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Toxicity Of Lambda-Cyhalothrin On Haematological Profile Of Anabas Testudineus (Bloch)

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Abstract
Lambda-cyhalothrin, a widely used synthetic pyrethroid insecticide, is known for its high efficacy in pest control. However, its toxicity to non-target aquatic organisms, such as fish, raises environmental and ecological concerns. This study evaluates the impact of Lambda-cyhalothrin (LCT) on the haematological profile of Anabas testudineus (Bloch), a hardy freshwater fish species. Statistical analysis using independent t-tests confirmed significant differences ($p < 0.05$) across nearly all parameters between control and treated groups. Graphical representations (bar and line charts with ±SD) supported these findings, illustrating consistent haematological disruption with increasing dose. These findings highlight the hematotoxic potential of the test substance and underscore the need for further investigation into its mechanism of action and safety profile.

Keywords: *Lambda-cyhalothrin, haematological, Anabas testudineus, fish*

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I. Introduction

The growing demand for food has led to the widespread use of pesticides in agriculture in recent years. However, the application of pesticides has led to environmental contamination, which has had a significant impact on living things. For example, 99.9% of all pesticides end up changing environmental components, while only 0.1% of all insecticides reach the bugs. (Marigoudar et al., 2009). Through a variety of natural processes, including soil erosion and surface runoff, pesticides are introduced into Indian natural water bodies, endangering drinking water supplies and harming a wide variety of non-target phytoplankton, zooplankton, and higher trophic organisms, including fish and fish predators (Mondal et al. 2018; Rajmohan et al. 2020; Kalyabina et al. 2021). By modulating the activities of many enzymes and metabolites, pesticide accumulation in tissue causes many physiological and biochemical changes in fish (Sarma et al. 2013). Pesticides alter the rate of enzymatic reactions and may also inhibit certain enzymes. Pesticide exposure in fish results in a considerable reduction in total protein levels, an increase in blood glucose levels, and significant alterations in total bilirubin, albumin, urea, inorganic phosphate, and cholesterol levels in serum. Pesticides also induce the production of reactive oxygen species (Ullah et al. 2019; Gonçalves et al. 2021). Aquatic environments are frequently contaminated by agrochemicals, including pesticides like LCT, which enter water bodies through agricultural runoff. Fish are highly sensitive to these pollutants, and their haematological parameters serve as reliable biomarkers of toxicity. *Anabas testudineus*, commonly known as the climbing perch, is a resilient species found in freshwater ecosystems. Studying the haematological response of this species to LCT exposure can provide insight into the potential risks associated with pesticide contamination.

II. Materials And Methods

Experimental Fish: Healthy specimens of *Anabas testudineus* (length: 10-15 cm, weight: 30-50 g) were collected from a local freshwater habitat of Bhagalpur Bihar and acclimatized in laboratory conditions for two weeks.

Chemical Exposure: Fish were exposed to sub-lethal concentrations (0.002, and 0.004 mg/L) of Lambda-cyhalothrin 5% for 28 days.

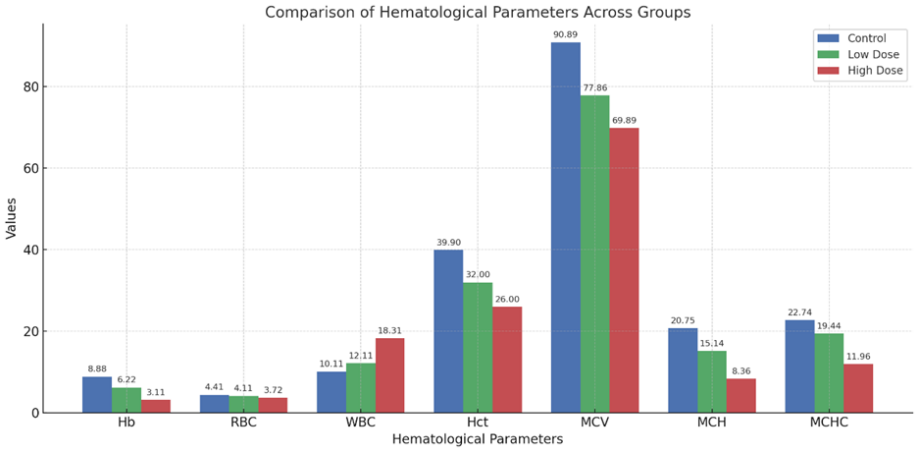
Blood Sampling: Blood was drawn from the caudal vein using heparinised syringes.

Haematological Analysis: Parameters including haemoglobin (Hb), red blood cell (RBC) count, white blood cell (WBC) count, haematocrit (Hct), mean corpuscular volume (MCV), mean corpuscular haemoglobin (MCH), and mean corpuscular haemoglobin concentration (MCHC) were analysed using standard techniques.

