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First Record of *Xiphophorus helleri* (Heckel, 1848) (Cyprinodontiformes: Poeciliidae) from the Bangka Island, Indonesia

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ABSTRACT

Xiphophorus helleri, commonly known as the swordtail, has been recorded for the first time in the Rngkui River of Pangkal Pinang City, Bangka Island, Indonesia. This introduction is likely the result of local aquarium enthusiasts releasing the species into the wild. Since its introduction, it appears that *X. helleri* has established a population in this aquatic ecosystem. The presence of exotic species like *X. helleri* poses significant threats to local biodiversity. These threats include competition for resources, predation on native species, hybridization with local fish, habitat modification, and the potential transmission of diseases. Such impacts can lead to declines in native and endemic fish populations, ultimately altering the ecological balance of the habitat. Given these concerns, it is crucial to monitor the presence and effects of *X. helleri* in the Rngkui River. Ongoing assessments can help determine the extent of its establishment and influence on local species and habitats. Implementing strategies to manage and mitigate the impacts of this exotic fish will be essential to protect the region's biodiversity and ensure the health of its freshwater ecosystems. Continued research and conservation efforts are recommended to address the challenges posed by introduced species.

INTRODUCTION

The diversity of freshwater fish in Indonesia is remarkably high, with 1,266 species documented in the country's inland waters as of 2022. This number reflects the wide range of aquatic habitats in Indonesia, from rivers and lakes to wetlands and reservoirs. Additionally, Indonesia's aquatic environment hosts over 8,500 species of fish, categorized by habitat types—ranging from freshwater to brackish and salty waters **(Valen *et al.*, 2024)**. These species exhibit varying degrees of endemism, with many

being native to the region, while others have been introduced, sometimes intentionally for aquaculture or ornamental purposes **(Herder *et al.*, 2022; Kang *et al.*, 2022)**. The richness of freshwater fish species is increasingly at risk due to human activities such as pollution, habitat destruction, and the introduction of non-native species **(Colin *et al.*, 2018; Costa *et al.*, 2021)**.

One such non-native species is *X. helleri* (commonly known as the Swordtail), a freshwater fish native to North and Central America. This species is part of the order Cyprinodontiformes and the family Poeciliidae **(Mabrouki *et al.*, 2020; Debnath *et al.*, 2021)**. *X. helleri* is indigenous to areas like southeastern Mexico, central Guatemala, southern Belize, and northwestern Honduras **(Rocamontes-Morales *et al.*, 2021)**. It is an ornamental fish that has been widely introduced around the world, including in Southeast Asia. In Indonesia, swordtails were first recorded in Java and Bali, likely brought in through the aquarium trade **(Rocamontes-Morales *et al.*, 2021; Budiantoro & Noor, 2023; Gustiano *et al.*, 2023).**

The introduction of non-native species like *X. helleri* to new environments often leads to ecological disruptions. In many cases, these species can become invasive, outcompeting local species for resources, altering habitats, or introducing diseases **(Islamy *et al.*, 2024)**. These invasions can have significant long-term effects on native biodiversity. *X. helleri* was likely introduced to Indonesia for ornamental purposes, and over time, it escaped into natural waters, establishing populations in the wild.

Invasive species like the swordtail can threaten the ecological balance of freshwater ecosystems by competing with native species for food and space, and by potentially altering the food web **(Isroni *et al.*, 2023; Jatayu *et al.*, 2023; Islamy *et al.*, 2024)**. This species' ability to reproduce quickly and adapt to a wide range of environments increases its potential for widespread distribution and ecological impact. In the case of *X. helleri* in Indonesia, this species' establishment in the wild represents an expansion of its range, and its presence in new areas, such as Bangka Island, is of particular concern.

The recent documentation of *X. helleri* on Bangka Island is an important addition to the growing body of knowledge on the species' range in Indonesia. By recording these sightings and studying the expansion of *X. helleri*, researchers can better understand its impact on local ecosystems. The spread of alien species like this is of concern to conservationists, as they may negatively affect the freshwater biodiversity that is already under pressure from human activities like deforestation, pollution, and overfishing.

