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The Invasive Amazon Sailfin Catfish (*Pterygoplichthys* spp.) as a Potential Biomonitor of Polluted River Ecosystems in Malaysia: An Ecotoxicological Reflection

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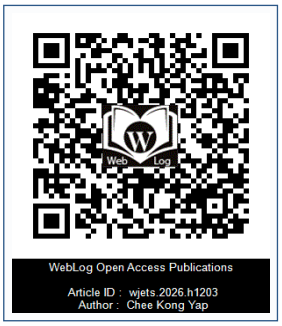

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Abstract

Biomonitoring is a fundamental component of ecotoxicology, providing insights into environmental quality through the responses of living organisms to pollution and habitat degradation. Traditionally, biomonitoring programmes have focused on species that accumulate contaminants or exhibit measurable physiological responses to environmental stress. In Malaysia, the invasive Amazon sailfin catfish (*Pterygoplichthys* spp.), commonly known as ikan bandaraya, has become widespread in urban and disturbed freshwater ecosystems. While the species is generally regarded as an invasive alien fish threatening native biodiversity, its ecological distribution may also provide valuable information regarding environmental quality. This reflection paper proposes a novel ecotoxicological perspective in which *Pterygoplichthys* spp. may function as a biomonitor of degraded river ecosystems. The concept emerged from field observations, student reflections noting that the species appears to thrive in polluted waters, and public statements by Prof. Mohammad Noor Noor Amal indicating that increasing populations of ikan bandaraya may reflect deteriorating river conditions. By integrating invasion ecology, freshwater biomonitoring principles, and published studies from Malaysia, this paper explores the potential use of *Pterygoplichthys* occurrence, abundance, and population dominance as indicators of ecosystem disturbance. The paper argues that while the species remains an invasive organism requiring management attention, its ecological success may simultaneously provide valuable information regarding pollution, habitat modification, and declining ecosystem health. This perspective broadens the traditional scope of ecotoxicological biomonitoring and highlights the potential role of invasive species as indicators of environmental degradation in tropical freshwater ecosystems.

Keywords: Biomonitoring; Ecotoxicology; Invasive Species; *Pterygoplichthys*; Freshwater Pollution; River Ecosystem Health

Introduction

Ecotoxicology has long relied on biological organisms as indicators of environmental quality. The fundamental principle underlying biomonitoring is that living organisms integrate environmental conditions over time and therefore provide information regarding ecosystem health that may not be fully captured through chemical measurements alone [1]. Organisms such as mussels, snails, fish, aquatic plants, and benthic invertebrates have been widely used to assess pollution, habitat degradation, and ecological risk because their occurrence, abundance, physiology, and contaminant burdens reflect environmental conditions [2].

In Malaysia, biomonitoring studies have frequently utilized marine mussels such as *Perna viridis* and blood cockles such as *Tegillarca granosa* to evaluate heavy metal pollution and environmental quality. However, freshwater ecosystems present unique challenges because pollution sources, hydrological dynamics, and ecological disturbances vary substantially across river systems. Consequently, there is increasing interest in identifying additional biological indicators capable of reflecting freshwater ecosystem condition.

One species that has attracted considerable scientific and public attention is the Amazon sailfin catfish (*Pterygoplichthys* spp.), commonly known as ikan bandaraya. Originally introduced through the ornamental fish trade, the species has established self-sustaining populations throughout Malaysian freshwater ecosystems [3, 4]. Numerous studies have documented its occurrence in

