BioInvasions Records (2024) Volume 13, Issue 1: 233–240

Rapid Communication

# First record of the Asian freshwater fish *Pseudorasbora parva* (Temminck and Schlegel, 1846) from Lake Bracciano (Central Italy)

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**Citation:** Ventura M, Valente T, Seminara M, Careddu G, Sporta Caputi S, Calizza E, Rossi L, Costantini ML (2024) First record of the Asian freshwater fish *Pseudorasbora parva* (Temminck and Schlegel, 1846) from Lake Bracciano (Central Italy). *BioInvasions Records* 13(1): 233–240, https://doi.org/10.3391/bir.2024.13.1.21

**Received:** 28 June 2023

**Accepted:** 16 October 2023

**Published:** 9 December 2023

**Handling editor:** Markéta Ondračková

**Thematic editor:** Karolina Bącela-Spychalska



## Abstract

The presence of the cyprinid *Pseudorasbora parva* is here reported for the first time in Lake Bracciano (Central Italy), a dormant volcanic lake not connected to other water bodies. The lake, historically classified as oligo-mesotrophic, has a surface area of 57 km$^2$ and its maximum depth is 165 m. *Pseudorasbora parva* specimens were first collected during a fish community survey in 2017 and again in 2022. Their total length and body weight ranged from 21 and 81 mm and from 0.25 and 6.43 g, respectively. Since Lake Bracciano is not part of a system of connected water bodies, this record could be evidence of at least a translocation event prior to the first record of 2017, suggesting the need for additional studies and measures to deal with the spread of this invasive species.

**Key words:** alien species, first detection, introduced species, pan-continental invasion, stone moroko, topmouth gudgeon

## Introduction

The topmouth gudgeon *Pseudorasbora parva* (Temminck and Schlegel, 1846), also known as the stone moroko, is a small cyprinid originating from eastern Asia. Its average total length is 8 cm (5.2 g according to the length-weight relationship reported in Verreycken et al. 2011), although specimens up to 12.5 cm (21.6 g) have been found (Berg 1964; Verreycken et al. 2011). The native range includes the catchments of the Amur River and the Pearl River in mainland Asia, as well as the islands of Taiwan, Hainan and part of Japan (Gozlan et al. 2002, 2010). This species can be found in both lentic and lotic waters, including brackish waters, and exhibits high plasticity in habitat use (Cakic et al. 2004; Gozlan et al. 2010; Onikura and Nakajima 2013). Its tolerance of a wide variety of environmental conditions, together with distinctive life history traits (e.g. rapid growth, early maturity and high fecundity; Katano and Maekawa 1997; Britton et al. 2007) and the ability to deal with generalist pathogens and parasites (Czeczuga et al. 2002; Kakalova and Shonia 2008), enable *P. parva* to rapidly establish permanent populations when introduced into new water bodies (Caiola and De Sostoa 2002; Gozlan et al. 2002, 2010; Lusk et al. 2010).

Mainly due to the development of cyprinid aquaculture and ornamental fish trade, in the 1950s *P. parva* was accidentally introduced into almost all freshwater ecosystems in the countries/regions surrounding the Sea of Japan, where it was not originally distributed (Hokkaido island in Japan, China and Mongolia; Gozlan et al. 2010; Bogutskaya 2022). Between the 1960s and 1990s, *P. parva* was also introduced into many European countries, maybe due to the accidental transfer of eggs during the import of carp eggs for farming purposes (Bănărescu 1964; Bianco 1988). The remarkable phenotypic plasticity of this species and the high level of genetic diversity have facilitated the dispersion of *P. parva* in non-native countries (Falka et al. 2007; Gozlan et al. 2010). Furthermore, possibly due to its small size and dim colouring, the presence of *P. parva* is often reported for the first time when the population is already established, on average after 4 years, which reduces the possibility of eradication (Britton et al. 2008; Gozlan et al. 2010). As a result, in less than 50 years *P. parva* has become a pan-continental invasive species, with at least 32 countries invaded from Central Asia to North Africa (Perdices and Doadrio 1992; Gozlan et al. 2010).