The presence of *X. helleri* in new locations like Bangka Island highlights the need for ongoing monitoring and management of freshwater habitats in Indonesia. Efforts to protect native species from the impacts of invasive aliens require both proactive management strategies—such as preventing further introductions—and reactive measures, including the removal or control of established invasive species. Understanding the dynamics of species range expansion and invasion is crucial for preserving Indonesia's rich freshwater biodiversity and maintaining the health of its

aquatic ecosystems. The ongoing spread of *X. helleri* in Indonesia emphasizes the importance of early detection, monitoring, and mitigation of invasive species to safeguard the country's native freshwater biodiversity.

MATERIALS AND METHODS

During fieldwork conducted in January-February 2023, specimens of *X. helleri*, commonly known as the swordtail, were collected from the Rangkui River in Pangkal Pinang, Bangka Island, Indonesia, using a cast net and fish trap **(Fadjar *et al.*, 2019; Hasan *et al.*, 2020, 2021)**. A total of ten specimens were preserved in 10% formaldehyde, while two specimens were preserved in 96% ethanol for further study. The identification of these species was based on a morphological technique developed by Kallman **(Zhou, 2023)**.

The collection methods employed, such as cast nets and fish traps, are standard practices in ichthyological studies, allowing for effective sampling of fish populations in freshwater environments **(Fadjar *et al.*, 2019; Hasan *et al.*, 2020, 2021)**.The preservation of specimens in formaldehyde and ethanol is crucial for maintaining the integrity of the samples for subsequent morphological and genetic analyses. These methods ensure that the specimens can be examined accurately, allowing researchers to identify species and to study their ecological roles.

The morphological identification technique developed by Kallman is particularly relevant for *X. helleri*, as it allows for the differentiation of this species from closely related taxa within the Poeciliidae family. Kallman's work has provided a foundational framework for the identification of various *Xiphophorus* species, emphasizing the importance of morphological characteristics in taxonomic classification **(Zhou, 2023)**. This technique is essential for understanding the biodiversity of freshwater fish in Indonesia, especially in light of the increasing threats posed by habitat loss and invasive species.

RESULTS AND DISCUSSION

New record

Indonesia – Bangka Island, Pangkal Pinang – Rungkui River; ten specimens caught using a fish trap; photograph taken.

Fig 1. Life specimen of *X. helleri* from Bangka Island

Species identification

According to **Zhou (2023)**, the specimens of *X. helleri* from Bangka Island have been identified based on distinct morphological characteristics. This species, commonly known as the swordtail, is easily recognizable on the island due to the absence of other species in the genus *Xiphophorus* in the local aquatic environment. The identification of *X. helleri* in this new location is significant, as it highlights the spread of this species beyond its original introduction points and its establishment in natural habitats such as those on Bangka Island.

X. helleri is known for its unique physical features, which help differentiate it from other freshwater fish species in its environment. The meristic characteristics (the number of specific body parts such as fins and rays) are important for accurate species identification. For *X. helleri*, these are as follows:

- *Dorsal spines (total): 0*
  This indicates that the swordtail lacks any spiny rays in its dorsal fin. Instead, its dorsal fin is composed of soft rays.
- *Dorsal soft rays (total): 11-14*
  The dorsal fin is made up of 11 to 14 soft rays, which is typical for this species, giving it a flexible, elongated fin that is prominent on its back.
- *Anal spines: 0*
  The anal fin of *X. helleri* also lacks any spines, again consisting solely of soft rays.
- *Anal soft rays (total): 8-10*
  The anal fin has 8 to 10 soft rays, providing stability and maneuverability in swimming.

