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Social media: an emerging, fast, cheap, and effective tool for detection of non-native fish species

Mídias sociais: uma ferramenta emergente, rápida, barata e eficaz para detecção de espécies de peixes não nativas

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Abstract: Aim: People share on social media images (photos and videos) about their daily lives, mainly related to leisure. Ecological studies using data from social media have been growing, demonstrating that validating this information lends confidence to the studies and highlights the effectiveness of this approach. Many non-native species can be easily identified through images, and these records can be used to investigate non-native species (e.g., fish). Therefore, we report the occurrence of two non-native fish species (Cichliformes, Cichlidae) in Brazil. **Methods:** The records were made by anglers and shared on social media (Instagram®). **Results:** Based on the records, it was possible to update the area of occurrence of Zebra tilapia *Heterotilapia buttikoferi* and Jaguar guapote *Parachromis managuensis*. **Conclusions:** Analyzing data available on social media is already recognized as an effective and low-cost tool for ecological studies. Thus, there is a huge urgency in creating participatory research programs with social media users, due to the efficiency in identifying the occurrence and distribution of non-native species, which can assist management strategies for introduced species in Brazil.

Keywords: aquatic ecosystems; ornamental fish; cichlidae; new record; invasive species.

Resumo: Objetivo: As pessoas compartilham, em mídias sociais, imagens (fotos e vídeos) sobre seu cotidiano, principalmente relacionadas ao lazer. Estudos ecológicos utilizando dados oriundos de mídias sociais vêm crescendo, demonstrando que a validação dessas informações confere confiança aos estudos e destaca a eficácia desta abordagem. Muitas espécies não nativas podem ser facilmente identificadas através de imagens e esses registros podem ser usados para investigar espécies não nativas (por exemplo, peixes). Diante disso, reportamos a ocorrência de duas espécies de peixes (Cichliformes, Cichlidae) não nativos no Brasil. **Métodos:** Os registros foram feitos por pescadores amadores e compartilhados em mídia social (Instagram®). **Resultados:** Com base nos registros foi possível atualizar a área de ocorrência de Zebra tilápia *Heterotilapia buttikoferi* e Jaguar guapote *Parachromis managuensis*. **Conclusões:** Analisar os dados disponíveis nas redes sociais é reconhecido como uma ferramenta eficaz e de baixo custo para estudos ecológicos. Assim, existe uma enorme urgência em criar programas de pesquisa participativa com usuários de mídias sociais, devido a eficiência em identificar a ocorrência e distribuição de espécies não nativas, podendo auxiliar as estratégias de manejo de espécies introduzidas no Brasil.

Palavras-chave: ecossistemas aquáticos; peixes ornamentais; cichliformes; novo registro; espécies invasoras.

1. Introduction

Biological invasions, driven by the introduction of non-native organisms through human activities, have left a growing legacy of environmental degradation and economic losses across the globe (Frehse et al., 2016; Adelino et al., 2021; BPBES, 2024; Seebens et al., 2025). In Brazil, a considerable proportion of these invasive species are fish (BPBES, 2024), including both marine (e.g., *Opsanus beta*) and freshwater species (e.g., *Micropterus salmoides*) (Frehse et al., 2016; Pereira & Vitule, 2019; Carvalho et al., 2020). These introductions are often linked to human economic activities and occur via multiple pathways, such as maritime transport, aquaculture, sport fishing, biological control, and the ornamental fish trade (Vitule, 2009; Magalhães & Vitule, 2013; Adelir-Alves et al., 2018; Soeth et al., 2018; Adelir-Alves et al., 2019; BPBES, 2024). Once introduced, non-native fish species can pose serious threats to native biodiversity and aquatic ecosystems by outcompeting local species, preying on native fauna, introducing new pathogens, and causing genetic disruptions through hybridization (IPBES, 2023; Carneiro et al., 2025).