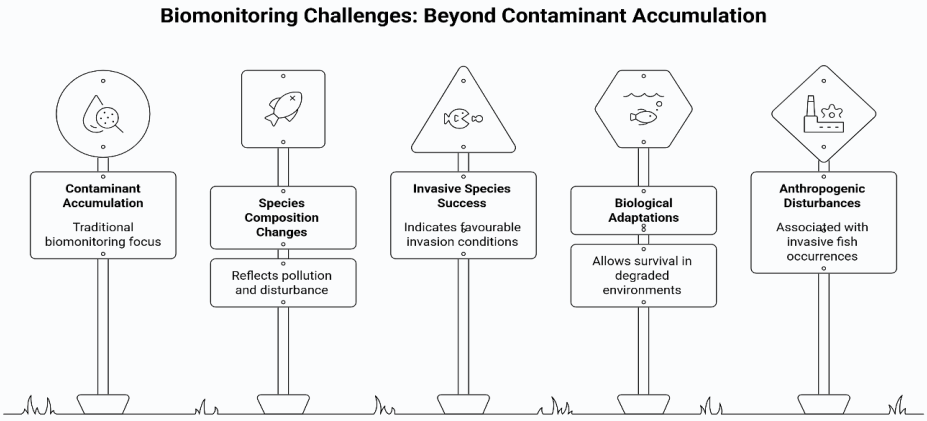

Figure 1: Expanding Biomonitoring Beyond Contaminant Accumulation: Integrating Biological, Ecological, and Anthropogenic Indicators for Comprehensive Ecosystem Health Assessment.

urban rivers, reservoirs, drainage systems, and highly modified aquatic habitats.

Interestingly, observations from both scientific studies and public discourse suggest that *Pterygoplichthys* populations often become particularly abundant in environmentally degraded waterways. During discussions involving river ecology, one student remarked that "they like polluted waters." This simple observation was later reinforced by comments from Prof. Mohammad Noor Noor Amal, who noted that increasing populations of ikan bandaraya may indicate declining river health and deteriorating water quality [5, 6]. These observations raise an intriguing ecotoxicological question: Can invasive sailfin catfish function as biomonitors of degraded freshwater ecosystems?

Biomonitoring Beyond Contaminant Accumulation

Traditionally, biomonitoring focuses on contaminant accumulation. Organisms are sampled, tissues are analysed, and pollutant concentrations are quantified. However, ecological biomonitoring extends beyond contaminant measurements. Species composition, abundance, diversity, and community structure can also serve as indicators of environmental condition.

Figure 1 illustrates the evolution of biomonitoring from its traditional emphasis on contaminant accumulation toward a more comprehensive ecosystem-based framework. While the accumulation of pollutants in sentinel organisms remains a fundamental component of environmental assessment, the figure highlights four additional dimensions that strengthen ecological interpretation, namely species composition changes, invasive species success, biological adaptations, and anthropogenic disturbances. Together, these indicators provide complementary information on habitat quality, ecological resilience, environmental stress, and human induced pressures that may not be detected through chemical measurements alone. By integrating biological responses with ecological processes and anthropogenic influences, this multidimensional approach enhances the ability of biomonitoring programmes to detect early environmental changes, evaluate ecosystem integrity, and support evidence-based conservation and environmental management within the context of ecosystem sustainability and planetary health.

Freshwater ecologists frequently use fish assemblages as indicators of river health. Changes in species richness, abundance, and community composition often reflect pollution, habitat alteration, and ecosystem disturbance. Sensitive species typically decline under environmental stress, while tolerant species become increasingly dominant.

From this perspective, the ecological success of *Pterygoplichthys* may itself constitute a biomonitoring signal. Rather than measuring pollutant concentrations directly, the occurrence and abundance of the species may reflect ecological conditions favourable to invasion but unfavourable to many native fishes.

Why Does *Pterygoplichthys* Thrive in Disturbed Rivers?

Several biological characteristics contribute to the remarkable success of *Pterygoplichthys* in degraded environments. The species possesses facultative air-breathing capabilities that allow survival under low dissolved oxygen concentrations. It can tolerate poor water quality, elevated organic loads, and substantial habitat modification. Its heavily armoured body reduces predation pressure, while parental care behaviour enhances reproductive success [7].