The first report of *P. parva* in Italy dates back to 1988 when it was found in irrigation channels in Emilia Romania (north-east Italy). Later *P. parva* reached the Po River (the largest Italian river catchment area; Sala and Spampanato 1990). In 1994 the presence of the species was reported in central Italy (Umbrian stretch of Tiber River and Chiascio River, Carosi et al. 2016). From here *P. parva* rapidly spread in all directions, probably due to natural dispersion (Carosi et al. 2016; Puzzi et al. 2021). Italian literature highlights that at the end of the 1990s the species was already acclimatized in Lake Trasimeno (Ghetti et al. 2007; Lorenzoni and Ghetti 2012). Currently stable populations of the species are present in all regions of northern and central Italy (Bianco and Ketmaier 2001; Carosi et al. 2016; Puzzi et al. 2021). The lack of records in southern Italy has been attributed partly to limited data availability but is more likely due to the fact that the species initially colonized the Po River basin, gradually expanding southwards (Puzzi et al. 2021). We present here the first records of *P. parva* from the isolated Lake Bracciano (Central Italy).

## Materials and methods

### *Study area*

Lake Bracciano is one of the largest (57 km$^2$) and deepest (165 m) lakes in central Italy, situated about 30 km northwest of Rome. It has one emissary (the Arrone River), which is currently not fed by the lake because the lake is below the outflow level (Ventura et al. 2023). The lake, historically classified as oligo-mesotrophic with increasing anthropogenic N inputs in summer (Fiorentino et al. 2017), is located in the Natural Regional Park of Bracciano-Martignano and includes several Natura 2000 sites (https://natura2000.eea.europa.eu/). It hosts a rich variety of aquatic flora and fauna, including endemic

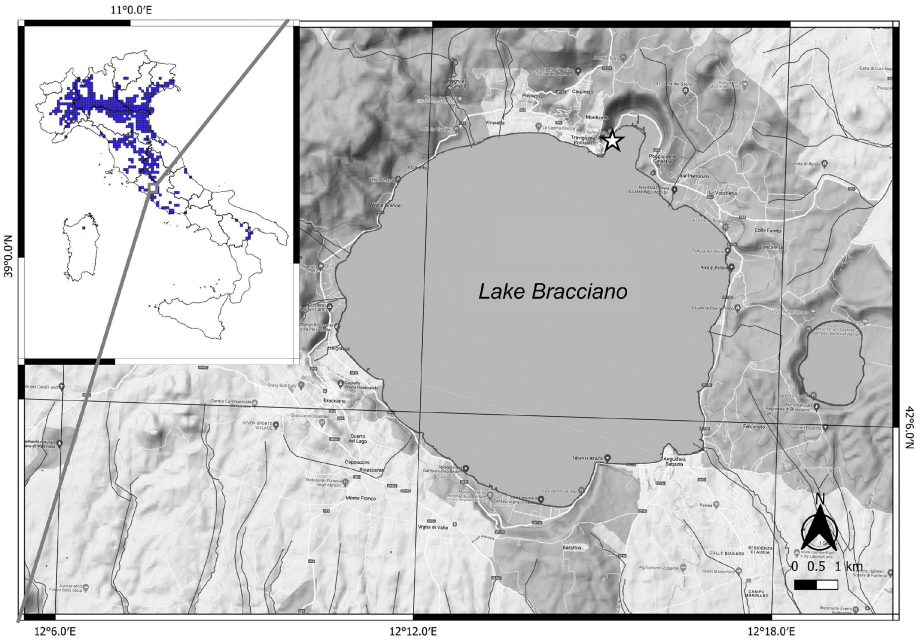


**Figure 1.** Distribution of *Pseudorasbora parva* in Italy (from Puzzi et al. 2021) with detail of Lake Bracciano (Central Italy, Natural Regional Park of Bracciano-Martignano). The star symbol indicates the sampling location (42°9.464'N, 12°15.061'E) where two specimens of *P. parva* were caught in August 2022.

species and fish of major economic interest (Calizza et al. 2021; Ventura et al. 2023). However the original structure of the fish community has been strongly modified by species introduction and restocking. As a result, non-native fishes are almost more numerous than native ones. They include the largemouth bass (*Micropterus salmoides* Lacépède), the whitefish (*Coregonus lavaretus* L.), the European perch (*Perca fluviatilis* L.), the pumpkinseed (*Lepomis gibbosus* L.), the gambusia (*Gambusia holbrooki* Girard), the crucian carp (*Carassius carassius* L.), the common rudd (*Scardinius erythrophthalmus* L.), the Eurasian ruffe (*Gymnocephalus cernua* L.), the Common carp (*Cyprinus carpio* L.) and the roach (*Leucos aula* Bonaparte) (Ventura et al. 2023).

