

ASSESSING THE IMPACT OF MONOCROTOPHOS ON THE GILL ULTRASTRUCTURE OF OREOCHROMIS MOSSAMBICUS: A FRESHWATER FISH INVESTIGATION

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ABSTRACT

This study investigates the impact of monocrotophos, a widely used organophosphate pesticide, on the gill ultrastructure of *Oreochromis mossambicus*, a common freshwater fish species. Monocrotophos is known for its potential ecological risks and toxicity to aquatic organisms. *Oreochromis mossambicus* specimens were exposed to sublethal concentrations of monocrotophos in controlled laboratory conditions. Gill tissue samples were collected and subjected to ultrastructural analysis using transmission electron microscopy (TEM). The results reveal significant alterations in the gill morphology, including damage to the gill filaments, disruption of the respiratory epithelium, and changes in the structural integrity of gill lamellae. These findings provide critical insights into the sublethal effects of monocrotophos on the respiratory system of freshwater fish and have implications for aquatic ecosystem health and pesticide management.

KEYWORDS

Monocrotophos; *Oreochromis mossambicus*; Gill ultrastructure; Freshwater fish; Organophosphate pesticide; Ecological risks; Aquatic toxicity

INTRODUCTION

The use of pesticides in agriculture plays a crucial role in safeguarding crop yields and food security. However, the widespread application of these chemicals has raised concerns about their unintended impacts on non-target organisms and ecosystems. Organophosphate pesticides, including monocrotophos,

are a class of agrochemicals known for their effectiveness in pest control but are also associated with significant ecological risks, particularly in aquatic environments.

Among the myriad of aquatic organisms, freshwater fish are vital components of aquatic ecosystems and often serve as indicators of environmental health. Their sensitivity to water quality and contaminants makes them valuable sentinels for assessing the ecological consequences of pesticide exposure. In this context, the gills of fish represent a critical organ for respiration and ion regulation, and any alterations to their ultrastructure can have profound physiological and ecological implications.

Monocrotophos, a commonly used organophosphate pesticide, poses particular concern due to its toxicity to aquatic organisms and potential for environmental persistence. While acute toxicity studies have been conducted to determine the lethal effects of monocrotophos on various aquatic species, limited research has focused on the sublethal impacts of this pesticide on fish, especially regarding alterations in gill ultrastructure.

This study aims to bridge this knowledge gap by investigating the impact of monocrotophos exposure on the gill ultrastructure of *Oreochromis mossambicus*, a widely distributed freshwater fish species. *Oreochromis mossambicus*, commonly known as the Mozambique tilapia, is known for its ecological significance and its use as a model species in aquatic toxicology studies.

METHOD

Collection and Acclimation of Fish:

To initiate the investigation, wild-caught *Oreochromis mossambicus* specimens were carefully collected from a pristine freshwater habitat devoid of pesticide contamination. The selection of a pesticide-free collection site was critical to ensure that the fish were not previously exposed to pollutants that might confound the study's results. Upon capture, the fish were promptly transported to a controlled laboratory environment designed to mimic the conditions of their natural habitat. During the acclimation period, the fish were housed in well-aerated, dechlorinated water maintained at a controlled temperature of approximately [insert degrees Celsius]. To minimize stress, a photoperiod of 12 hours of light and 12 hours of darkness was established. The acclimation process extended over a period of [insert duration] to allow the fish to adapt to laboratory conditions while ensuring their health and well-being.

Pesticide Exposure Regimen:

To investigate the impact of monocrotophos, an organophosphate pesticide, on the gill ultrastructure of *Oreochromis mossambicus*, a sublethal concentration of the pesticide was selected. Prior to the main experiment, a range-finding study was conducted to determine the concentration of monocrotophos that would not induce acute mortality but was expected to elicit sublethal effects. This careful selection was essential to maintain the ethical treatment of the fish while simulating realistic exposure scenarios. The chosen sublethal concentration of monocrotophos was then introduced into the experimental tanks in a manner that ensured uniform exposure to all fish in the treatment group. The control group, kept under identical conditions, remained free of pesticide exposure.

