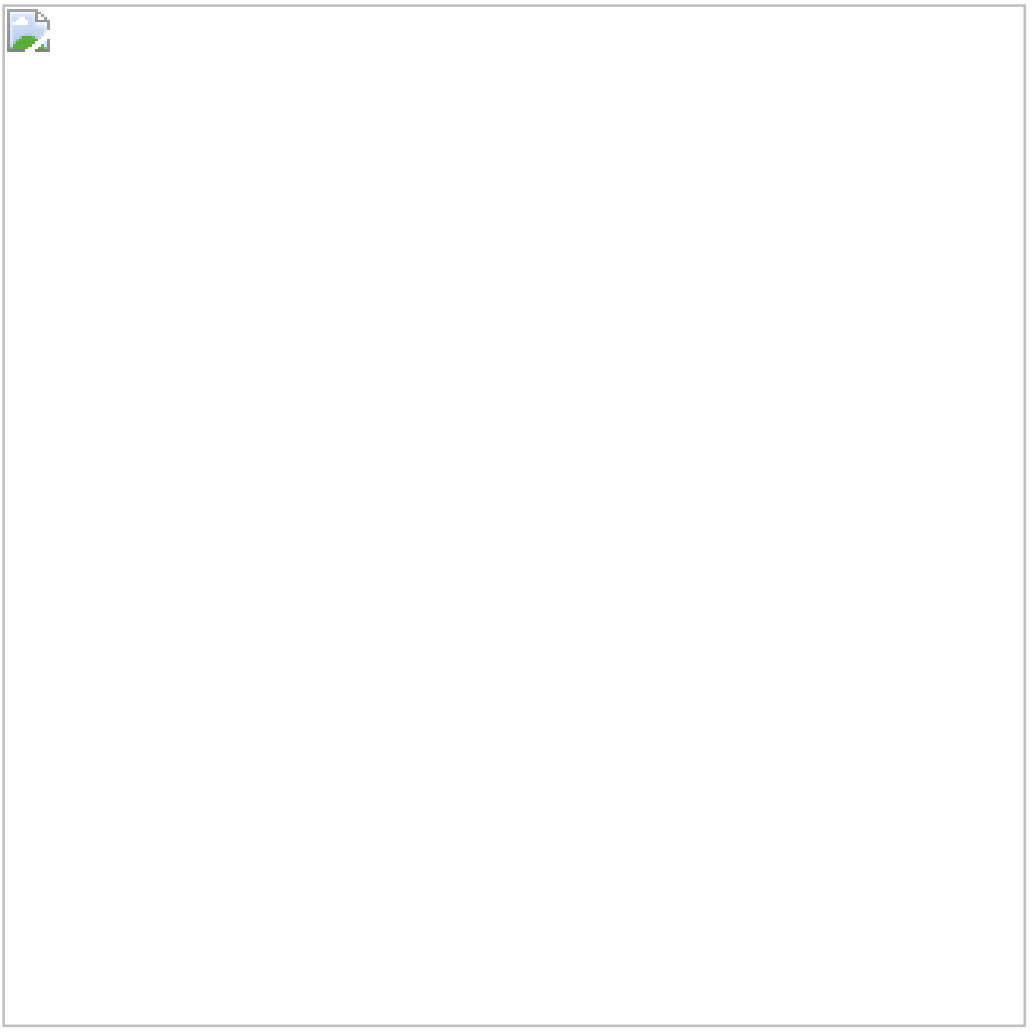

Social media and genetic evidence demonstrate the expansion of an invasive fish in India

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Source: Journal of Vertebrate Biology, 73(23087)

Published By: Institute of Vertebrate Biology, Czech Academy of Sciences

URL: https://doi.org/10.25225/jvb.23087

Journal of Vertebrate Biology

Open Access

J. Vertebr. Biol. 2024, 73: 23087 DOI: 10.25225/jvb.23087

RESEARCH PAPER

Social media and genetic evidence demonstrate the expansion of an invasive fish in India

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Received 10 October 2023; Accepted 12 December 2023; Published online 19 March 2024

Abstract. The use of digital data sources, such as social media, in iEcology has opened up new opportunities for research on species distribution and biological invasions. Invasive species can cause significant damage to biodiversity and ecosystem services, making early detection and intervention crucial. Ornamental fish species are a particular concern, as many have been imported to India for aquaria and have caused direct damage to local biodiversity. South American invasive catfish species belonging to the family Loricariidae have been introduced to many parts of the world outside their natural range, including India. Despite a lack of published records, this study used social media and internet sources to identify 28 sites of occurrence of suckermouth armoured catfish in the River Krishna basin across four Indian states. Through morphological and genetic analysis, the invasive loricariid fish collected from the River Krishna basin at Bhigwan was confirmed to be *Pterygoplichthys pardalis*. In addition, sentiment analysis of social media content and other internet sources revealed that 60.71% of individuals perceive the introduction of suckermouth armoured catfish to their region as a threat. This insight could prove advantageous as society is more likely to support eradication activities necessary to prevent further damage to the ecosystem.