Even with a growing scientific understanding of the negative impacts caused by non-native fish on native biodiversity and ecosystem functioning (Vitule, 2009; Frehse et al., 2016; Pelicice et al., 2017; Soares et al., 2023), introductions continue to rise throughout Brazil (BPBES, 2024; Dechoum et al., 2024), pointing to a disconnect between knowledge and management. Brazil is known for its continental area, biodiversity, and uniqueness in terms of aquatic ecosystems, aspects that make the prevention, detections, and management of non-native species particularly challenging (Vitule, 2009; Pelicice et al., 2017; BPBES, 2024).

Brazilian authorities make some efforts, such as the National Strategy for Invasive Alien Species (Brasil, 2018) and the National Biodiversity Monitoring Program (Monitora Program), however, the effectiveness of these actions remains limited. Partly because they often conflict with legislation that favors biological invasion processes, especially when they are related to the expansion of agribusiness and aquaculture (commercial and ornamental) (Pelicice et al., 2014, 2017; Faria et al., 2023).

Another challenge is that biological invasions are dynamic processes occurring across temporal and spatial scales, which require continuous monitoring to support timely and effective management actions (BPBES, 2024). Species distribution data enables the early identification of new introductions, monitoring of range expansions, detection of dispersal pathways, and prioritization of control efforts (Dechoum et al., 2018; Dechoum et al., 2024). However, the costs of conducting research and monitoring in a large country like Brazil represent a major barrier to effective management (Vitule, 2009; Vitule et al., 2019; Faria et al., 2023). As a result, substantial knowledge gaps remain regarding the occurrence and distribution of invasive species, limiting the development of evidence-based management strategies adapted to regional contexts (BPBES, 2024; Seebens et al., 2025).

Nevertheless, contributory research models (e.g. social media data), which can be part of the broader citizen science framework (Bonney et al., 2009; Shirk et al., 2012), have proven effective in supporting studies on non-native fish species, by broadening spatial and temporal monitoring coverage, especially when integrated with digital platforms (e.g., Magalhães et al., 2017; Geller et al., 2021; Carvalho et al., 2022). Citizen science refers to the involvement of non-professional scientists in the production of scientific knowledge, with varying levels of objectives and engagement, from simple data contribution to full involvement in research design, data analysis and result dissemination (Eitzel et al., 2017; Haklay et al., 2021). Even when limited to sharing data through online participation, this approach provides valuable support for biodiversity monitoring (Dickinson et al., 2012; Bonney et al., 2014; Theobald et al., 2015), especially in countries with limited resources.

Here, we explore the potential of the Projeto Meros do Brasil database to support the monitoring of non-native species, as it also includes records of non-target organisms. Among the records compiled, we selected two fish species (*Heterotilapia buttikoferi* and *Parachromis managuensis)*, due to their ecological relevance as non-native species in Brazil. This study follows a contributory citizen science approach, using data collected through social media platforms (Bonney et al., 2009; Shirk et al., 2012). Sharing data on the occurrence of non-native species is critical for ecological monitoring, early detection, and the implementation of targeted management actions to curb their expansion and protect native biodiversity (Pocock et al., 2024). Based on this approach, we report new records of the two selected fish species and provide an updated map of their distribution using published occurrence data from Brazil.

2. Material and Methods

The Projeto Meros do Brasil has conducted, since 2018, citizen science research with divers and anglers to obtain records of Atlantic goliath grouper (*Epinephelus itajara*) along the Brazilian coast (see Meros do Brasil, 2025). Although *E. itajara* are the main focus of the project, records of different species are also found and received through online platforms. Among the records, we selected two fish species (*Heterotilapia buttikoferi* and *Parachromis managuensis)*, due to their ecological relevance for being non-native in Brazil.

For the database of Projeto Meros do Brasil, social media platforms and networks of divers and anglers are systematically monitored using hashtags (e.g., #meros; #epinephelusitajara) and active search to identify relevant information. Species records (photographs and videos) along with associated metadata such as location and date available on these platforms are compiled into the project database (following methodologies described in Geller et al., 2021). Fishermen are contacted to obtain consent for the use of images and related data in the project. This communication helped establish a community network, which in turn facilitated the flow of additional records and information via direct channels, including WhatsApp.