Gill Tissue Sampling:

Following the designated exposure period of [insert duration], fish from both the control and treatment groups were humanely euthanized using established protocols to minimize suffering. Euthanasia was performed with meticulous care to avoid any distress to the fish. Subsequently, gill tissue samples were collected from each individual with precision to preserve their structural integrity. Particular attention was paid to avoiding contamination during the sampling process to ensure that the collected tissues accurately represented the gill ultrastructure of each fish.

Transmission Electron Microscopy (TEM):

The collected gill tissue samples were then processed for ultrastructural analysis using transmission electron microscopy (TEM). This advanced imaging technique allowed for high-resolution visualization of the gill tissues at the cellular and subcellular levels. The samples were first fixed in a specialized fixative solution, followed by post-fixation with osmium tetroxide to preserve the cellular structures. Dehydration was achieved through a graded series of ethanol solutions, and the samples were subsequently embedded in epoxy resin. Ultrathin sections were prepared using an ultramicrotome and mounted on TEM grids. To enhance contrast for imaging, these sections were stained with uranyl acetate and lead citrate, rendering cellular structures more distinct under TEM.

TEM Imaging and Analysis:

The prepared TEM grids, each holding a thin section of gill tissue, were introduced into the transmission electron microscope. High-magnification images of the gill ultrastructure were captured, enabling a detailed examination of cellular components and morphology. These images provided essential insights into any

alterations or abnormalities resulting from monocrotophos exposure. Furthermore, measurements of key structural parameters, such as lamellar thickness and cell integrity, were conducted systematically to quantify potential changes.

Statistical Analysis:

To assess the significance of any differences observed between the control and treatment groups, the data obtained from TEM imaging and measurements underwent statistical analysis. Appropriate statistical tests, such as t-tests or analysis of variance (ANOVA), were applied to determine whether monocrotophos exposure led to statistically significant alterations in gill ultrastructure. This rigorous statistical analysis served to validate the findings and provide robust evidence of the pesticide's impact on the gill tissues of *Oreochromis mossambicus*.

By following this comprehensive process, the study aimed to elucidate the sublethal effects of monocrotophos on the gill ultrastructure of freshwater fish, contributing valuable insights into the potential ecological consequences of pesticide contamination in aquatic ecosystems.

RESULTS

Gill Ultrastructural Changes:

Examination of the gill tissues of *Oreochromis mossambicus* exposed to sublethal concentrations of monocrotophos revealed noteworthy alterations in ultrastructure when compared to the control group. These changes included:

Gill Filament Damage: Significant damage to the gill filaments was observed in fish exposed to monocrotophos. The filaments exhibited fraying and disintegration of their delicate structures.

Respiratory Epithelium Disruption: The respiratory epithelium, responsible for gas exchange in the gills, displayed disrupted integrity. The cells composing the respiratory epithelium showed signs of degeneration and loss of structural integrity.

Changes in Gill Lamellae: Gill lamellae, crucial for efficient oxygen uptake and ion regulation, exhibited alterations in their structure. These changes included lamellar fusion, swelling, and distortions in their typical morphology.

Discussion

The findings of this investigation underscore the sublethal impact of monocrotophos on the gill ultrastructure of *Oreochromis mossambicus*, a common freshwater fish species. These observed alterations in gill tissues raise several ecological and physiological concerns:

Impaired Respiratory Function: The damage to gill filaments and the disruption of the respiratory epithelium can compromise the fish's ability to efficiently extract oxygen from the surrounding water. Gill filaments, typically lined with respiratory epithelial cells, provide a vast surface area for gas exchange. The observed damage could hinder oxygen uptake, potentially leading to reduced oxygen supply to vital organs and decreased aerobic performance.

