



Histopathological Assessment Of *Mystus Gulio* In Relation To Environmental Stress In Veli Lake, Thiruvananthapuram, Kerala

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Abstract:

Histopathology is a sensitive biomonitoring approach because tissue-level lesions can integrate exposure to complex mixtures of environmental stressors. This study assessed environmental stress in Veli Lake, Thiruvananthapuram, using *Mystusgulio* as a sentinel fish species. Two hundred fish were examined over ten months, alongside monthly measurements of water temperature, pH, salinity, dissolved oxygen, and hardness. Histological analysis of gill and liver tissues revealed substantial pathological changes, including lamellar shortening and fusion, epithelial lifting, tissue degeneration, hepatocellular disorganization, pyknosis, pigment deposition, vascular enlargement, and necrosis. Gill cyst-like lesions and monogenean attachment were also observed.

The findings indicate that fluctuations in pH, salinity, hardness, and dissolved oxygen were associated with significant tissue injury, demonstrating the potential of *M. gulio* histopathology as a biomonitoring tool for environmental stress in Veli Lake.

Key words: *Mystusgulio*; fish histopathology; gill; liver; Veli Lake; environmental stress; water quality; biomonitoring.

Introduction

Coastal and estuarine fishes are exposed simultaneously to natural variation in temperature, salinity and oxygen availability and to anthropogenic stressors such as sewage, industrial effluents, hydrocarbons and trace metals. Chemical measurements describe the presence of stressors, but they do not by themselves establish biological effect. Contemporary ecotoxicological frameworks therefore increasingly combine physicochemical measurements with organism-level biomarkers, including histological endpoints, to improve environmental diagnosis [1,2].

Fish gills are particularly informative because they maintain continuous contact with the surrounding water and participate in respiration, ion regulation and acid-base balance. Hepatic tissue provides a complementary endpoint because the liver receives contaminants and their metabolites through the circulation and is central to detoxification, energy storage and intermediary metabolism. Lesions such as epithelial lifting, lamellar fusion, necrosis, vacuolation, nuclear condensation and pigment accumulation have consequently been used as indicators of environmental disturbance in fishes [3–6].

Veli Lake, in the Thiruvananthapuram coastal region of Kerala, is a shallow estuarine/backwater system subject to urban, industrial and recreational pressures. Earlier environmental descriptions have identified sewage and industrial discharges as important contributors to deterioration of the Veli–Akkulam wetland complex, while more recent work continues to document anthropogenic contamination in the wider system [7]. The study records describe potential inputs associated with Travancore Titanium Products, English Indian Clay, sewage-bearing canals, recreational boating and coir-related organic wastes. These sources are treated here as reported exposure contexts rather than as individually demonstrated causes of the lesions.

The objective of the present manuscript is to synthesize the supplied experimental observations into a concise, publication-style assessment of environmental stress in Veli Lake using *M. gulio* as a sentinel fish, with emphasis on physicochemical variation and gill and liver histopathology.

Materials And Methods

Study design and specimen collection

A total of 200 specimens of *Mystus gulio* were examined during monthly sampling over ten consecutive months. Twenty fish were collected in each month using cast nets in estuarine, tidal-river and lake habitats associated with Veli. Fish with obvious mechanical injuries were discarded at the collection site.

In the laboratory, total length, body mass and sex were recorded. External surfaces were examined using a stereomicroscope for visible disease signs, cysts and other lesions. Internal organs, including gills and liver were removed for histological processing.

Histological processing

Representative organ tissues were preserved in 10% neutral buffered formalin. Following routine tissue processing and paraffin embedding, sections approximately 5 µm thick were prepared and stained with Harris haematoxylin and eosin (H&E). The sections were examined by light microscopy for changes in tissue architecture, cellular organization and nuclear morphology. The present synthesis concentrates on gill and liver findings because these are the organs for which descriptive histopathological observations and photographic records were supplied.

Water-quality measurements

Water samples were collected monthly at the time of fish sampling. Surface-water temperature was recorded at the collection site using a mercury thermometer. Dissolved oxygen was determined from samples collected in BOD bottles, fixed on site and analyzed by a modified Winkler titrimetric procedure. Total hardness was determined by EDTA titration using 0.01 M EDTA, ammonia buffer and Eriochrome Black T. Salinity was determined by silver-nitrate titration using potassium chromate as indicator.

Environmental exposure context

The source records identify several potential pollution pathways around Veli Lake: industrial effluent associated with Travancore Titanium Products and English Indian Clay, sewage conveyed through urban drainage/canal systems, hydrocarbon inputs associated with recreational boating, and organic wastes associated with coir retting activities. Independent environmental literature also reports industrial and sewage-related pressures in the Veli–Akkulam system [7,8]. The present study therefore interprets the histological findings as responses occurring under a mixed environmental exposure regime rather than assigning lesions to a single chemical.

