



## Presence of Midas Cichlid (*Amphilophus citrinellus* Günther, 1864) (Actinopterygii : Cichlidae) on Bangka Island, Indonesia: An Invasive Non-Native Species

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### ABSTRACT

The Midas cichlid (*Amphilophus citrinellus*), a freshwater fish endemic to the San Juan River in Costa Rica, Central America, has been recorded as an invasive species present in various parts of the world, including Indonesia. Its introduction into public waters has primarily occurred through aquarium or fish farm releases. Known for its adaptability, *A. citrinellus* has demonstrated a remarkable ability to reproduce rapidly, leading to the formation of large populations within invaded ecosystems. The presence of this species has been recognized as disruptive to aquatic communities, where it negatively impacts native species and dominates ecosystems as an invasive entity. In this research, the expansion of *A. citrinellus* to Bangka Island, Indonesia, was documented, representing a new range extension. A total of ten specimens were collected from the Jembatan 12 River in Pangkal Pinang, Bangka Island, and identified as *A. citrinellus* based on morphological characteristics described by Kullander and Hartel in 1997. This identification was made possible by examining specific diagnostic features which confirmed their classification. The findings of this study contribute to an understanding of the extent of the Midas cichlid's invasion and the potential impacts on native and endemic species in the region. The continued spread of *A. citrinellus* poses threats to local biodiversity by altering the balance of aquatic ecosystems, often to the detriment of native fish communities. This research highlights the need for monitoring and management strategies to mitigate the adverse effects of invasive species like the Midas cichlid. Insights from this study are intended to support conservation efforts aimed at preserving biodiversity and maintaining ecosystem stability in regions affected by invasive species.

### INTRODUCTION

Indonesia hosts approximately 8,500 fish species classified by habitat type, including saltwater, brackish, and freshwater environments (Nugraha *et al.*, 2023). Of

these, 1,266 species are freshwater fish, encompassing endemic, native, introduced (non-native), and reintroduced species (Miqueleiz *et al.*, 2024). Indonesia has around 54 introduced freshwater fish species, 14 of which are classified as invasive and 4 as potentially invasive. These invasive species pose significant risks to biodiversity, potentially dominating ecosystems, reducing native species diversity, and altering freshwater ecosystem structures (Robin *et al.*, 2023).

Non-native fish, which live outside their original habitats, can significantly threaten biodiversity if they become invasive. These species often tolerate environmental changes, such as temperature variations and low oxygen levels, allowing them to establish themselves in new environments (Lenz *et al.*, 2011; Lennox *et al.*, 2019; Byers *et al.*, 2022). Additionally, non-native fish can reproduce rapidly, leading to large populations that can result in the extinction of local species due to intense predation and competition for resources (Fadjar *et al.*, 2019; Hasan *et al.*, 2021; Islamy *et al.*, 2024). Furthermore, these foreign species can transmit diseases that affect native fish.

Most invasive freshwater species in Indonesia were introduced by humans, either for increased fisheries production or ornamental purposes (Andriyono & Fitrani, 2021). Currently, the Cichlidae family dominates the 14 invasive species, one example being *A. citrinellus*. This species has proliferated in several Indonesian reservoirs, with recent records showing that it constitutes 37% of the fish population in the Sermo Reservoir, Yogyakarta (Ohee *et al.*, 2020). *A. citrinellus*, originally from the Atlantic slopes of Nicaragua and Costa Rica (San Juan River basin and lakes such as Nicaragua, Managua, Masaya, and Apoyo) (Haryono & Wahyudewantoro, 2020), has significantly disrupted natural habitats in Indonesia through its adaptability and rapid growth, enabling it to dominate local ecosystems (Dadiono, 2023; Gustiano *et al.*, 2024).

Given its impact, consistent data collection on the spread and ecological effects of *A. citrinellus* is essential. This study presents the first documented presence of the Midas cichlid (*A. citrinellus*) on Bangka Island, Indonesia. Previously, this species was only reported on Java Island and certain lakes in Sumatra. This record enhances our understanding of species range expansion, particularly regarding invasive species that impact biodiversity and threaten native and endemic species through competition, predation, hybridization, habitat alteration, and disease transmission.

## MATERIALS AND METHODS

During fieldwork conducted in January and February 2023 at Jembatan 12 River in Pangkal Pinang, Bangka Island, Indonesia, *A. citrinellus* (Midas cichlid) specimens were collected using a combination of cast nets and fish traps (Fadjar *et al.*, 2019; Hasan *et al.*, 2020). This location, part of Bangka Island's freshwater systems, served as a key study site due to concerns about invasive species impacting native biodiversity.

The collected specimens underwent preservation in two methods to allow for diverse analytical approaches: five specimens were preserved in a 10% formaldehyde solution, ideal for long-term morphological studies, while two specimens were preserved in 96% ethanol, which is optimal for molecular studies, such as genetic analysis (**Jatayu et al., 2023; Kilawati et al., 2024**). The use of formaldehyde ensures that physical characteristics remain intact for examination under traditional morphological techniques, while ethanol preservation keeps DNA viable for potential genetic sequencing.