III. Results And Discussion:

Result

No. of Fishes	Group	Hb (g/dl)	RBC ($\times 10^6$/mm^3)	WBC ($\times 10^3$/mm^3)	Hct (%)	MCV(fl)	MCH (pg)	MCHC (g/dl)
10	Control	8.88 ± 0.63	4.41 ± 0.38	10.11 ±1.19	39.9 ±1.52	90.89± 5.14	20.75 ±1.12	22.74 ±0.88
10	0.002 mg/l	6.22 ± 0.22	4.11 ± 0.17	12.11 ± 1.17	32 ±1.34	77.86 ± 4.59	15.14 ± 0.82	19.44 ± 1.07
10	0.004 mg/l	3.11 ± 0.13	3.72 ± 0.23	18.31 ± 1.32	26 ±1.5	69.89 ± 5.91	8.36 ± 0.63	11.96 ± 0.85



The haematological profile of the control, low dose treated, and high dose treated groups is summarized below. A dose-dependent reduction in haemoglobin (Hb), hematocrit (Hct), red blood cell count (RBC), mean corpuscular volume (MCV), mean corpuscular haemoglobin (MCH), and mean corpuscular haemoglobin concentration (MCHC) was observed in treated groups compared to the control. Conversely, white blood cell (WBC) count showed a progressive increase with increasing dose.

- **Hb** significantly decreased from **8.88 ± 0.63 g/dl** in the control group to **6.22 ± 0.22 g/dl** in the low dose and further to **3.11 ± 0.13 g/dl** in the high dose group.
- **RBC** count slightly decreased from **4.41 ± 0.38 ×10⁶/mm³** (control) to **4.11 ± 0.17**, and to **3.72 ± 0.23** in the high dose group.
- **WBC** count increased significantly from **10.11 ± 1.19 ×10³/mm³** to **12.11 ± 1.17** and peaked at **18.31 ± 1.32**.
- **Hct**, **MCV**, **MCH**, and **MCHC** showed similar decreasing trends, consistent with the development of **dose-dependent microcytic hypochromic anemia**.

Discussion

The present study evaluated the hematological alterations in response to treatment at varying doses, comparing a control group with two treated groups. The findings demonstrate a clear, dose-dependent impact on several key hematological indices, particularly markers associated with erythropoiesis and immune response.

A significant decline in hemoglobin (Hb), hematocrit (Hct), mean corpuscular volume (MCV), mean corpuscular hemoglobin (MCH), and mean corpuscular hemoglobin concentration (MCHC) was observed in both treated and higher treated groups compared to control. In the higher treated group, Hb decreased sharply to 3.11 ± 0.13 g/dl from 8.88 ± 0.63 g/dl in controls, while Hct dropped from 39.9 ± 1.52% to 26 ± 1.5%. Such reductions are indicative of anemia, likely microcytic and hypochromic in nature, as evidenced by the concurrent decline in MCV (from 90.89 ± 5.14 fl to 69.89 ± 5.91 fl) and MCHC (from 22.74 ± 0.88 g/dl to 11.96 ± 0.85 g/dl). These findings suggest impaired erythropoiesis or increased erythrocyte destruction, potentially due to the toxic or suppressive effects of the treatment on bone marrow function or iron metabolism (Vaziri et al., 2001; Prasanthi et al., 2005).

In contrast, a progressive and significant increase in white blood cell (WBC) count was noted across the treatment groups, peaking at 18.31 ± 1.32 $\times 10^3/mm^3$ in the higher treated group versus 10.11 ± 1.19 $\times 10^3/mm^3$ in controls. Elevated WBC levels typically reflect an inflammatory or immune response, which may suggest systemic stress, infection, or direct immunomodulatory effects of the administered agent (García et al., 2007). This leukocytosis could also be secondary to tissue damage or oxidative stress, both of which are common features in response to certain toxic agents or high-dose drug exposure (Rahman et al., 2012).

The relatively smaller change in red blood cell (RBC) count compared to the more drastic alterations in Hb and Hct suggests that the anemia observed may not be solely due to decreased RBC production, but rather a combination of reduced hemoglobin synthesis and cell size, as supported by the reductions in MCH and MCV. This pattern aligns with previous studies reporting similar hematological disruptions following exposure to xenobiotics or toxic compounds that impair iron utilization or induce oxidative damage (Oyewole et al., 2014).

Collectively, these findings support the hypothesis that the treatment induces hematotoxicity in a dose-dependent manner, compromising red cell indices while simultaneously stimulating a leukocytic response. Further studies are warranted to elucidate the underlying mechanisms, such as bone marrow histopathology, oxidative stress biomarkers, and inflammatory cytokine profiling.

IV. Conclusion

The present study demonstrates that administration of the test substance induces **dose-dependent hematological alterations**, particularly affecting erythrocyte indices. Both low and high dose treatments resulted in significant reductions in **hemoglobin (Hb)**, **hematocrit (Hct)**, **mean corpuscular volume (MCV)**, **mean corpuscular hemoglobin (MCH)**, and **mean corpuscular hemoglobin concentration (MCHC)**, indicative of **microcytic hypochromic anemia**. The **white blood cell (WBC)** count significantly increased with dose, suggesting an inflammatory or immune response to the substance.

Statistical analysis via independent **t-tests** confirmed that nearly all parameters showed highly significant differences ($p < 0.05$) between control, low dose, and high dose groups. The severity of hematological disruption in the high-dose group highlights the potential **hematotoxicity** of the compound, underscoring the need for **caution in its use and further investigation** into its mechanism of toxicity.

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