The species identification is made by picture analyses, comparing morphological characteristics to confirm the species identification (e.g., body coloring), and the identification was supported by the description of a specimen (Froese & Pauly, 2024). Furthermore, experts in fishes were consulted to confirm identification. To ensure data quality and minimize duplication, all records collected from social media were cross-checked using associated metadata such as location, date, and image content. Duplicate records were identified and removed based on these parameters. Additionally, records with unclear or questionable identifications were filtered out during expert validation to reduce potential biases and improve the reliability of the dataset.

Complementing social media, we searched for published records in Brazil of the non-native fish species found, based on bibliographic searches (see Table 1), conducted in Google Scholar (Google, 2025) and WoS - Web of Science (Clarivate Analytics, 2025). We used combinations of the following search terms: "*Heterotilapia buttikoferi* + Brazil" and "*Parachromis managuensis* + Brazil".

For the localization, we analyzed geographic distribution through confirmed occurrences or records. The approximate location of the captures found was verified and confirmed in Google Earth Pro. Geographic coordinates of captures were obtained using information available in published articles and grey literature. In cases where the location was only named, we used average coordinate points through Google Earth (WGS84). In addition, QGIS v.3.28.10 (QGIS Development Team, 2025) was used as a georeferencing tool to create a map indicating all identified fish occurrence points in Brazil (Geller et al., 2021).

3. Results

Our search for published records in Brazil of the non-native fish species found resulted in a time series of records for *Heterotilapia buttikoferi* and *Parachromis managuensis* (see Table 1). Social media data validated two new records of non-native Cichlidae species that were registered at different localities in Brazil, the Zebra tilapia *H. buttikoferi* (Hubrecht, 1881) (Figure 1A; Table 1) and the Jaguar guapote *P. managuensis* (Gunther, 1867) (Figure 1B; Table 1). Together, these records updated the geographic distribution of the non-native species *H. buttikoferi* and *P. managuensis* in Brazil (Figure 2).

The first record of Zebra tilapia, *H. buttikoferi* (Hubrecht, 1881), in Brazil occurred in 2012, in the Pereira de Miranda reservoir, located in the Curu River basin (Santana et al., 2017). The species was subsequently recorded further south in 2014, in the Uberabinha River, a tributary to the Araguari drainage, Paranaíba river basin (Santana et al., 2017). The most recent published record of the species was from the Ilha Solteira Reservoir, located

Table 1. Records of *Heterotilapia buttikoferi* and *Parachromis managuensis* in Brazil (geographic distribution). States: Ceará (CE), Paraíba (PB), Pernambuco (PE), Bahia (BA), Minas Gerais (MG), and São Paulo (SP). Biomes: Cerrado (Cer), caatinga (Caa) and Atlantic Forest (Atl).

Specie	Record year	Site	State	Biome	Source	Lat	Long
Heterotilapia buttikoferi	2012	Pereira de Miranda reservoir	CE	Caa	Santana et al. (2017)	-3,800	-39,265
	2014	Uberabinha River	MG	Atl	Sampaio et al. (2017)	-18,679	-48,505
	2016	Ilha Solteira reservoir	SP	Atl	Orlandi-Neto et al. (2022)	-20,003	-50,867
	2020	Juqueri River (Paulo de Paiva Castro Reservoir)	SP	Atl	This study	-23,333	-46,665
Parachromis managuensis	2003	São Francisco River	BA	Cer/ Caa	Barbosa and Leitão (2003)	-13,519	-43,374
	2006-2007	Açude Capoeiras	PE	Atl	França et al. (2017)	-8,731	-36,635
	2006-2007	Una River	PE	Caa	França et al. (2017)	-8,544	-36,483
	2006-2007	Chata River	PE	Caa	França et al. (2017)	-8,718	-36,263
	2006-2007	Ipojuca River	PE	Atl	França et al. (2017)	-8,367	-36,423
	2006-2007	Tacaimbó Stream	PE	Caa	França et al. (2017)	-8,336	-36,292
	2006-2007	Capibaribe River	PE	Caa	França et al. (2017)	-8,013	-36,062
	2006-2007	Jucazinho Reservoir	PE	Atl	França et al. (2017)	-7,966	-35,743
	2011	Doce River	MG	Atl	Barros et al. (2012)	-20,247	-42,885
	2012	Açude Saco	PE	Caa	França et al. (2017)	-7,925	-38,278
	2014	Capibaribe River	PE	Caa	França et al. (2017)	-8,060	-34,985
	2015	Carpina Reservoir	PE	Atl	França et al. (2017)	-7,895	-35,339
	2015-2016	Pajeú river	PE	Caa	Resende et al. (2020)	-7,925	-38,278
	2018	Paraíba do Norte River	PB	Caa	Ramos et al. (2018)	-7,365	-35,485
	2024	Jaboatão River	PE	Atl	This study	-8,235	-34,947

