

# RE-DISCOVERY OF THE INVASIVE GUPPY *POECILIA RETICULATA* (PETERS, 1859) (POECILIIDAE) IN MOROCCO

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The aquarium and pet trade represents a significant vector for biological invasion, with animals escaping or being released by traders and hobbyists. This can have environmental and/or economic impacts, facilitating the spread of alien species across the globe. One of the best-known aquarium fish is the guppy *Poecilia reticulata* (Peters, 1859), a popular ornamental fish, native to America but extensively distributed globally through the aquarium trade. This invasive fish species was recorded from a single site in Morocco in 1973 and was thought to have disappeared from the wild. This study highlights the first observation of the guppy in the thermal waters of Sidi Hrazem, thus extending its range into the Sebou basin and Morocco. The aim of this paper is to update our knowledge of the guppy *Poecilia reticulata* in Moroccan waters by presenting a new record of this invasive species, providing insights into the impact of the ornamental animal trade on its progressive spread and improving our understanding of its ecology in the invaded areas of North Africa.

**Keywords:** alien species, tropical aquarium fish, progressive dispersal, new records, North Africa

El Caidi, S., Taybi, A.F. & Mabrouki, Y.: Ponovni nalaz invazivne ribe gupi *Poecilia reticulata* (Peters, 1859) (Poeciliidae) u Maroku. *Nat. Croat.*, Vol. 34, No. 1, 111-118, Zagreb, 2025.

Trgovina akvarijskim i kućnim ljubimcima predstavlja značajan vektor za biološke invazije, pri čemu životinje mogu ili pobjeći, ili ih puštaju trgovci i hobisti. To može imati utjecaj na okoliš i/ili ekonomiju, omogućavajući širenje stranih vrsta diljem svijeta. Jedna od najpoznatijih akvarijskih riba je gupi *Poecilia reticulata* (Peters, 1859.), popularna ukrasna riba porijeklom iz Amerike, široko globalno rasprostranjena putem akvarijske trgovine. Ta invazivna vrsta ribe zabilježena je samo na jednom mjestu u Maroku 1973. godine i otada se smatralo da je nestala iz divljine. Ovaj rad ističe prvo opažanje gupija u termalnim vodama Sidi Hrazema, čime se proširuje njen areal na područje Sebou i Maroko. Cilj ovog rada je ažurirati naše znanje o vrsti *Poecilia reticulata* u marokanskim vodama predstavljanjem novog nalaza te invazivne vrste, pružajući uvid u utjecaj trgovine ukrasnim životinjama na njezino progresivno širenje i poboljšavajući naše razumijevanje njene ekologije u zahvaćenim područjima sjeverne Afrike.

**Ključne riječi:** strane vrste, tropske akvarijske ribe, progresivno širenje, novi nalazi, sjeverna Afrika

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## INTRODUCTION

Biological invasions are a major global challenge in our time; invasive species cause significant losses to biodiversity and to ecological services, to the global economy, and can directly harm agriculture and public health (DGEBUADZE *et al.*, 2018; HAUBROCK *et al.*, 2021). One of the most important pathways for biological invasions is the deliberate introduction of animals from the ornamental pet trade and aquariums. Although the majority of animals in this poorly regulated industry are confined throughout their lives, many animals escape deliberately or are released by traders or retailers (RAGHAVAN *et al.*, 2013; LOCKWOOD *et al.*, 2019).

One of the most successful and well known aquarium fishes is the Guppy *Poecilia reticulata* (Peters, 1859). Guppies, or millionfish, belonging to the family Poeciliidae Bonaparte, 1831, are tropical fish popular in the aquarium trade and for the breeding of many ornamental lines, known for their bright colours and livebearers, and are widely distributed throughout the world (GBIF, 2023).

Guppies are native to north-eastern South America and are characterised by sexually dimorphic colouration, which allows individuals of different sexes to be clearly distinguished. Male guppies are smaller than females and have caudal and dorsal fins for aesthetic display. Due to their vibrant colours, unassuming nature, small size (from 0.6 to 2.4 inches), straightforward breeding process and hardy qualities, guppies have become cosmopolitan and have flourished in many different countries throughout the Americas, Europe, Asia, Australia and Africa (HERRE, 1940; FROESE & PAULY, 2000; GBIF, 2023; NEKRASOVA *et al.*, 2023).