Data treatment

Because the supplied material provides ranges and graphical monthly trends rather than a complete raw-data matrix, descriptive statistics are reported as observed ranges. No new inferential tests, effect sizes or contaminant-specific dose–response relationships were generated from the photographs. Histological interpretations were based on the supplied descriptions and photomicrographs.

Table 1. Summary of physicochemical observations in Veli Lake

Parameter	Observed range	Interpretive feature in supplied record
Water temperature (°C)	24–30	Minimum in February; maximum in April
Air temperature (°C)	27–32	Minimum in February; maximum in April
pH	5.5–7.6	Near-neutral in Aug–Oct; acidic during later months
Salinity (ppt)	8.2–12.3	Maximum in March
Dissolved oxygen (ml L ⁻¹)	3.3–7.3	Peak in October; low values in April
Hardness (mg CaCO ₃ L ⁻¹)	42–182	Highest in September; minimum in December

Results

Physicochemical characteristics

The monthly record showed pronounced temporal variation in the Veli Lake water regime. Water temperature varied between 24 °C in February 2021 and 30 °C in April 2021, while atmospheric temperature ranged from 27 °C to 32 °C over the same period. Surface-water pH was 7.6 during August–October but subsequently shifted toward acidic conditions; the lowest reported value was 5.5 in May 2021. Such a shift represents a substantial change in hydrogen-ion activity relative to the near-neutral early-season observations.

Salinity remained within a brackish range and fluctuated from 8.2 to 12.3 ppt, with the maximum reported in March. Dissolved oxygen varied widely, from 3.3 to 7.3 ml L⁻¹, with the highest concentration in October and a pronounced low in April. Total hardness ranged from 42 to 182 mg CaCO₃ L⁻¹. The highest hardness was recorded early in the sampling sequence, followed by a sharp decrease to the minimum in December and subsequent recovery. Together, these

measurements indicate a dynamically changing aquatic environment rather than a constant exposure condition.

Gill pathology

The gills of affected *M. gulio* were described as flaccid and apparently shortened. Small cyst-like structures were observed on the gills of many examined fish, and monogenean individuals identified in the source record as *Centrocestes formosanus* were attached to adjacent gill filaments. Normal branchial architecture consists of primary filaments bearing serially arranged secondary lamellae, with a thin epithelial barrier over the capillary-rich respiratory surface.

In affected fish, the secondary lamellae showed extensive structural disruption. In some regions, lamellae were completely damaged, with loss of tissue continuity. The epithelial and pillar-cell components and associated connective tissue displayed varying degrees of injury. Epithelial lifting and detachment from the underlying tissue were prominent in several regions, with adjacent epithelial surfaces becoming closely apposed toward the base of the filament. Nuclear scattering within the gill arch was also noted.

The dominant morphological abnormalities were shortening of secondary lamellae and fusion of gill tissues, accompanied by thickening and damage of the central rachis in several filaments. These lesions are consistent with reduced effective respiratory surface and impaired branchial function. Contemporary fish-pollution studies similarly identify epithelial lifting, lamellar fusion, hyperplasia and necrotic damage as common histological responses to aquatic contamination and chemical stress [4–6].

Liver pathology

The liver showed conspicuous cellular and architectural alterations. Hepatocytes had lost their regular shape and spatial arrangement, and pyknotic nuclei were frequently observed. Small white spot-like areas were reported in 10 of the 200 examined fish. In some regions, hepatocytes remained relatively intact and occurred in recognizable groups, whereas other areas showed marked structural disorganization.

Brownish pigment deposits were scattered through the hepatic tissue. Enlargement of nuclei and condensation of nuclear material were evident, together with necrotic degeneration of hepatocytes and enlargement of blood vessels. The peripheral glandular cells were described as pale staining, while nuclear membranes appeared thickened and nucleoli were prominent. Overall, the hepatic architecture was described as altered and undergoing progressive damage.

The observed combination of pyknosis, necrosis, nuclear condensation, pigment accumulation and loss of normal hepatocellular organization is compatible with chronic cellular stress. Similar hepatic responses, including vacuolation, necrosis, nuclear abnormalities and vascular alterations, have been documented in fishes exposed to contaminated aquatic environments [4,6].

Discussion

The environmental record and tissue observations together indicate that *M. gulio* in Veli Lake experienced substantial physiological stress during the study period. The most notable physicochemical features were episodic acidity, variable salinity and hardness, and a broad dissolved-oxygen range. Histological biomarkers are particularly valuable under such mixed-exposure conditions because they integrate biological effects over time and can reveal injury that cannot be inferred from a single water-quality measurement [1,2].