Distinguishing characteristics

Aside from the meristic traits, *X. helleri* can be recognized by several key features:

- **Swordtail shape and size**
  X. helleri is a medium to large species, with males typically exhibiting the characteristic "swordtail" feature—a long, straight, and pointed extension of the caudal fin (tail). This appendage is a distinguishing feature of the species and is highly visible, making identification easier in the field. The swordtail itself is generally slender and tapers to a sharp point.
- **Midlateral stripe**
  One of the most visually striking features of *X. helleri* is its midlateral stripe, which runs along the sides of the fish from the head to the tail. This stripe is typically red in color and is a distinguishing feature in the species. The vibrant color contrast with the rest of the body makes it stand out among other fish species in the region.
- **Gonopodial ray features**
  Males *X. helleri* possess specialized reproductive organs called gonopodia (modified anal fins). In this species, the terminal segment of gonopodial ray 3 is produced into a crescent-shaped hook at the end, with the blade pointed distally (toward the tail). This structure is used in mating behavior, where the male uses the gonopodium to transfer sperm to the female. The hook shape is unique to the species and is critical for distinguishing it from other Poeciliidae family members.

Distribution

X. helleri is a freshwater species native to North and Central America **(Kallman & Kazianis, 2006; Culumber *et al.*, 2013)**. This species was introduced to Indonesia by ornamental fish then this species was released and established into the aquatic habitat by humans and became alien species to the aquatic habitat. Alien fishes are most likely invasive and pose a threat to native species **(Jatayu *et al.*, 2023; Islamy *et al.*, 2024)**. Moreover, invasive alien species (IAS) can have a wide range of negative consequences, including the extinction of native species by competition and predation, and cascading food levels web impacts at the community and ecosystem levels **(Valen *et al.*, 2024)**.

X. helleri was first recorded in the natural habitat of Java and Bali. In this research, then we recorded the first sighting of a *X. helleri* in Rangkui River Pangkal Pinang, Bangka Island, Indonesia during the fieldwork on January-February 2023 (Fig. 2).

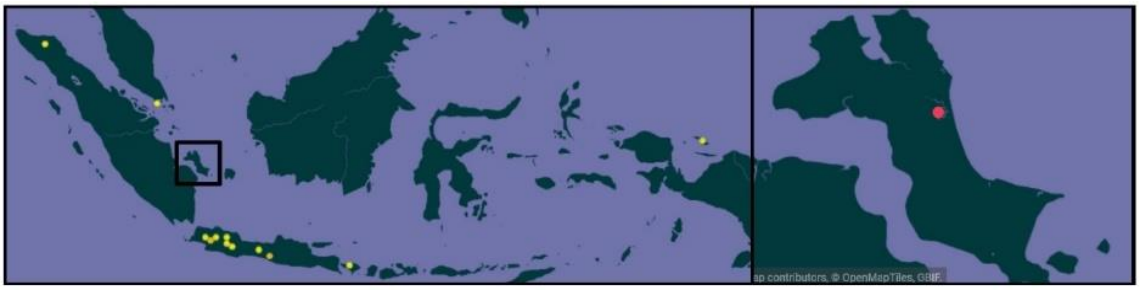

Fig. 2. Distribution of *X. helleri* in Indonesia, red circle is first record for Bangka Island (www.gbif.org)

However, the presence of *X. helleri* in the Rangkui River (Fig. 3) might be dangerous for the existence of native fish and endemic fish. The native fish that are inhabiting the area will eventually be damaged directly and indirectly. The direct impact of the presence of non-native species is through resource competition, predation, hybridization, habitat alteration, disease transfer (infection or parasitism), and genetic repercussions. Furthermore, non-native fish can breed quickly and grow to have large numbers. Native fish may become extinct as a result of high competition for food and space, as well as widespread predation.