Species identification relied on a morphological approach following the technique established by Kullander and Hartel in 1997. This method involves examining specific physical characteristics of *A. citrinellus*, such as body shape, fin configuration, and unique coloration patterns, which are distinct within the Cichlidae family. The identification process required detailed comparison with documented morphological traits to ensure accuracy, highlighting the robustness of Kullander and Hartel's method in differentiating *A. citrinellus* from similar species within the same family.

## RESULTS AND DISCUSSION

### New record

A new record has been documented for Indonesia with the discovery of *A. citrinellus* (Midas cichlid) on Bangka Island, specifically in Bangka Induk Regency, at Kolong Parit 5, Belinyu. The exact coordinates of this discovery are 1°59'45"S and 105°73'53"E, marking the presence of this non-native species in a new region. The specimen was collected by D. Ramadhanu using a traditional fish trap, a passive capture method effective for studying both the presence and behavior of aquatic species in local ecosystems.

Kolong Parit 5 is a freshwater reservoir located near Belinyu, an area characterized by tropical conditions favorable for aquatic biodiversity. This body of water is part of a network of reservoirs and small rivers in Bangka Induk, which support various fish species, including both native and introduced ones. The discovery of *A. citrinellus* in this location is particularly significant, as it underscores the adaptability of the species to diverse environments outside its native Central American range.

This site, often affected by activities like tin mining and local agriculture, is experiencing changes in water quality and habitat structure, which can impact native fish populations. The presence of *A. citrinellus* could intensify these impacts by introducing competition for resources, potential predation on smaller fish, and habitat disruption. This discovery highlights the importance of monitoring and managing invasive species to safeguard the ecological balance of freshwater systems in Bangka and surrounding regions.

### Species identification

On Bangka Island, *A. citrinellus* (Midas cichlid) is relatively easy to identify, as few species have similar characteristics. The Midas cichlid has a laterally compressed body and relatively fleshy lips. The head constitutes about one-third of the fish's standard length. Its dorsal fin typically has 15 to 17 spines, with the fin length increasing rapidly up to the fifth spine, then more gradually to the last spine. The anal fin has 10 to 13 spines, and the cheeks are covered with five rows of scales. Additionally, the caudal peduncle is deeper than being long (Fig. 1).

During the breeding season, some individuals may develop a distinct nape ridge. This feature can appear in both males and females, although it is generally much smaller and less noticeable in females. *A. citrinellus* displays a broad color range, including white, orange, yellow, and red variations. Some individuals have a motley appearance, with color patches on their bodies rather than a single uniform hue.



**Fig. 1.** Live specimens of of Midas cichlids from Bangka Island

### Range extension

The Midas cichlid (*A. citrinellus*) has been reported to have several adverse ecological impacts, primarily due to its territorial behavior and dominance in new environments. This article reports an outbreak of the Midas cichlid on Bangka Island, Indonesia (Fig. 2). This species can establish large populations that threaten local endemic fish populations, leading to its classification as an invasive species that adversely affects aquatic communities (**Barluenga & Meyer, 2010; Elmer *et al.*, 2010**). Recent observations indicate an outbreak of the Midas cichlid on Bangka Island, Indonesia, where its presence was previously documented only in a few lakes across Java,

Sumatra, and Sentani Papua (Kautt *et al.*, 2016). The new record of the Midas cichlid in Bangka Island contributes significantly to understanding species range expansion, which is crucial for effective conservation strategies and environmental risk assessments regarding alien invasions (Kautt *et al.*, 2018).

The presence of exotic fish species like the Midas cichlid poses significant threats to native and endemic fish populations. The direct impacts include competition for resources, predation, disease transmission, habitat alteration, and genetic influences through hybridization (Manousaki *et al.*, 2012; Franchini *et al.*, 2013). These interactions can lead to declines in native fish populations, as invasive species often outcompete them for food and space, and can introduce diseases to which local species have no immunity (Machado-Schiaffino *et al.*, 2017). The ecological consequences of such invasions underscore the necessity for ongoing monitoring and research to inform conservation efforts and mitigate the risks associated with invasive species (Barluenga & Meyer, 2010).

