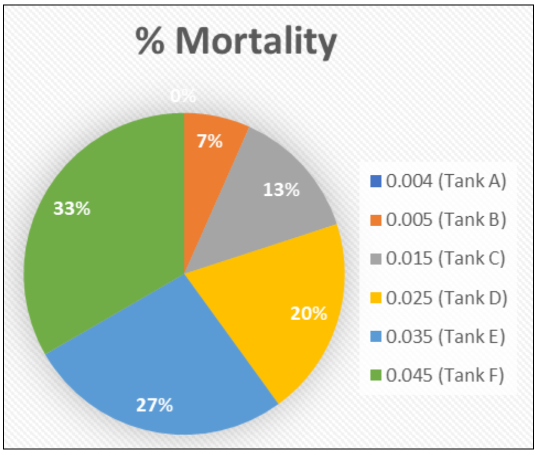

Fig 2: Pie chart showing mortality % increased with different concentrations

3.2. Discussion

In the present study, *Anabas testudineus* were exposed to increasing concentrations of LCT for 96 hours to determine the pesticide's acute toxicity. The mortality data showed a clear dose-dependent pattern. No mortality was observed in (0.004 mg/20L), while complete mortality (100%) occurred at the highest concentration (0.045 mg/20L). Intermediate concentrations produced progressive increases in mortality: 20% at 0.005 mg/20L, 40% at 0.015 mg/20L, 60% at 0.025 mg/20L, and 80% at 0.035 mg/20L. Using probit analysis, the 96-hour LC_{50} value was calculated to be approximately 0.020 mg/20L.

In a study reported that 96 hrs LC_{50} of analytical grade LCT chemical in *Labeo rohita* fingerlings as 2.72 ug/L. This chemical also caused aberrant swimming behavior in fish which suggested that Lambda-cyhalothrin highly toxic to fish (Gadhave *et al.*, 2014) [3].

Similarly, Saha and Kaviraj (2003) [8] reported an LC_{50} value of 0.02 mg/L for cypermethrin in *Heteropneustes fossilis*, which closely resembles the values obtained in the present study.

In addition to mortality, various behavioral changes were observed among the exposed fish (Halappa & David, 2009) [4]. These included erratic and rapid swimming, excessive surfacing, loss of equilibrium, and eventual lethargy before death. Such behavioral abnormalities are commonly reported in pyrethroid toxicity studies and are attributed to the neurotoxic action of these compounds, which disrupt normal nerve function by interfering with sodium channel kinetics (Bradbury & Coats, 1989) [2]. These changes serve as early indicators of pesticide exposure and can significantly impair a fish's ability to feed, avoid predators, and reproduce.

The sensitivity of *Anabas testudineus* to Lambda-cyhalothrin, a relatively low-persistence pesticide, highlights the potential ecological risk it poses, especially in areas where its runoff into aquatic systems is likely. Although Lambda-cyhalothrin is considered less persistent in the environment compared to organophosphates, its acute toxicity to non-target species like fish remains a pressing concern (Hoque *et al.*, 2009) [9]. In an acute toxicity test of gamma-cyhalothrin and LCT were highly toxic to zebra fish, and the toxicities for both formulations were equivalent (Wang *et al.*, 2007) [11]. The primary mechanism for LCT dissipation is thought to be alkaline hydrolysis in the water close to the surface of macrophytes and phytoplankton (Leistra *et al.*, 2003) [7].

This study underscores the need for stricter control and monitoring of pesticide use near aquatic habitats. Moreover, it suggests that toxicity assessments should not only focus on mortality but also consider sublethal and behavioral effects that can compromise fish health and biodiversity over time. Future studies should explore long-term exposure effects, bioaccumulation potential, and impacts on fish physiology and reproduction.

4. Conclusion

The present study clearly demonstrates that LCT, even at very low concentrations, exhibits significant acute toxicity to the freshwater fish *Anabas testudineus*. The observed 96-hour LC_{50} value of 0.020 mg/20L reflects the high sensitivity of this species to the pesticide and highlights the potential ecological risks associated with its widespread use in agriculture. In conclusion, while LCT is effective for pest control in agriculture, its toxicological impact on aquatic life cannot be overlooked. Environmental management strategies should prioritize buffer zones, improved pesticide application methods, and continuous ecological risk assessment. Future research should explore sub-lethal and chronic effects, bioaccumulation patterns, and potential recovery mechanisms in fish exposed to pyrethroids. Such studies are essential for building a comprehensive understanding of the long-term consequences of pesticide contamination in aquatic ecosystems and ensuring more sustainable use of chemical inputs in agriculture.

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6. Conflict of Interest

I confirm that there are no conflicts of interest. I have fully disclosed any sources of support or collaboration, and the work has been carried out with honesty and transparency.

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