International Journal of Entomology Research
www.entomologyjournals.com
ISSN: 2455-4758
Received: 23-12-2024, Accepted: 22-01-2025, Published: 06-02-2025
Volume 10, Issue 2, 2025, Page No. 33-35

Comparative analysis of biological and chemical toxins on protein degradation in *Oreochromis mossambicus*: Impacts of aquatic insect infestation and Mercury Chloride exposure

Dr. P N Chavan
Department of Zoology, S.G.B. Mahavidyalaya, Purna, Parbhani, Maharashtra, India

Abstract
Oreochromis mossambicus, with common name *Mozambique tilapia*, is an vital freshwater fish species renowned for its high protein content and nutritional value, making it a significant contributor to food security in aquatic-dependent communities. Since it directly affects ecological and commercial worth of this species, it is imperative to comprehend the reasons causing protein degradation. This investigation evaluates that how protein content of *O. mossambicus* is affected by biological toxins from four aquatic pathogenic insects: water scorpions (*Nepidae*), diving beetles (*Dytiscidae*), backswimmers (*Notonectidae*), and gigantic water bugs (*Belostomatidae*). Additionally, the chemical toxin mercury chloride ($HgCl_2$) was studied for comparison.
Godavari River at Nanded, Maharashtra, was selected as sampling site for collection of the fish samples and obtained *O. mossambicus* fishes are divided into three groups: a healthy control group, a group exposed to aquatic insect toxins, and a group exposed to sub-lethal concentrations (1.25 ppm) of $HgCl_2$. The Folin-Lowry method is reliable to measure the amount of protein hence it is used to measure the protein content in the gill, liver and muscle tissues during a 15-day exposure period. The results revealed that, in comparison to the control group, fish exposed to both biological and chemical toxins had a much lower protein content. The toxins from gigantic water bugs, or *Belostomatidae*, were the biological stresses that most severely degraded proteins. Even at low concentrations, mercury chloride ($HgCl_2$) showed notable toxicity on protein content of the fish tissues. Additionally, fish exposed to chemical and biological toxins at the same time experienced heightened effects, demonstrating a synergistic effect on tissue protein degradation. This study emphasizes how critical it is to keep an eye out for chemical pollutants and pathogenic insect infestations in aquatic environments to protect fish health as well as biodiversity and its components. These negative consequences might be lessened by putting tactics like habitat management to control insect populations and tougher regulations for industries to restrict mercury as well as heavy metal pollution into practice. The nutritional value, assurance of no toxicity and ecological balance of *Mozambique tilapia* (*O. mossambicus*) depend on such measures.

Keywords: *Oreochromis mossambicus*, protein degradation, chemical toxicity ($HgCl_2$), biological toxins, aquatic insects, environmental management

Introduction

Proteins are essential macromolecules that perform crucial tasks in cells, such as offering structural support, enabling enzymatic reactions, and controlling metabolism (Lehninger, 1984) [9]. Because of their exceptional nutritional qualities and good protein quality, freshwater fish—like *O. mossambicus*, formerly known as *Mozambique tilapia*—are a significant source of dietary protein for humans (NRC, 1993; Lovell, 1989). *O. mossambicus* is regarded as a crucial species in aquaculture systems around the world because of its ability to grow fluently in a variety of habitats (Mukhtar, 2023) [11]. This species is particularly susceptible to environmental stresses *viz*. biological toxins sourced from aquatic insects in the form of lesions or diseases and chemical pollutants such as heavy metals sourced from different industries, which can adversely impact protein metabolism and overall health (Kumar *et al*., 2017).