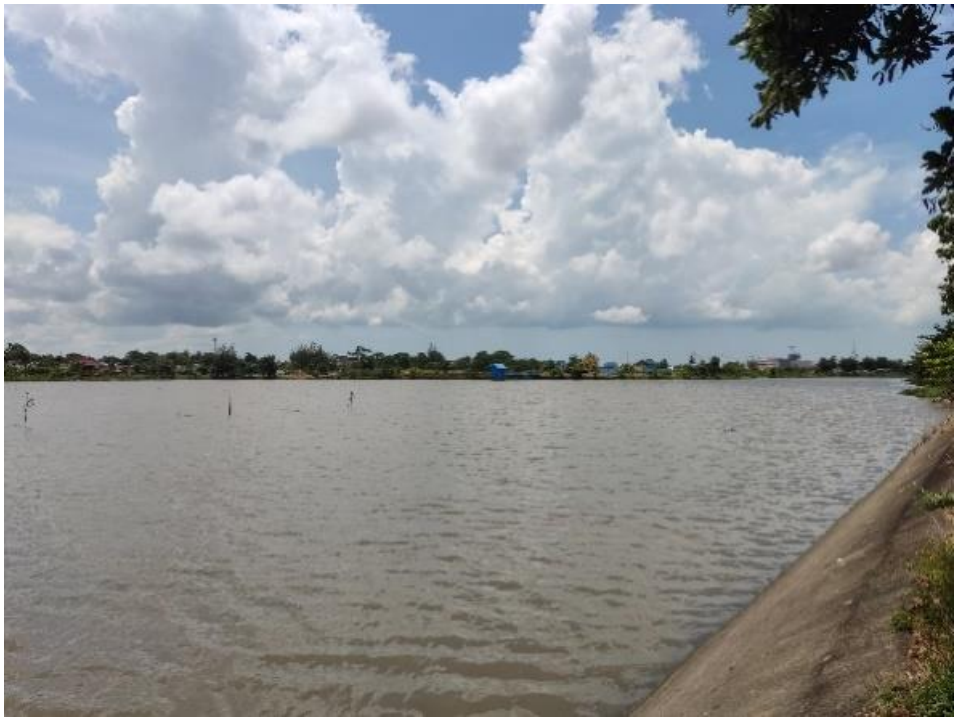

Fig. 3. The location of *X. helleri* were found in Bangka Island

The release of non-native fish species into natural ecosystems is a significant environmental concern, and in Indonesia, it is illegal to intentionally introduce or cultivate fish species that could endanger local biodiversity, human health, or the

environment. This is explicitly regulated under Law Number 31 of 2004, which addresses the conservation and protection of fishery resources and aquatic ecosystems in Indonesia. According to Article 86, Paragraph 2, individuals or entities involved in cultivating fish that could pose a risk to fish resources, the surrounding environment, or human health can face severe legal consequences, including up to 6 years of imprisonment and a fine of up to IDR 1.5 billion. This law highlights the serious implications of releasing non-native species, which is especially relevant in the case of *X. helleri* (Swordtail).

Legal protection against invasive species

The regulation reflects Indonesia's commitment to maintaining the health of its aquatic ecosystems, which are home to a wide range of endemic species. The introduction of non-native species, particularly invasive ones, poses a direct threat to the delicate balance of these ecosystems. Non-native species like *X. helleri*, which were introduced into Indonesian waters (likely for ornamental or aquaculture purposes), can disrupt the ecological dynamics and pose a risk to native fish populations and biodiversity. In particular, species with invasive tendencies can outcompete native fish for food, shelter, and reproductive space, thereby threatening the survival of indigenous species.

By prohibiting the release of non-native fish, the law aims to safeguard the integrity of Indonesia's aquatic ecosystems and prevent further damage to its rich biodiversity, which includes numerous endemic fish species. The enforcement of this law is crucial to ensuring the continued health of freshwater environments, especially in regions where biodiversity is already under threat due to human activity, such as habitat destruction, water pollution, and overfishing.