Gill lesions are mechanistically plausible under fluctuating water chemistry because the gill is the primary interface between the fish and its surrounding medium. Epithelial lifting, lamellar fusion, epithelial thickening and tissue destruction can increase the diffusion distance for gases and ions and reduce the functional respiratory surface. Experimental and field studies of polluted fishes have repeatedly reported comparable branchial responses, including lamellar fusion, epithelial disruption and necrotic changes [4,5,9]. The concurrent observation of small cyst-like lesions and monogenean attachment is important because parasites themselves can produce focal branchial injury; therefore, not every lesion should automatically be attributed to chemical pollution.

The liver findings provide evidence of a systemic component of stress. Pyknosis and condensation of nuclear material are morphological signs of severe cellular injury, while necrosis indicates loss of hepatocellular integrity. Pigment accumulation may reflect increased phagocytic activity and the handling of cellular breakdown products. Comparable liver responses have been documented in fish inhabiting pesticide- and metal-impacted waters, where histological alterations were associated with broader biochemical evidence of physiological disturbance [3,4,6].

The environmental context is consistent with a mixed-source exposure scenario. Historical descriptions of the Veli–Akkulam system identify industrial effluents and sewage as important pressures, and heavy-metal contamination has also been documented in sediments of the coastal wetland complex [7,8]. Recent evidence from other polluted aquatic systems demonstrates that integrating tissue pathology with chemical measurements provides a stronger basis for environmental assessment than either line of evidence alone [1,2,5].

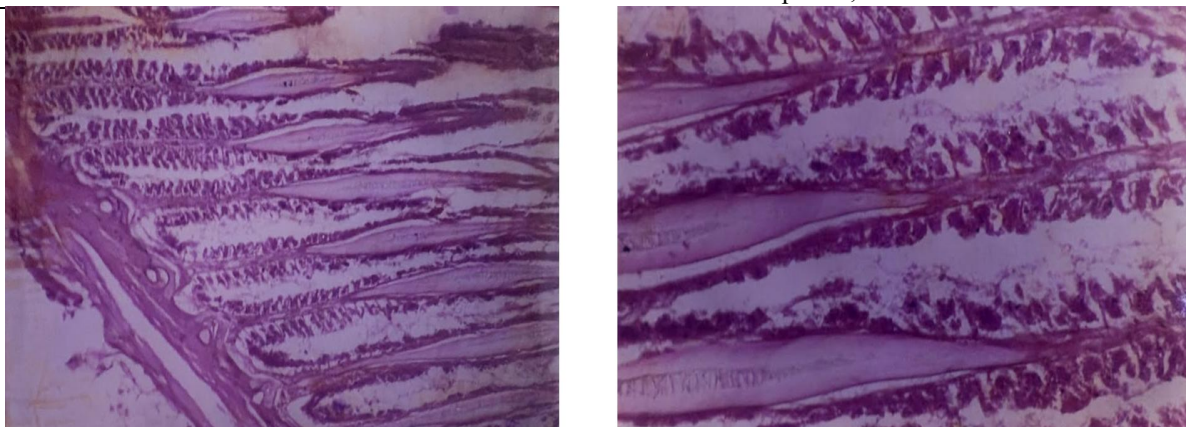


Fig1: Section of the gill of *Mystusgulio* with pollution induced changes

Integrated interpretation

The concurrence of water-quality fluctuations and multi-organ tissue injury supports the interpretation of *M. gulio* as a useful sentinel organism for Veli Lake. The pattern is not consistent with a single isolated physiological endpoint: branchial injury points to direct environmental interface stress, whereas hepatic degeneration indicates internal metabolic and cellular consequences. Current biomonitoring literature emphasizes that multiple biomarkers are most informative when they are interpreted together and alongside measurements of environmental exposure [1,2].

Reduced dissolved oxygen may have increased physiological burden during the lower-oxygen months, while acidic conditions and changing salinity may have imposed additional osmoregulatory and acid-base challenges. Where contaminants such as metals or hydrocarbons are present, gill and liver tissues can provide complementary evidence of exposure and effect.