Figure 2 summarizes the principal biological and physiological characteristics that contribute to the remarkable ecological success of invasive *Pterygoplichthys* spp. in degraded freshwater environments. The figure highlights four key adaptations: effective parental care that enhances offspring survival and reproductive success, facultative air breathing that allows persistence in oxygen depleted waters, a heavily armoured body that reduces predation risk, and broad tolerance to poor water quality, including high organic loads and polluted habitats. These complementary traits enable the species to survive where many native fishes experience physiological stress or population decline. Consequently, the increasing abundance and geographical expansion of *Pterygoplichthys* are often associated with anthropogenically disturbed aquatic ecosystems, making the species a valuable biological indicator of environmental degradation while simultaneously posing ecological challenges through competition with native fauna and alteration of ecosystem structure and function.

These adaptations provide significant ecological advantages within polluted and disturbed river systems. While sensitive native fishes may decline due to environmental stress, *Pterygoplichthys* populations often persist and expand. Consequently, their increasing abundance may indicate a shift in ecological conditions favouring tolerant species over sensitive native taxa.

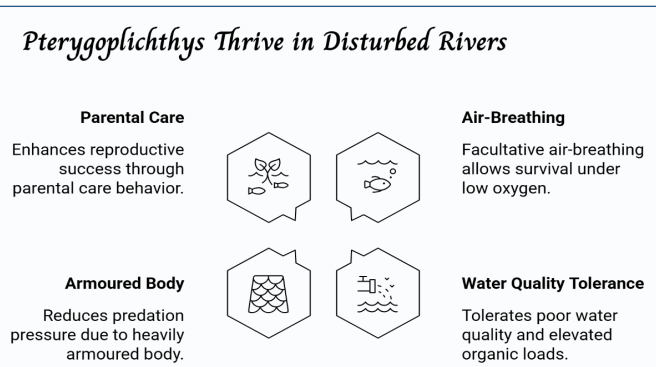

Figure 2: Biological and physiological adaptations that enable *Pterygoplichthys* spp. to thrive in disturbed freshwater ecosystems.

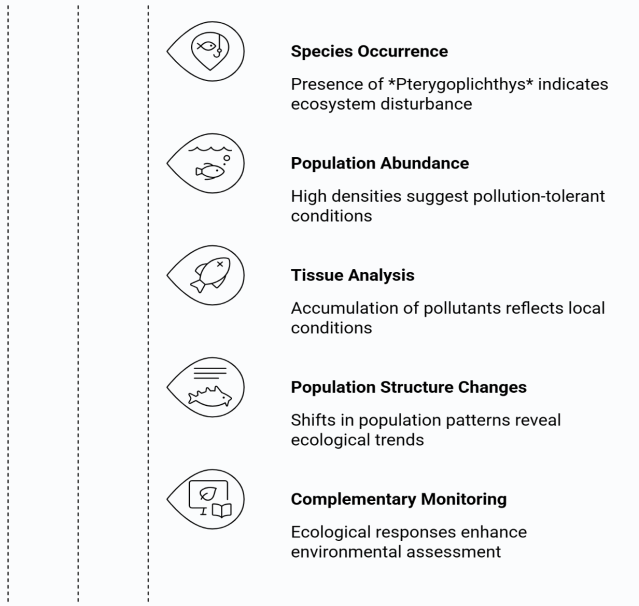

Figure 3: Using invasive Amazon Sailfin Catfish (*Pterygoplichthys* spp.) as an ecotoxicological indicator for assessing freshwater ecosystem health.

Studies conducted in the Klang Valley support this interpretation. Saba *et al.,* [8] reported that invasive fish occurrences were positively associated with anthropogenic disturbances and degraded environmental conditions. Similarly, Prof. Amal has repeatedly emphasized that high populations of ikan bandaraya frequently occur in rivers exhibiting signs of ecological deterioration [5, 6].