According to Abowei and Ukoroije (2012) [1], aquatic insects, such as giant water bugs, backswimmers, diving beetles, and water scorpions, are also an important component of freshwater ecosystems; also involved in food web that support ecological balance. However, some species pose as dangerous and pathogenic to Pisces, causing harm by envenomation, parasitism, or sometime even predation that has an immediate negative impact on the health of the fish and fish life. Such interactions may elicit stress responses in fish, frequently leading to protein breakdown (Banaee, 2013) [4]. Mercury chloride ($HgCl_2$), a prevalent industrial contaminant, presents a considerable danger to aquatic organisms. $HgCl_2$, even at sub-lethal concentrations, impairs protein synthesis and hastens protein degradation in fish tissues, resulting in metabolic abnormalities and inhibited growth (Fathi *et al*., 2018; Ahmad *et al*., 2022) [2, 7]. In this research investigation, attempts were made to comparative evaluation of biological toxins from particular aquatic insects and Mercury Chloride ($HgCl_2$) impacts on the tissue protein breakdown in *O. mossambicus*. The research seeks to elucidate the physiological effects of tissue-specific protein synthesis and protein degradation due to stresses, offering critical insights for environmental monitoring and conservation efforts.

Materials and Methods

Oreochromis mossambicus fish samples were obtained from the Godavari River in Nanded, Maharashtra, with the aid of local fisherman. The samples were segregated into three groups: Group A as control, Group B (fish subjected to aquatic insect toxins), and Group C (fish exposed to 1.25 ppm mercury chloride). Before initiating the experimentation, the fishes were acclimatized to laboratory conditions for 15 days and were provided with Tubifex slices over this duration. Protein concentrations in the liver, muscle, and gill tissues were quantified utilizing the Folin-Lowry technique as denoted by Lowry *et al*., (1951) [10]. The experimental data were analysed using biostatistical methods, including the calculations of mean and standard deviation, to guarantee accurate and dependable results.

Results and Discussion

The findings indicated substantial protein depletion in all organs (tissues) of fish subjected to both biological and chemical toxins (Table 1). The protein level in the liver tissues of the control (group A) was 15.36 ± 0.21 mg/gm, which decreased to 13.23 ± 0.15 mg/gm in fish subjected to biological toxins and 12.43 ± 0.45 mg/gm under mercury chloride ($HgCl_2$) exposure. These observations highlight the susceptibility of live tissues to oxidative stress and metabolic disruptions. Exposure to $HgCl_2$ led to a 19.1% decrease in protein content of liver tissues, aligning with its function in producing reactive oxygen species (ROS). Biological toxins, especially from *Belostomatidae*, disturbed metabolic pathways, resulting in impacted protein synthesis and degradation of protein.

Table 1: Comparative analysis of toxins on the protein content of different tissues of *Oreochromis mossambicus*

Sr. No.	Fish Tissue	Protein Content (mg/gm) wet weight of Tissue		
		Control	Biological Toxin	Chemical Toxin
1	Liver	15.36 ± 0.21	13.23 ± 0.15	12.43 ± 0.45
2	Muscle	13.44 ± 0.35	12.47 ± 0.21	11.66 ± 0.4
3	Gill	12.1 ± 0.7	08.67 ± 0.25	09.46 ± 0.21

(Each value is mean of six observations ± SD)

In muscle tissue, protein content decreased by 7.2% due to biological toxins and by 13.2% due to chemical toxins, indicating the utilization of muscle proteins as an energy source during stress. The findings correspond with the research conducted by Dasuri *et al*. (2013) [6] and Shahjahan *et al*. (2022) [15], both of which indicated substantial muscle protein breakdown attributable to heavy metals. Gill tissues exhibited the most significant protein depletion, with decreases of 28.3% due to biological toxins and 21.8% due to $HgCl_2$. Due of their direct exposure to the environment, gills are especially vulnerable to oxidative damage from harmful substances. Biological toxins from aquatic insects namely *Dytiscidae* and *Nepidae were* recognized to degrade gill proteins, compromising essential respiratory and osmoregulatory activities (Moore *et al*., 2018). The aquatic insects of present investigation are shown in the Figure 1.