in the Upper Paraná River region, Brazil, in 2016 (Orlandi-Neto et al., 2022) (Table 1).

The Jaguar guapote, *P. managuensis* (Gunther, 1867), is registered for the first time in the mangrove, a brackish water environment (Table 1). The first reported record of *P. managuensis* in Brazil was in 2003, in the middle São Francisco River Basin (Barbosa & Leitão, 2003). Between 2006 and 2018, the occurrence of *P. managuensis* was recorded in Una, Ipojuca, Capibaribe, and Pajeú river basins in the state of Pernambuco (França et al., 2017; Resende et al., 2020), in Paraíba do Norte River basin at Soledade dam, in the state of Paraíba (Ramos et al., 2018), and at the upper Doce River in the Risoleta Neves Hydroelectric Reservoir, in the state of Minas Gerais (Barros et al., 2012).

4. Discussion

The new records of *H. buttikoferi* and *P. managuensis* found on social media improve the knowledge about their current distribution and suggest a potential expansion into new habitats. These findings underscore the importance of a contributory model of citizen science for continuous research on the occurrence, distribution, and impacts of non-native species, supporting the development of effective public policies. The progression of these invasions can compromise the integrity of aquatic ecosystems, requiring increasing efforts for mitigation and control (Essl et al., 2020; Flood et al., 2020). Therefore, integrating public engagement, scientific research, and environmental policies is essential to address the challenges posed by biological invasions. For

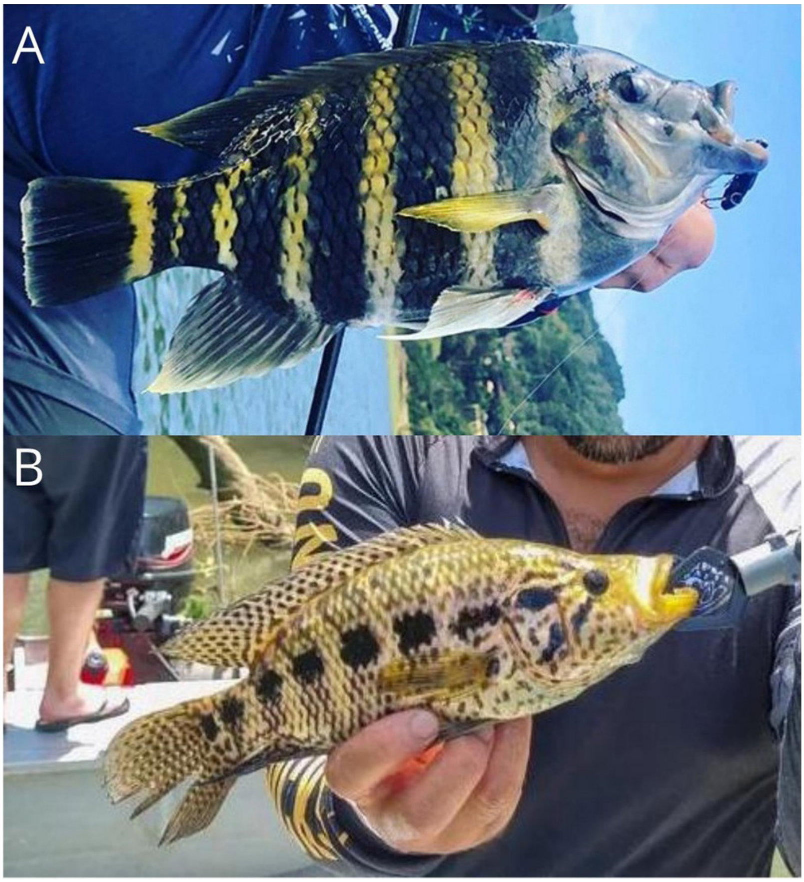

Figure 1. New records of *Heterotilapia buttikoferi* (A) and *Parachromis managuensis* (B).