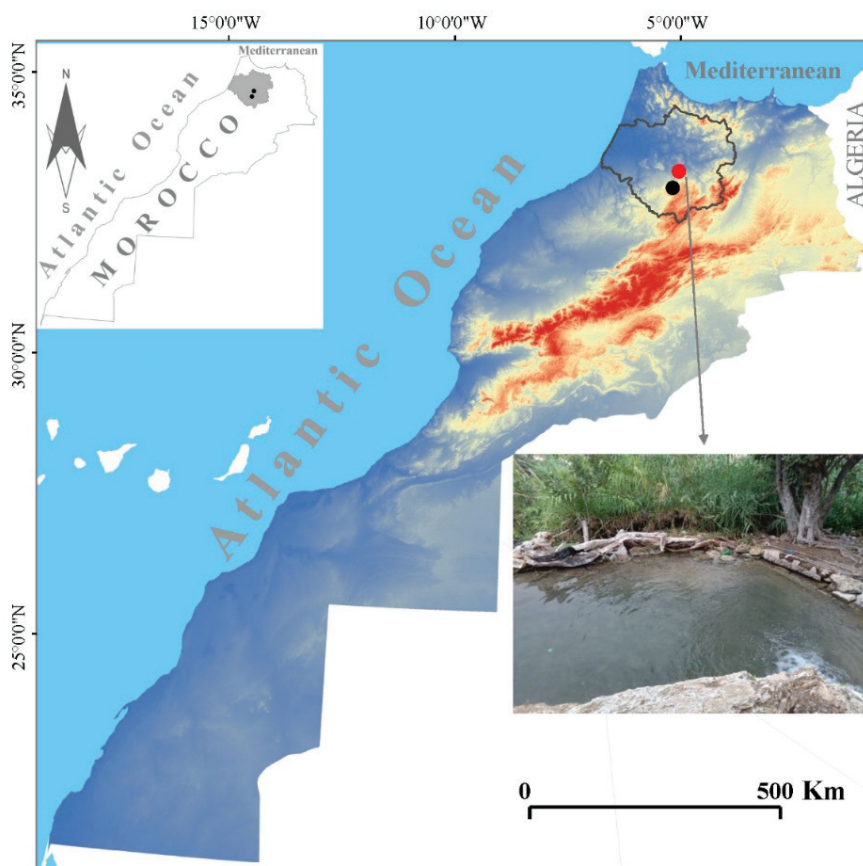
In Africa, *Poecilia reticulata* has been documented in 41% of countries. This species was introduced into West, East and Central Africa for the biological control of mosquitoes (PRITCHARD CAIRNS *et al.*, 2024). In the late 1980s, introductions related to the ornamental trade in South Africa resulted in the escape of captive fish, with its populations now mainly restricted to urban freshwater habitats. Occurrences of *Poecilia reticulata* are rare in North Africa and were observed only in Algeria and Morocco in the 1970s (PIMENTEL *et al.*, 2001; iNaturalist community, 2024; PRITCHARD CAIRNS *et al.*, 2024; SNOEKS & THEETEN, 2024).

A wild population of *P. reticulata* was discovered in Morocco in 1973. At that time, the species was only known from one site, Imouzzar Kandar spring (GBIF, 2023), which has since dried up. We therefore decided to exclude this species from our recently published list of invasive taxa with confirmed presence in Moroccan continental waters (TAYBI *et al.*, 2023a). Recent extensive surveys in Morocco have, however, revealed new populations of the guppy *Poecilia reticulata*. The aim of this study is to update information about this invasive species in Moroccan waters, to shed light on its progressive spread and to improve the understanding of its ecology in the invaded regions of North Africa.

## MATERIALS & METHODS

The guppies were caught by dragging a fishing net during routine hydrobiological and monitoring studies on the occurrence and impact of invasive species in Morocco, which we have been conducting since 2014. The field studies were carried out in different parts of the country, mainly in the north, in, for example, the Moulouya river basin, the Middle Atlas massif and the Sebou river basin (Fig. 1). Quantitative sam-