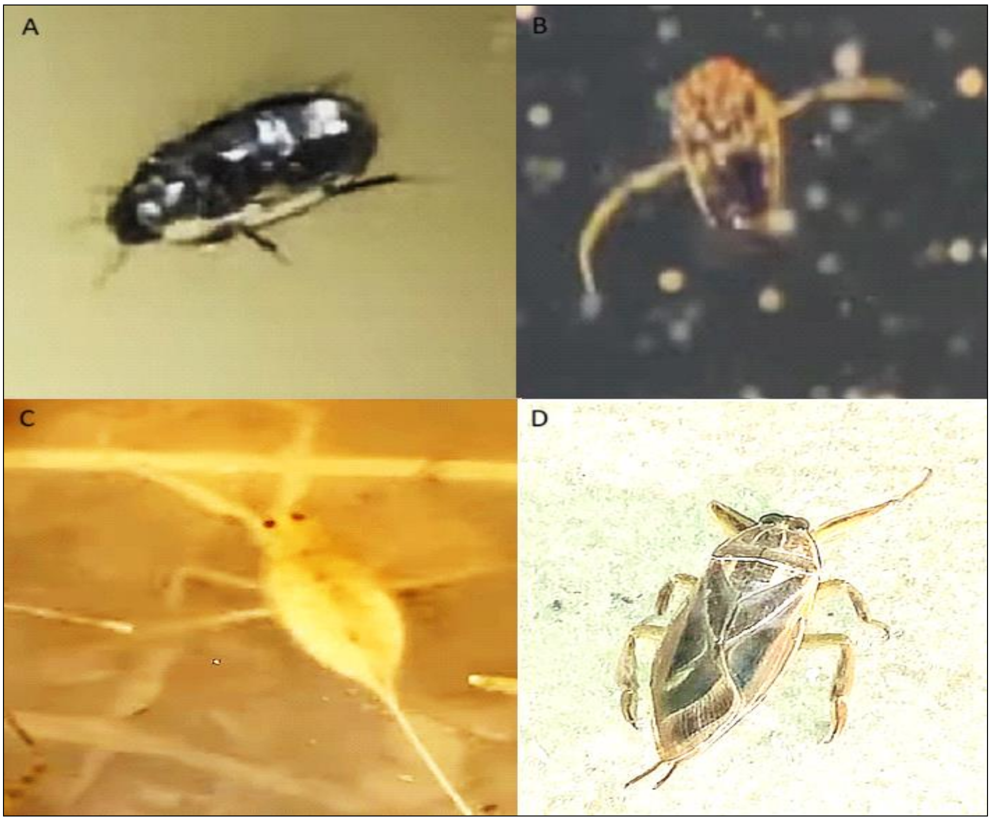

Fig 1: Aquatic Insects

A. Diving Beetle, B. Back Swimmer, C. Water Scorpion, D. Giant Water Bug)

These findings highlight tissue-specific susceptibilities to toxins, with $HgCl_2$ provoking systemic oxidative stress and biological poisons inflicting localized harm. The results demonstrate the cumulative effects of different stresses, as depicted in Figure 2.

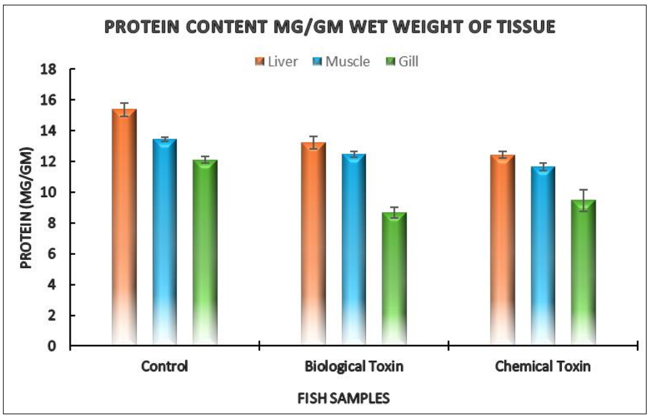

Fig 1: Comparative analysis of impact of control, aquatic insect-oriented toxins and $HgCl_2$ on protein content of freshwater fish *Oreochromis mossambicus*

Conclusion

This experiment shows that exposure to $HgCl_2$ and biological toxins from aquatic insects produce severe physiological stress and protein degradation in *O. mossambicus*. The study found that the gills, liver, and muscle all have tissue-specific vulnerabilities, with the gills suffering from the most severe protein depletion. These findings highlight the critical need for effective monitoring of the environment and mitigation strategies to reduce mercury exposure and manage harmful insect infestations. Future research should focus on bioremediation techniques and the molecular mechanisms underlying toxin-induced protein degradation in order to preserve aquatic ecosystems.