Key words: Loricariidae, *Pterygoplichthys pardalis*, suckermouth armoured catfish, River Krishna basin, South Asia, ornamental trade

Introduction

Countries like India, with more than 50% of the population using social media platforms such as Facebook, Twitter, Instagram and YouTube (We Are Social & Hootsuite 2022), unknowingly generate huge amounts of biodiversity-related data (Barve 2014). Such data gathered from digital sources initially collected for other objectives can be employed to quantify patterns and processes in the natural environment, and this methodology is referred to as iEcology. Digital data can offer insights into the distributions, spread dynamics, life history, and effects of invasive non-native species within the iEcology framework (Jarić et al. 2020a). With the development of iEcology, digital data sources are now used in research, including studies on species distribution and biological invasions (Jarić et al. 2021). These data can be crucial in protecting nature, especially in the cost-effective early detection of invasive species (Simberloff et al. 2013, Pace et al. 2019). Various texts or audio-visual records often reflect sentiments towards a particular natural object or human behaviour considering a natural object (Jarić et al. 2020b).

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Analysis of this information can significantly help understand the human perspective when designing conservation measures. The term 'sentiment' refers to feelings and emotions expressed in phrases, usually textual, but can also be a form of behavioural expressions such as gestures (Zadeh et al. 2016). Sentiment analysis seeks to understand the emotions expressed this way and is usually classified as negative, neutral or positive (Liu 2020).

Due to their competitive nature, invasive species interact with native species by predation and feeding competition. Invasive species may also facilitate the transmission of disease and parasite infections (Helfman 2007, Tripathi 2014). Additionally, invasive species can cause trophic alterations, health hazards, and economic damage, adversely impacting ecosystem services (Singh 2021). The global increase in non-native species populations has been attributed to the pet trade (Lockwood et al. 2019). Among 300 alien fishes in India, 291 were imported for aquarium keeping (Singh & Lakra 2011). It has been documented that invasive ornamental fish species cause direct damage to Indian biodiversity (Tripathi 2014).

Commonly known suckermouth armoured catfish of the family Lorricaridae have been introduced to many parts of the world outside their natural range, especially in the tropics and subtropics, including India, where they have established successful reproducing populations in inland waters (Bijukumar et al. 2015, Orfinger & Goodding 2018, Raj et al. 2020). These catfish consume fish eggs, outcompete native algal consumers (Hoover et al. 2004), and affect local fisheries because of their high abundance (Mendoza-Carranza et al. 2010). Although only some records of Loricariid catfishes, such as *Pterygoplichthys*, have been published from a few parts of India, their invasive distribution and effects on the ecosystem are still to be investigated.

In this study, we utilised social media and internet sources to determine the occurrence of suckermouth armoured catfish in the River Krishna basin along with genetic evidence. Additionally, we analysed the sentiments towards this catfish from available internet sources.

Material and Methods

Following ethical standards, we compiled the occurrence data from social media, grey literature, and online news using a structured Boolean search to retrieve only publicly available posts and information using related keywords (Table S1). To verify the records, we used the methodology given by Toivonen et al. (2019). We visited one of the localities identified through social media at Ujani Dam, Bhigwan (18.299° N, 74.761° E) (the River Bhima of the River Krishna basin (henceforth RKB) and collected 27 fish from the local fish market). Fish obtained were identified following the keys of Armbruster & Page (2006). We isolated DNA from the fin clip using QIAamp DNA Mini Kit (Qiagen, Hilden, Germany) following the protocol provided by the manufacturer and further used in PCR to amplify the mtDNA COI gene cytochrome oxidase subunit I (cox1) gene with primers FishF1 and FishR1 (Ward et al. 2005) following Bijukumar et al. (2015). The obtained sequence was deposited under accession number OQ719883 in GenBank NCBI.

We analysed the sentiment of all video posts, news and reports on social media and other internet sources following Keelan et al. (2007) and Briones et al. (2012) by categorising them into three groups based on their tone and content: 1) positive – if the creators expressed positive emotions about fish presence and did not view it as a threat; 2) negative – if the creators express negative emotions and see the presence as a threat; 3) neutral – if the creators did not express the above perspectives.

Results and Discussion

Through social media, online news, and grey literature, we identified 28 sites of occurrence of suckermouth armoured catfish in the RKB across four states of India, as listed in Table S1. Telangana had 14 sightings, Maharashtra had six, and Karnataka and Andhra Pradesh both had four sightings. All fish seen on social media and the internet expressed the morphological characteristics of suckermouth armoured catfish (Loricariidae).