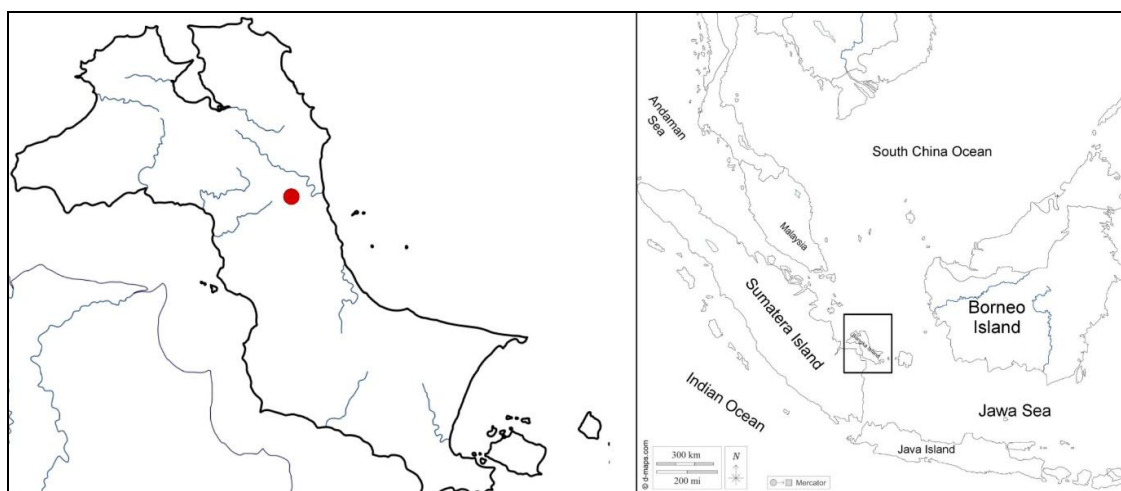


Fig. 2. Location of Midas cichlids in Bangka Island

The Bangka Belitung province, situated in western Indonesia, is recognized for its rich biodiversity. However, freshwater fish populations on Bangka Belitung Island have been moderately declining. This decrease has been attributed to the adverse effects of tin mining, which has led to environmental quality reduction due to chemical pollution and physical alterations within river ecosystems. As a result, these rivers have become increasingly vulnerable to degradation and biodiversity loss.

The Midas cichlid (*A. citrinellus*) is classified as an omnivorous species, with mature individuals consuming a variety of food sources, including algae, snails, smaller fish, and insects. Juveniles are fed primarily on plankton and small invertebrates, such as copepods, as well as mucus secreted by their parents. This species is naturally found in lakes, reservoirs, and ponds, to which it is well-adapted under diverse conditions. The unexpected discovery of Midas cichlids in the Jembatan 12 River on Bangka Island (Fig.

3) has demonstrated the species' adaptability and capacity to survive across various types of habitats.



**Fig. 3.** Habitat of Midas cichlids in Bangka Island

A total of 10 Midas cichlid specimens of various sizes (20–30mm SL) were collected from the Jembatan 12 River. During sampling, several native species of Bangka Island, including *B. cheeya*, *H. nemurus*, *B. selifer*, *O. hasselti*, *A. testudineus*, *T. trichopterus*, *B. edithae*, *C. striata*, *H. pogonatus*, *Macrobrachium* sp., and *P. maculata*, were also found. In addition, four non-native freshwater species (*T. pectoralis*, *C. gariepinus*, *G. affinis*, and *C. quadricarinatus*) were identified in the same habitat as the Midas cichlids.

The dominance of the Midas cichlid (*A. citrinellus*) in the Jembatan 12 River, as well as in other aquatic environments, has been attributed to its rapid breeding capabilities, which enable large population growth similar to other invasive species. This proliferation has led to declines in native fish populations due to increased predation and competition for food and habitat space (Barluenga & Meyer, 2010). Furthermore, the introduction of invasive fish like the Midas cichlid has been linked to disease transmission, increasing risks to local biodiversity and ecosystem stability (Kautt *et al.*, 2018). Significant ecological impacts, including the disruption of local aquatic community balance, have been observed due to the competitive and territorial nature of Midas cichlids, which can severely impact the survival of endemic species (Härer *et al.*, 2017).

Therefore, preventive measures are seen as essential to limit the spread of invasive species like the Midas cichlid and to protect native fish populations. These conservation efforts are deemed crucial for preserving biodiversity and ensuring the health of aquatic ecosystems (Elmer *et al.*, 2010). The threats posed to native fish communities by the



rapid growth and competitive behavior of Midas cichlids underscore the importance of effective conservation strategies to mitigate invasive species challenges (Manousaki *et al.*, 2012).

## CONCLUSION

The discovery of Midas cichlid (*Amphilophus citrinellus*) in the Jembatan 12 River on Bangka Island, Indonesia, marks a new record for the country and broadens the species' known invasion range. The identification of ten individuals of varying sizes, along with their defining characteristics, confirms them as *A. citrinellus*. The presence of other fish species in the same habitat adds valuable insights into species diversity, expansion, and regional biogeography. This information is important for river classification and conservation efforts, especially for managing the impact of non-native, potentially invasive species. *A. citrinellus*, as a dominant species, influences the ecosystem by competing for resources, preying on other species, interbreeding, altering habitats, spreading disease, and impacting genetic diversity. This species' rapid breeding and potential for large population growth make it a significant invasive threat.

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