Potential ecological impact of *X. helleri*

X. helleri is considered an alien species in Indonesia, and its presence in the wild has the potential to cause ecological harm, particularly to native species that have evolved in these waters over long periods. Specifically, the introduction of *X. helleri* to freshwater habitats on Bangka Island can negatively affect several endemic fish species that are already present in these ecosystems. Some of the species that are particularly vulnerable to the impact of *X. helleri* include:

1. *Barbodes sellifer* (commonly known as the Sailfin Barb)
   This species is a type of freshwater barb that is native to Indonesia. *B. sellifer* is an important part of the freshwater food web, playing a role in nutrient cycling and the control of smaller organisms. However, this species could be threatened by the presence of *X. helleri*, especially if the latter competes for the same resources, such as food and breeding spaces, or if it preys on the smaller fish that *B. sellifer* might rely on.

2. *Hamirhampodon pogonathus*
   This species is another example of a native fish in Indonesia that could be impacted by the introduction of non-native species. *H. pogonathus* is a species of freshwater fish with specific ecological roles in the ecosystem. The establishment of *X. helleri* in shared habitats could result in competition for food or space, potentially displacing or outcompeting *H. pogonathus*. Additionally, non-native species often bring with them diseases or parasites that native species are not equipped to deal with, which could further threaten their populations.

3. *Aplocheilus amartus* (commonly known as the Killifish)
   A. amartus is another native species found in Indonesian freshwater habitats, often inhabiting shallow, slow-moving waters. The introduction of *X. helleri* could have serious consequences for *A. amartus*, particularly because of the Swordtail's aggressive nature and potential to outcompete other species. Additionally, *X. helleri* 's ability to adapt to a variety of environmental conditions could give it a competitive edge over more specialized species like *A. amartus*.

The risks of invasive species

The ecological risks posed by *X. helleri* are not limited to competition for resources. Invasive species like this can also affect the food web, potentially disrupting the relationships between predator and prey. For example, *X. helleri* might prey on smaller fish or invertebrates that are vital to the diets of native fish species, further diminishing the food sources for indigenous species. The presence of non-native species in a habitat can lead to biological homogenization, where distinct, native ecosystems lose their uniqueness and become dominated by a few, often invasive, species.

In some cases, non-native species like *X. helleri* can introduce new diseases or parasites into an ecosystem. Native fish species may not have developed immunity to these threats, making them highly susceptible to health declines or even population crashes. Furthermore, *X. helleri* may alter the physical or chemical properties of the water in subtle ways (e.g., through feeding behavior or waste products), which can affect water quality and the overall health of the ecosystem.

Legal and ecological responsibility

Under Indonesian law, the release of non-native fish like *X. helleri* is strictly prohibited due to the potential harm these species can cause to the environment. Individuals or organizations found violating this law by introducing such species into natural water bodies can face serious penalties, including imprisonment and heavy fines. The aim is to protect Indonesia's natural fish resources, prevent ecological imbalances, and ensure that freshwater biodiversity is preserved for future generations.

The protection of species like *B. sellifer*, *H. pogonathus*, and *A. amartus*—which are integral to the aquatic ecosystems of Indonesia—is critical. These species have evolved over millennia in Indonesia's freshwater systems and are an essential part of the country's aquatic biodiversity. The disruption of these populations by invasive species like *X. helleri* could lead to cascading ecological effects that would be difficult, if not impossible, to reverse.

CONCLUSION

This study records the first occurrence of *X. helleri* in the Rangkui River, Pangkal Pinang, Bangka Island, Indonesia, marking its spread beyond Java and Bali. Originally native to North and Central America, *X. helleri* was introduced to Indonesia as an ornamental fish, later establishing itself in natural habitats. As an invasive alien species, it poses potential threats to local ecosystems by competing for resources, predation, and habitat alteration, endangering native species such as *B. sellifer*, *H. pogonathus*, and *A. amartus*. The introduction of *X. helleri* highlights the need for a more strict control on releasing non-native species, as stipulated by Indonesian Law Number 31 of 2004, to protect native biodiversity.

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