Two genera of Loricariid fish, *Hypostomus* and *Pterygoplicthys* (Naik et al. 2013, Sandilyan 2022), have been documented in India. Based on its morphological characteristics, we have determined that an invasive loricariid fish discovered in the RKB at Bhigwan belongs to the genus *Pterygoplichthys*. This species is distinct from *Hypostomus* due to the presence of 13 dorsal fin rays (Fig. 1). Previous research by Bijukumar et al. (2015) has found evidence of two species of *Pterygoplichthys* in southern India. During our study, adult fish collected from Bhigwan displayed geometric patterns of light lines on the head, and spots on the lateral side that unite to form chevrons (Fig. 1). This

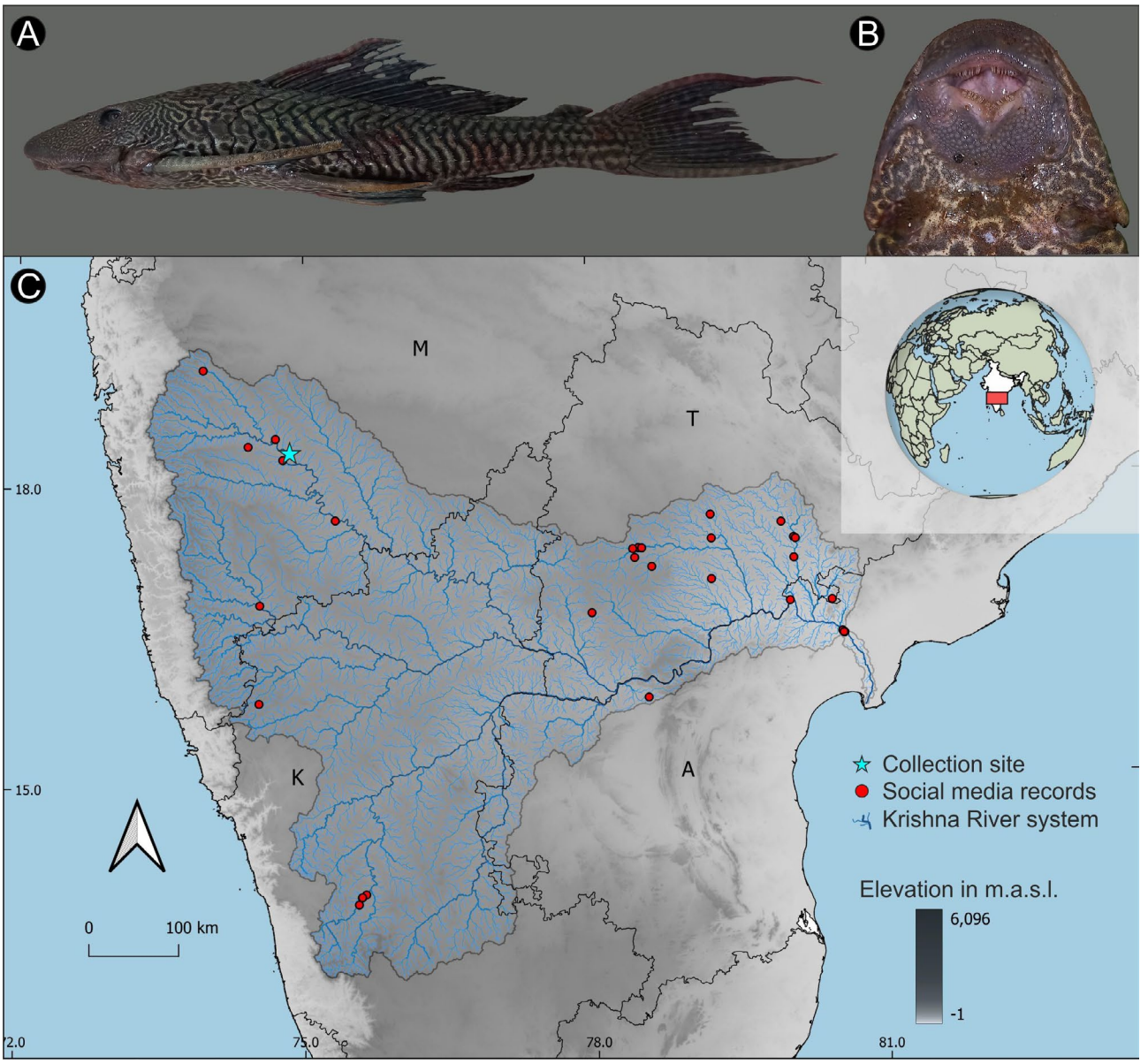

Fig. 1. A) *Pterygoplichthys pardalis* in lateral view SL: 15.96 mm; B) mouth; C) map showing the collection site and social media records of armoured sailfin catfish in the River Krishna basin, India.

unique pattern confirms their identity as *P. pardalis* (Armbruster & Page 2006). Additionally, this species has discrete dark ventral spots that usually resemble leopard-like spots and rarely include vermiculation (Armbruster & Page 2006; Fig. 1). Four of the 27 examined individuals (size range 123.2-231.0 mm SL) were gravid females, which supports the assumption of an established breeding population.