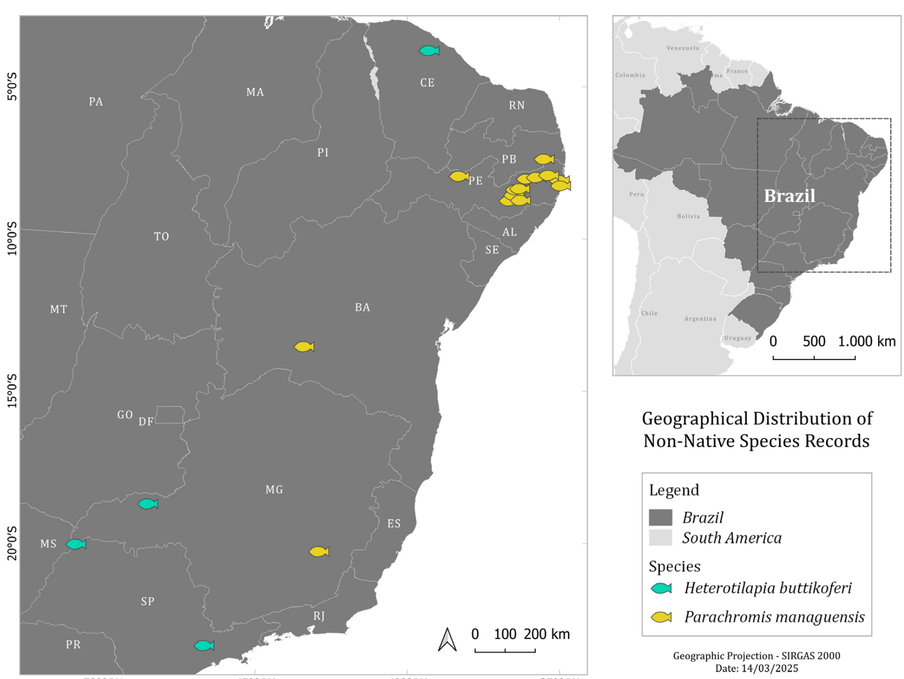

Figure 2. Geographical distribution of *Heterotilapia buttikoferi* and *Parachromis managuensis* in Brazil. Records from Barbosa & Leitão (2003), França et al. (2017), Sampaio et al. (2017), Santana et al. (2017), Ramos et al. (2018), Resende et al. (2020), Orlandi-Neto et al. (2022) and this study.

example, data from the iNaturalist platform were used to update the distribution and track the expansion of the Green Mussel (*Perna viridis*) along the Brazilian coast, highlighting the valuable role of contributory research in monitoring invasive alien species (Akira-Umeno et al., 2025). Furthermore, it would be highly relevant for research such as that by Haubrock et al. (2025) could rethink about considering intra-country invasion and local citizen science data in the future.

The introduction of *H. buttikoferi*, originally from West Africa (Daget et al., 1991), has been associated with the aquarium trade (Wei et al., 2021; Instituto Hórus, 2024) and aquaculture escapes (Sampaio et al., 2017). Similarly, *P. managuensis*, native to Central America, has been introduced through aquaculture escapes (Barbosa et al., 2017; França et al., 2017), aquarium trade, and recreational fishing (Instituto Hórus, 2024). While some trades are legal, improper handling can lead to accidental escapes, further contributing to the spread of non-native species (Gubiani et al., 2018). For that, stronger enforcement of regulations on the trade and cultivation of non-native fish for economic, recreational, or aesthetic benefits is essential to prevent new introductions.