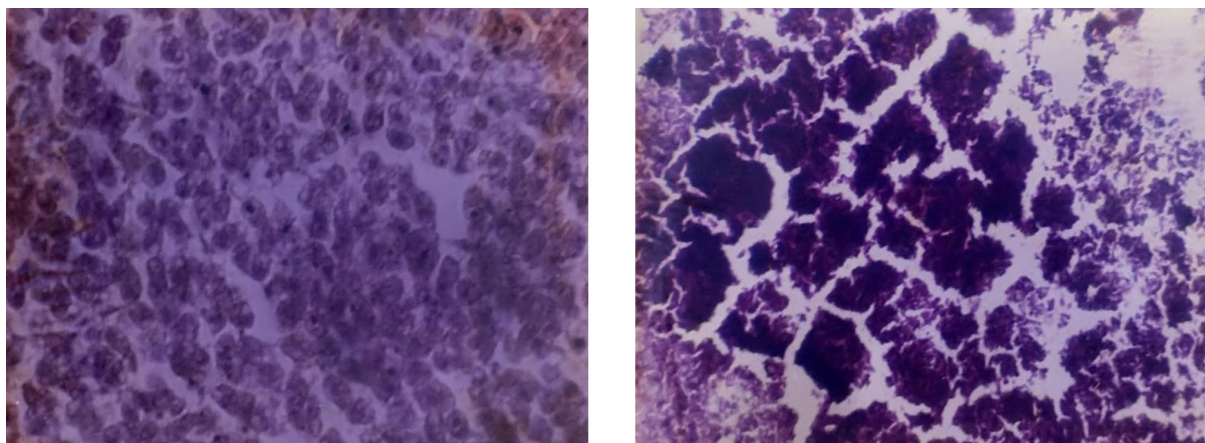


Fig 2: Photomicrograph of *Mystusgulio* liver showing pollution-induced histopathological changes.

Conclusion

The present assessment demonstrates substantial histopathological disturbance in *Mystus gulio* associated with a variable and environmentally stressed Veli Lake system. Water temperature, pH, salinity, dissolved oxygen and hardness showed marked temporal variability, including acidic conditions and low dissolved oxygen during parts of the sampling period. The gills displayed shortening and fusion of secondary lamellae, epithelial lifting and detachment, tissue destruction and rachial thickening, while the liver showed disorganization of hepatocytes, pyknosis, nuclear condensation, pigment deposition, necrosis and vascular changes. These lesions are consistent with sublethal environmental stress and support the use of fish histopathology as an early-warning component of aquatic biomonitoring [1,4,5].

References

1. Arunkumar, K. S., Joseph, S. and Thomas, J. (2010). Heavy metal concentration in the coastal wetlands of Thiruvananthapuram district, southern India. *J. Environ. Sci. Eng.* 52(2), 131–136.
2. Gusso-Choueri, P. K., Choueri, R. B., de Araújo, G. S., Cruz, A. C. F., Stremel, T. R. O., de Campos, S. X., Abessa, D. M. S. and Ribeiro, C. A. O. (2022). Univariate or multivariate approaches for histopathological biomarkers in the context of environmental quality assessments? *Mar. Pollut. Bull.* 181, 113828.
3. Leena Grace, B. (2007). Physico-chemical features of Veli Lake, southwest coast, India. *J. Ind. Pollut. Control.*

- 23(2), 307–312.
4. Lomartire, S., Marques, J. C. and Gonçalves, A. M. M. (2021). Biomarkers based tools to assess environmental and chemical stressors in aquatic systems. *Ecol. Indic.* 122, 107207.
 5. Mahapatra, A., Mistri, A., Gupta, P., Kar, S., Mittal, S. and Singh, R. K. (2022). Toxicopathological impact of sub-lethal concentrations of lead nitrate on the gill of the catfish *Heteropneustes fossilis*. *Acta Histochem.* 124(2), 151848.
 6. Monteiro, D. A., Kalinin, A. L., Rantin, F. T. and McKenzie, D. J. (2021). Use of complex physiological traits as ecotoxicological biomarkers in tropical freshwater fishes. *J. Exp. Zool. A Ecol. Integr. Physiol.* 335(9–10), 745–760.
 7. Moussa, M. A., Mohamed, H. R. H. and Abdel-Khalek, A. A. (2022). The antioxidant defense capacities and histological alterations in the livers and gills of two fish species, *Oreochromis niloticus* and *Clarias gariepinus*, as indicative signs of the Batts drain pollution. *Environ. Sci. Pollut. Res.* 29, 71731–71741.
 8. Oliveira, H. H. Q., Reis-Filho, J. A., Nunes, J. A. C., dos Santos, R. M., Santiago, E. F. E., Aguilar, L., Affonso, P. R. A. M. and da Cruz, A. L. (2022). Gill histopathological biomarkers in fish exposed to trace metals in the Todos os Santos Bay, Brazil. *Biol. Trace Elem. Res.* 200, 3388–3399.
 9. Schuijt, L. M., Peng, F. J., van den Berg, S. J. P., Dingemans, M. M. L. and Van den Brink, P. J. (2021). (Eco)toxicological tests for assessing impacts of chemical stress to aquatic ecosystems: Facts, challenges, and future. *Sci. Total Environ.* 795, 148776.
 10. Shah, Z. U. and Parveen, S. (2022). Oxidative, biochemical and histopathological alterations in fishes from pesticide contaminated river Ganga, India. *Sci. Rep.* 12, 3628.
 11. Swaleh, S. B., Banday, U. Z., Al-Asadi, M. and Usmani, N. (2020). Biochemical profile and gene expression of *Clarias gariepinus* as a signature of heavy metal stress. *Environ. Pollut.* 264, 114693.