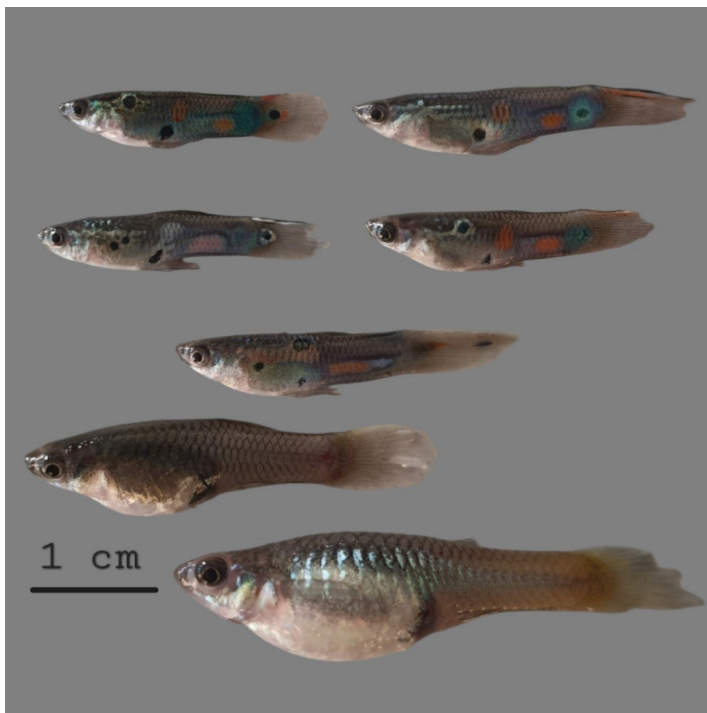
pling of the fish fauna was carried out using nets, searching for the most suitable areas for the species studied. Sampling lasted an average of one hour over an area of 10m<sup>2</sup> at each station, enough time to capture virtually all the fish in each area. Captured alien species were measured using callipers and preserved in 90% ethanol or 10% formalin solution, while native fish (especially Cyprinidae juveniles) were returned to the water after measurement (see TAYBI *et al.*, 2020 for more details). Conductivity, pH, dissolved oxygen and temperature were measured *in situ* with a multiparametric measuring device (WTW, MultiLine P4). The biological oxygen demand after 5 days (BOD<sub>5</sub>) and nitrate (N–NO<sub>3</sub>) of the water were measured in the laboratory. Voucher specimens of *Poecilia reticulata* were deposited at Sidi Mohamed Ben Abdellah of Fez, Morocco (USMBA, EC, 101023). The benthic invertebrate fauna of the site was also collected, using a Surber sampler (with a surface of 20 × 25 cm) equipped with a 500 mm mesh net.



**Fig. 1.** Distribution of *Poecilia reticulata* in the Sebou river basin and Morocco (old record black, new record red) and its habitat at Sidi Harazem river.

## RESULTS

After being considered to have disappeared and being excluded from the list of invasive taxa with confirmed presence in Moroccan continental waters, *Poecilia reticulata* was rediscovered in the country from a new locality. The invasive fish was recorded from another site in the Sebou river basin, from the thermal waters of the Sidi Hrazem river (Figs.1-2, Tab. 1). The lack of studies on the Moroccan ichthyofauna could be the reason why this distribution has not been previously detected. As the northern part of Morocco has recently been extensively surveyed for fish species (including the Oriental region and the Sebou river basin), future surveys may report this species elsewhere. In the new locality, *P. reticulata* was found near river banks and among aquatic vegetation, often associated with shallow, stagnant or slowly flowing water. The species was found with two highly endemic freshwater fish species i.e. the Moroccan barb *Carasobarbus fritschii* Günther, 1874, and the Moroccan spiny loach *Cobitis maroccana* Pellegrin, 1929. In addition to the invasive mosquito fish *Gambusia holbrooki* Girard, 1859, the latter species was largely dominant. The viperine water snake *Natrix maura* (Linnaeus, 1758) and the Saharan frog *Pelophylax saharicus* (Boulenger in Hartert, 1913) were also found.



**Fig. 2.** The different males and females of *P. reticulata* captured in Sidi Harazem river, Morocco.

The aquatic invertebrate fauna of the site consists of: *Physella acuta* (Draparnaud, 1805), *Melanopsis* cf. *praemorsa* (Linnaeus, 1758) and *Melanoides tuberculata* (O.F. Müller, 1774) (Mollusca); *Anax parthenope* Selys, 1839 and *Gomphus simillimus maroccanus* Lieft-

inck, 1966 (Odonata); *Baetis* sp. and *Habrophlebia* sp. (Ephemerotera); *Laccobius* sp. and *Hydraena* sp. (Coleoptera); *Hydropsyche* sp. (Trichoptera); and different dipteran larvae (Chironomidae and Culicidae).

All fish (fifteen specimens) had the same morphotype. The size interval of the captured fish varies from 2.1 to 3.3 cm for males (measured to the tip of their caudal fin) and from 3.1 to 5.3 cm for females. The number of captured individuals of *P. reticulata* is relatively low in this first study. This could either be due to the competition with *Gambusia holbrooki*, which was largely dominant in invaded sites, or to *P. reticulata* specimens having been confused with *G. holbrooki*, given the strong resemblance between juveniles and immature females of the two species. The abundance and physico-chemical parameters of the water at each new site are presented in Tab. 1.