Tripathi (2014) mentioned three species of *Pterygoplichthys* besides *P. pardalis* in India. However, the cytochrome oxidase subunit I sequence (accession number OQ719883) obtained within our study has a 100% match with the reference sequences of *P. pardalis* (accession number MN854556) collected from its native range in the upper River Amazon (de Queiroz et al. 2020), with coverage of 100%.

Interestingly, we obtained most of the records from hilly regions. This pattern of occurrence suggests that *P. pardalis* may prefer cooler regions in the RKB, similar to the trend of distribution observed in hilly areas of Malaysia (Vythalingam et al. 2022). However, a more thorough investigation considering eco-biological and anthropogenic variables is necessary to understand the invasion pattern. The physical characteristics of *P. pardalis*, like its rigid outer plates, capacity to endure low-oxygen environments, ability to survive without water for 30 h, and capability to create nest holes for protection against predators (Gibbs & Groff 2014), make it highly adaptable to establish and expand in the area. Being an invasive fish species, it presents a significant danger to the native fish populations in tropical and subtropical freshwater ecosystems (Liang et al. 2005, Godwin

et al. 2016). This catfish may compete with the local fish population, especially benthic fishes, due to niche overlap (Hoover et al. 2004, Chaichana & Jongphadungkiet 2012). *P. pardalis* has a similar feeding behaviour to *Garra mullya* and *G. bicornuta* (Atkore et al. 2020), which occur in RKB, indicating its potential impact on these two species as well as on *Balitora laticauda*. The external bony plates that form the catfish's flexible armour make it difficult for predators to feed on them. They also hide in burrows during the breeding season, making them challenging to locate (Wakida-Kusunoki et al. 2007, Qasim & Jawad 2022). No information is available regarding the native predators of *P. pardalis* in India except the otter *Lutrogale perspicillata* (Gowtham et al. 2022). Furthermore, *P. pardalis* is not commercially exploited, allowing their population to expand without many obstacles (Wakida-Kusunoki et al. 2007). According to Raj et al. (2020), the successful invasion of *P. pardalis* in India is likely due to its rapid growth, high growth performance index, and continuous recruitment throughout the year. They suggest increasing fishing pressure by targeting juveniles less than 30 cm in length to control the population. But this may not be practical; therefore, we propose using environmental DNA for early detection of this species in the RKB and employing large fish traps at breeding sites (80 cm length × 25 cm width × 25 cm height with a mesh of 1 × 1 cm and a single cone-shaped inlet) as used by Dubreuil et al. (2021). Together, these methods could help constrain or eradicate this fish species.

Based on our analysis of social media content and other internet sources, 60.71% of records were evaluated as negative, meaning that the introduction of suckermouth armoured catfish has been perceived as a threat. In some countries, such as Malaysia, it has been noted that people are aware of the adverse effects of introducing non-native fish species. However, they still welcome them if the species is economically valuable (Saba et al. 2021). Tropical countries like Indonesia and Brazil started consuming *P. pardalis* (Munandar & Eurika 2016, Elfidasari et al. 2022), but no evidence from India was found during our search. Its absence from the commercial catch might be an advantage since there may be greater societal acceptance of eradication activities, including commitment of resources.

Our findings are important for stakeholders and decision-makers in developing strategies to successfully mitigate the invasion of suckermouth armoured catfish in India.

Acknowledgements

The authors thank the local fishermen at Bhigwan, Pune, for providing fish samples and information. The study was partially funded by the institutional grant SGS conducted at the Czech University of Life Sciences Prague under No. SV23-11-21260.

Author Contributions

Conceptualisation: P. Kumkar, L. Kalous; fieldwork: C.R. Verma, M. Pise, P. Kumkar, L. Kalous; data extraction and analysis: C.R. Verma, M. Pise, P. Kumkar; laboratory work: C.R. Verma, T. Khare, P. Kumkar. All authors contributed equally to manuscript preparation.

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Supplementary online material

Table S1. Occurrence data of *Pterygoplichthys pardalis* obtained from social media and their sources (https://www.ivb.cz/wp-content/uploads/JVB-vol.-73-2024-VermaCh.R.-et-al.-Table-S1.pdf).