Ikan Bandaraya as an Ecotoxicological Indicator

Figure 3 presents a conceptual framework demonstrating how invasive Amazon sailfin catfish (*Pterygoplichthys* spp.) can function as valuable ecotoxicological indicators of freshwater ecosystem condition. The framework integrates five complementary indicators, namely species occurrence, population abundance, tissue contaminant accumulation, population structure changes, and complementary ecological monitoring. The presence and increasing dominance of *Pterygoplichthys* often reflect environmental degradation because this pollution tolerant species is capable of thriving under conditions that are unsuitable for many native fishes. Analyses of contaminant concentrations in fish tissues provide direct evidence of local pollutant bioavailability, while variations in population size and demographic structure may indicate long term ecological disturbances and habitat alteration. When these biological indicators are interpreted together with conventional physicochemical measurements, they provide a more comprehensive assessment of ecosystem health, environmental quality, and anthropogenic impacts, thereby strengthening freshwater biomonitoring programmes and supporting evidence-based conservation and environmental management.

From an ecotoxicological perspective, several biomonitoring applications may be proposed. First, species occurrence may function as a qualitative indicator of ecosystem disturbance. Rivers supporting large populations of *Pterygoplichthys* may warrant further investigation regarding water quality, habitat modification, and biodiversity status.

Second, population abundance may provide a semi-quantitative indication of environmental degradation. Extremely high population densities could signal conditions favourable to pollution-tolerant species and unfavourable to native fish communities.

Third, tissue analyses may provide information regarding

contaminant bioavailability. Because *Pterygoplichthys* inhabits benthic environments and feeds on biofilms, detritus, and sediment-associated organic matter, the species may accumulate pollutants reflective of local environmental conditions.

Fourth, changes in population structure may reveal ecological shifts over time. Long-term monitoring of abundance, recruitment, and distribution patterns may help identify trends in river health and ecosystem recovery.

These potential applications do not replace conventional chemical monitoring but rather complement existing biomonitoring approaches by incorporating ecological responses into environmental assessment.

Reflections from an Ecotoxicologist

As an ecotoxicologist, I find the concept particularly intriguing because it challenges traditional perspectives regarding invasive species. Most discussions focus on the negative ecological consequences of invasions, including competition with native species, habitat modification, and biodiversity loss. While these concerns remain valid, invasive species may simultaneously provide valuable ecological information.

The idea that an invasive fish can serve as a biomonitor initially appears paradoxical. However, ecotoxicology has always relied upon organisms that respond predictably to environmental conditions. If *Pterygoplichthys* consistently exhibits positive associations with degraded habitats, then its occurrence and abundance may provide useful ecological signals regarding environmental quality.

This perspective also reinforces an important lesson about environmental assessment. Ecosystem health cannot be evaluated solely through chemical analyses. Biological responses often reveal ecological realities that may not be immediately apparent through water chemistry measurements alone. Organisms integrate environmental conditions continuously, making them valuable indicators of long-term ecosystem status.

Conclusion

The invasive Amazon sailfin catfish (*Pterygoplichthys* spp.) is widely recognized as an ecological threat to Malaysian freshwater ecosystems. However, observations from field studies, student reflections, and the expertise shared by Prof. Mohammad Noor Noor Amal suggest an additional perspective. The species may function as a biomonitor of degraded river ecosystems because its abundance and distribution are frequently associated with polluted and disturbed habitats.

Although further empirical research is required to validate this concept, the proposed framework broadens the scope of ecotoxicological biomonitoring by considering invasive species as indicators of environmental condition. In this context, ikan bandaraya becomes more than an invasive fish. It becomes a biological signal, reflecting ecological changes occurring within Malaysian rivers. Understanding and interpreting that signal may contribute to more effective freshwater ecosystem assessment, conservation, and management.

Declaration on the Use of Artificial Intelligence

The author declares that generative artificial intelligence tools were used in a supportive capacity during the preparation of this manuscript. These tools assisted with language refinement, structural organisation, and stylistic clarity of the text. All ideas, interpretations, reflections, and conclusions presented in this paper are the author's own and are grounded in personal experience and scholarly judgment. The author retains full responsibility for the content, accuracy, originality, and integrity of the manuscript.

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