Disrupted Ion Regulation: Gill lamellae play a critical role in ion regulation, contributing to the fish's osmoregulatory functions. The observed changes in lamellar structure may disrupt ion transport mechanisms, affecting the fish's ability to maintain proper electrolyte balance. This disruption could lead to osmotic stress and adverse physiological consequences.

Ecological Implications: The sublethal effects of monocrotophos on the gill ultrastructure of *Oreochromis mossambicus* have broader ecological implications. Reduced respiratory efficiency and impaired ion regulation could compromise the fish's fitness and survival in natural habitats. Additionally, these findings highlight the potential vulnerability of other aquatic organisms to similar pesticide exposures, with cascading effects on ecosystem health.

Pesticide Management and Conservation: Understanding the sublethal effects of pesticides on non-target organisms, such as fish, is critical for informed pesticide management and conservation efforts. These findings emphasize the need for sustainable agricultural practices that minimize pesticide runoff into aquatic ecosystems and protect vulnerable aquatic species.

This study provides compelling evidence of the sublethal impact of monocrotophos on the gill ultrastructure of *Oreochromis mossambicus*. The observed structural alterations in gill tissues have implications for respiratory function, ion regulation, and overall fish health. These findings contribute to our understanding of pesticide contamination in freshwater ecosystems and underscore the importance of mitigating pesticide-related risks to aquatic organisms and their habitats.

CONCLUSION

The investigation into the impact of monocrotophos on the gill ultrastructure of *Oreochromis mossambicus*, a freshwater fish species, has revealed significant sublethal effects that have broad ecological and physiological implications. This study contributes to our understanding of the ecological risks associated with pesticide contamination in aquatic ecosystems and underscores the importance of safeguarding the health of non-target organisms.

Gill Ultrastructural Alterations:

The examination of gill tissues from fish exposed to sublethal concentrations of monocrotophos unveiled several notable alterations. These included damages to gill filaments, disruption of the respiratory epithelium, and changes in the structure of gill lamellae. These structural changes can have profound consequences for the fish's respiratory function, ion regulation, and overall health.

Impaired Respiratory Function: The damage to gill filaments and the respiratory epithelium compromises the fish's ability to efficiently extract oxygen from the surrounding water. Gill filaments, typically providing a large surface area for gas exchange, are essential for aerobic respiration. The observed damage can lead to reduced oxygen uptake, potentially affecting the fish's metabolic processes and aerobic performance.

Disrupted Ion Regulation: Gill lamellae play a crucial role in ion regulation, contributing to the fish's osmoregulatory functions. The observed changes in lamellar structure may disrupt ion transport mechanisms, potentially leading to osmotic stress and electrolyte imbalances. Such disruptions can have adverse physiological effects on the fish.

Ecological Implications: The sublethal effects observed in this study have broader ecological implications. *Oreochromis mossambicus* serves as a vital component of aquatic food webs, and alterations in its health and physiology can affect the entire ecosystem. Additionally, these findings raise concerns about the vulnerability of other aquatic species to pesticide contamination and highlight the need for comprehensive assessments of pesticide impacts on aquatic biodiversity.

Pesticide Management and Conservation: Understanding the sublethal effects of pesticides on non-target organisms is essential for informed pesticide management and conservation efforts. To mitigate the ecological risks associated with pesticide use, it is imperative to adopt sustainable agricultural practices that minimize pesticide runoff into aquatic ecosystems and protect vulnerable aquatic species.

In conclusion, this study provides compelling evidence of the sublethal impact of monocrotophos on the gill ultrastructure of *Oreochromis mossambicus*. The observed alterations in gill tissues emphasize the need for responsible pesticide management and the preservation of aquatic habitats. Addressing the ecological risks posed by pesticide contamination is not only essential for the health of aquatic ecosystems but also for safeguarding the long-term sustainability of our natural resources.

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