Heterotilapia buttikoferi and *P. managuensis* have been recorded in various biomes and habitats with distinct characteristics (e.g., streams, rivers, and reservoirs), highlighting their high adaptability to different environmental conditions. Once introduced, these species may benefit from the absence of natural predators and their capacity to thrive in diverse environments. Human-induced environmental alterations also exacerbate biological invasions by creating conditions that favor the establishment of non-native species (Pyšek et al., 2020; Comte et al., 2021). For example, artificial reservoirs have been found to support non-native species, often undermining more sensitive native populations (Johnson et al., 2008; Pereira et al., 2018).

The ecological impacts of *H. buttikoferi* on native ecosystems remain poorly understood; however, due to its many similarities with other Tilapia species, such as high physiological plasticity and the ability to tolerate broad environmental variations, it has the potential to cause massive invasions and impacts (Sampaio et al., 2017). Similarly, *P. managuensis* poses a significant threat to native communities due to its carnivorous diet and aggressive behavior (Barbosa et al., 2006). There is also evidence that this species has caused population decline in at least one native taxon where it has been introduced (Instituto Hórus, 2024). The Jaguar guapote is tolerant to salinity (Mendonça & Barbosa, 2005; Mendonça et al., 2006), the record reported in this study was in a brackish water ecosystem (mangrove). Other invasive cichlids have already been recorded in marine environments in Brazil (Franco et al., 2024), which may pose risks to biodiversity in both freshwater and marine environments. Furthermore, brackish estuaries are already known for harbouring a large number of non-native tolerant fish species which colonise upper to middle portions of these ecosystems, despite salinity conditions. This highlights the potential use of these ecosystems as stepping-stones or "salty bridges" for further spread phase of invasive processes through other basins by species that can endure moderate to high salinities, such as Cichliformes that have primary marine origin (Gutierre et al., 2014).

Management and conservation measures are essential to minimize the impacts of these biological invasions, and a contributory model of citizen science can play a crucial role in this process (Pocock et al., 2024). Systematic monitoring of non-native populations by local communities, in collaboration with researchers, can enhance early detection and help prevent the spread of invasive species (Essl et al., 2020; Pocock et al., 2024). Awareness programs, leveraging citizen engagement, can also educate the public about the risks associated with the introduction of non-native fish species and help implement joint actions to manage (control and/or eradicate) non-native fish species.

It is important to acknowledge that relying on a contributory model of citizen science involves potential limitations, such as species misidentification and sampling biases (Brown & Williams, 2019; Johnston et al., 2023). For this reason, the data should be validated by experts and complemented with other scientific sources to ensure more robust and reliable conclusions (Brown & Williams, 2019). Additionally, for this study, public participation was restricted to the provision of observational data, such as the posting of photographs and videos on social media. We acknowledge that this study does not encompass all dimensions of citizen science, and that this model of involvement may limit opportunities for co-production of knowledge and weaken community ownership or long-term engagement in the monitoring (Eicken et al., 2021). Despite these limitations, this approach remains a valuable and cost-effective tool for expanding the spatial and temporal coverage of biodiversity monitoring, which is especially urgent in the face of the rapid spread and growing impacts of invasive species.

5. Conclusion

The study reports updated geographic distributions of two non-native cichlid fish species in Brazil, *H. buttikoferi* (zebra tilapia) and *P. managuensis* (jaguar guapote), by combining contributory model of citizen science (e.g., data collected via social media) with published records. These species have been found across multiple river basins and habitats, including freshwater and brackish environments, demonstrating their adaptability and potential for further spread.

By demonstrating the utility of contributory data sources such as social media for updating species distributions, this approach can significantly enhance early detection and surveillance capabilities across vast and diverse ecosystems. Integrating these data with traditional monitoring methods allows for more comprehensive and cost-effective management strategies. Furthermore, fostering engagement with local communities and stakeholders through targeted communication channels may strengthen data flow and support adaptive management.

Future efforts should focus on expanding the network of contributors, and assessing the ecological impacts of invasive species through complementary field studies. These steps will help to refine monitoring efforts and inform more effective conservation actions to protect native biodiversity.

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Data availability

The entire dataset supporting the results of this study has been published in the article itself.

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