References

1. Abowei JFN, Ukoroije BR. The identification, types, taxonomic orders, biodiversity and importance of aquatic insects. British Journal of Pharmacology and Toxicology,2012:3(5):218-229.
2. Ahmad J, Ali AA, Iqbal M, Ahmad A, Qureshi MI. Proteomics of mercury-induced responses and resilience in plants: A review. Environmental Chemistry Letters,2022:20(5):3335-3355.
3. Ai Q, Mai K, Li H, Zhang C, Zhang L, Duan Q, *et al*. Effect of dietary protein to energy ratios on growth and body composition of juvenile Japanese seabass (*Lateolabrax japonicus*). Aquaculture,2004:230:507-516.
4. Banaee M. Physiological dysfunction in fish after insecticides exposure. Insecticides–Development of Safer and More Effective Technologies,2013:30:103-43.
5. Bickler PE. Amplification of snake venom toxicity by endogenous signaling pathways. Toxins,2020:12(2):68. https://doi.org/10.3390/toxins12020068
6. Dasuri K, Zhang L, Keller JN. Oxidative stress, neurodegeneration, and the balance of protein degradation and protein synthesis. Free Radical Biology and Medicine,2013:62:170-185. https://doi.org/10.1016/j.freeradbiomed.2012.09.025
7. Fathi M, Binkowski LJ, Azadi NA, Hamesadeghi U, Mansouri B. Co-exposure effects of mercury chloride (HgCl2) and silver nanoparticles (Ag-NPs) on goldfish (Carassius auratus): Histopathological changes, oxidative stress response, and bioaccumulation. Desalination and Water Treatment,2018:105:264-272.
8. Habib SA, Samah AAS. Effect of heavy metals pollution on protein biosynthesis in catfish. [Details unavailable for complete citation], 2013.
9. Lehninger AL. *Biochemistry* (3rd ed.). Kalyani Publishers, 1984.
10. Lowry OH, Rosen BJ, Farr AL, Randall RJ. Protein measurement with the folin-phenol reagents. Journal of Biological Chemistry,1951:193:265-275. https://doi.org/10.1016/S0021-9258(19)52451-6
11. Mukhtar F. Characterization of wnt1 for genetic biocontrol in *Mozambique tilapia*, *Oreochromis mossambicus* (Doctoral dissertation, Deakin University), 2023.
12. Pathak P, Kumar R. Toxicity of mercury chloride ($HgCl_2$) on total protein of liver, kidney, and gonads of fish *Heteropneustes fossilis* (Bloch). Journal of Emerging Technologies and Innovative Research,2020:7(11):900-905.
13. Ramakrishnan A. Quantitative Variation of Protein in the Tissues of a Fresh Water Fish Clarias batrachus Exposed to Mercury and Chromium, 2011.
14. Ramlingam K, Ramlingam K. Effect of sub-lethal levels of DDT, malathion, and mercury on tissue proteins of *Sarotherodon mossambicus* (Peters). Proceedings of the Indian Academy of Sciences (Animal Sciences),1982:91(6):501-505. https://doi.org/10.1007/BF03186426
15. Shahjahan M, Taslima K, Rahman MS, Al-Emran M, Alam SI, Faggio C. Effects of heavy metals on fish physiology: A review. Chemosphere,2022:300:134519. https://doi.org/10.1016/j.chemosphere.2022.134519
16. Vutukuru SS, Basani K. Acute effects of mercuric chloride on glycogen and protein content of zebrafish (*Danio rerio*). Journal of Environmental Biology,2013:34:277-281.
17. Walker AA, Weirauch C, Fry BG, King GF. Venoms of heteropteran insects: A treasure trove of diverse pharmacological toolkits. Toxins,2016:8(2):43. https://doi.org/10.3390/toxins8020043
18. Ynalvez RA, Gutierrez J, Gonzalez-Cantu H. Mini-review: Toxicity of mercury as a consequence of enzyme alteration. Biometals,2016:29:781-788. https://doi.org/10.1007/s10534-016-9963-z