**Tab. 1.** Abundance of *P. reticulata* and mean value of the water parameters measured at the sampling locality.

Sampling site	Sampling date	Number of specimens & size interval	Temperature	pH	Conductivity	Dissolved oxygen	BOD5	Nitrate
Sidi Harazem 34°01'41.6"N 4°53'03.7"W	10/10/2023	8 ♂ (2.1–3.3 cm ) 7 ♀ (3.1–5.3 cm)	29°C	6.9	1024 µs.cm-1	7,2 mg.l-1	6.45 mg.l-1	2.5 mg.l-1

DISCUSSION

The common guppy is recorded for the first time in the thermal waters of the Sidi Hrazem river. This new record is close to the first record from Imouzzer Kandar in 1973 and all belong to the Sebou river basin, one of the basins in Morocco most heavily invaded by alien fish species (TAYBI *et al.*, 2023a). The new finding certainly provides further evidence of the longstanding presence of the alien fish in the Sebou River basin, and particularly in the Fez-Meknes area. And as thermal springs and thermally polluted waters are known hotspots for non-native and potentially invasive species, monitoring of these sites is highly recommended.

Our work confirms the existence of acclimated wild populations of the common guppy *Poecilia reticulata* in Morocco, together with the eastern mosquitofish *Gambusia holbrooki* (Girard, 1859) and the swordtail *Xiphophorus hellerii* Heckel, 1848, bringing the number of Poeciliidae species occurring in Morocco to three, and the total number of alien fishes with confirmed presence in the country’s continental waters to 23 (FORD *et al.*, 2020; TAYBI *et al.*, 2023a). Most of these species were deliberately introduced during the 20th century through fish stocking programmes. Meanwhile, commercial activities related to aquarium and ornamental species appear to be the new emerging source favouring colonisation by many alien species in the freshwater ecosystems of Morocco (MABROUKI *et al.*, 2020; 2023a, b; TAYBI *et al.*, 2016; 2021; 2023b; 2024). The introduction of guppies to the African continent has been primarily aimed at the biological control of mosquitoes. Indeed, this species has demonstrated efficacy in controlling mosquito vectors and reducing *Plasmodium falciparum* Welch, 1897 infections in children in Grande Comore and Nigeria (SABATINELLI *et al.*, 1991; DEACON *et al.*,

2011; LAWAL *et al.*, 2012). Nevertheless, this does not appear to be the case in Morocco, where the prevailing approach is to introduce mosquitofish (*Gambusia holbrooki*) for mosquito control purposes. This suggests that the introduction of *P. reticulata* into the Moroccan wild has been mainly through the aquarium fish trade.

The alien *Poecilia reticulata* was found in a relatively stressed ecosystem in Morocco, either by organic pollution or by habitat alteration and modification in general, demonstrating ecological plasticity. The same observation has been made in various parts of the world (NOWAK *et al.*, 2008; NEKRASOVA *et al.*, 2023). Indeed, guppies owe their worldwide success to their adaptability and ability to thrive in a wide range of environmental and ecological conditions. The species is opportunistic and omnivorous. It has a wide range of feeding options, from benthic algae to aquatic insect larvae, and its food preferences vary seasonally (LAWAL *et al.*, 2012). Furthermore, this small fish with a benthopelagic lifestyle can inhabit a wide range of aquatic environments including estuaries, lakes, ponds, weedy ditches and canals. It is also able to adapt to niches in habitats that have been altered by human activities (PAGE & BURR, 1991; LAWAL *et al.*, 2012; NEKRASOVA *et al.*, 2023). *Poecilia reticulata* has good cold water tolerance (up to +12°C) and can thrive in hot and thermal waters (STRECKER *et al.*, 2011; NEKRASOVA *et al.*, 2021). Like all members of the Poeciliidae family, *P. reticulata* is an ovoviviparous freshwater fish. Females have the ability to store sperm for months, making it possible for even a single gravid female to start a new population (EVANS & MAGURRAN, 2020). Guppies have been observed to dominate the fish community in areas where they have been introduced. The introduction of these exotic fish species has led to population declines of native species through predation, including on native fish species and invertebrates (BREWER *et al.*, 1999; PORTILLA *et al.*, 2023). Consequently, it is necessary to carry out in-depth ecological monitoring studies of this invasive species in the ecosystems it has invaded, in Morocco and North Africa in general, in order to develop an effective invasive species management plan.

In recent years, the poorly regulated pet trade and aquarium trade have facilitated the spread of numerous non-native species in Moroccan freshwater, making it the country's main pathway for invasive species. As this sector is responsible for ecological and economic impacts, it requires increased control and regulation to mitigate the potential introduction of new alien species.

## CONCLUSION

This study reports for the first time the presence of the common guppy (*Poecilia reticulata*) in the thermal waters of the Sidi Hrazem River, thus extending its range into the Sebou basin, which is already heavily invaded by exotic species. This finding highlights the guppy's ability to adapt to disturbed environments, giving rise to concern for local biodiversity. It is crucial to step up ecological monitoring of these sites and regulate the aquarium fish trade in order to limit the introduction of new invasive species and protect Morocco's aquatic ecosystems.

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