### *Sample collection and measurements*

Water temperature, pH, dissolved oxygen and dissolved solids were recorded seasonally in 2017 along the littoral belt of the lake by multiparameter probe (Hanna instruments HI 9829). Twenty-six *P. parva* specimens were caught around the lake for the first time in July 2017 by electrofishing (Scubla IG200-2, up to the maximum depth of 1.5 m) during a fish community survey. Specimens were brought in laboratory, wet-weighed and their total length measured to the nearest mm. Not being aware that the presence of the species had not yet been reported in Lake Bracciano, samples were deydratated and pulverized for stable isotope analysis. Another two specimens were sampled during a fish community survey in August 2022 from the north-western shore of the lake (Figure 1) using umbrella fishing pots (90 × 30h cm, 9 holes) positioned at a depth of 2 m. Accurate photographs of these two specimens were taken for the present report and morphometric parameters were measured.

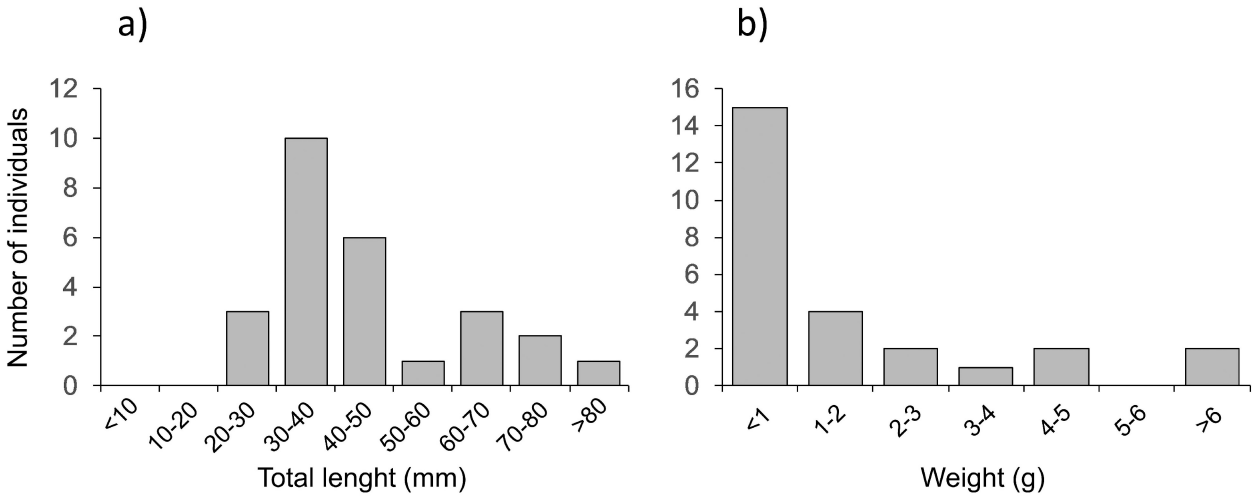


**Figure 2.** Distribution of the total length (a) and body weight (b) of the 26 *Pseudorasbora parva* caught in Lake Bracciano in June 2017.

## Results

In 2017 the min-max values of the main physicochemical parameters along the littoral belt of the lake were on average (± SE): temperature (°C) 12.3 ± 0.6–25.1 ± 1.2, pH 8.0 ± 0.6–8.7 ± 0.3, dissolved oxygen (mg/L) 8.1 ± 1.0–12.1 ± 1.4, total dissolved solids (ppm) 230.4 ± 9.1–250.1 ± 8.1.

The average (min-max) total length and body weight of the 26 *P. parva* specimens collected in 2017 were 46 mm (21–81 mm) and 1.67 g (0.25–6.43 g) respectively. Most of these specimens (10, accounting for 38% of the total caught) had a total length between 30 and 40 mm (Figure 2a). The second most representative group (6 individuals, 23% of the total) had a total length of 40–50 mm. The body weight of the majority of *P. parva* (15 specimens, 57% of the total number) was less than 1 g (Figure 2b). Other fish species sampled were *Lepomis gibbosus*, *Salaria fluviatilis* Asso, *Micropterus salmoides*, *Scardinius erythrophthalmus*, *Carassius carassius* and *Esox* sp. *Pseudorasbora parva* accounted for 18% of the total numbers and 2% of the total biomass of all fishes caught.

Photographs of the two *P. parva* specimens collected in 2022, together with morphological characteristics, are provided in Figure 3. The individuals' body parameters are shown in Table 1. Both individuals were similar in body weight, length, depth and width.

## Discussion

The detection of the cyprinid *P. parva* in Lake Bracciano, which is one of the largest and deepest Italian lakes, provides an important update concerning the expansion of the non-native range of the species. *Pseudorasbora parva* has been classified as an international pest and is listed as an invasive alien species of European Union concern (Welcomme 1992; European Commission 2016). Indeed, it can become numerically dominant in the fish communities of lentic ecosystems, becoming a potential vector of emergent infectious diseases

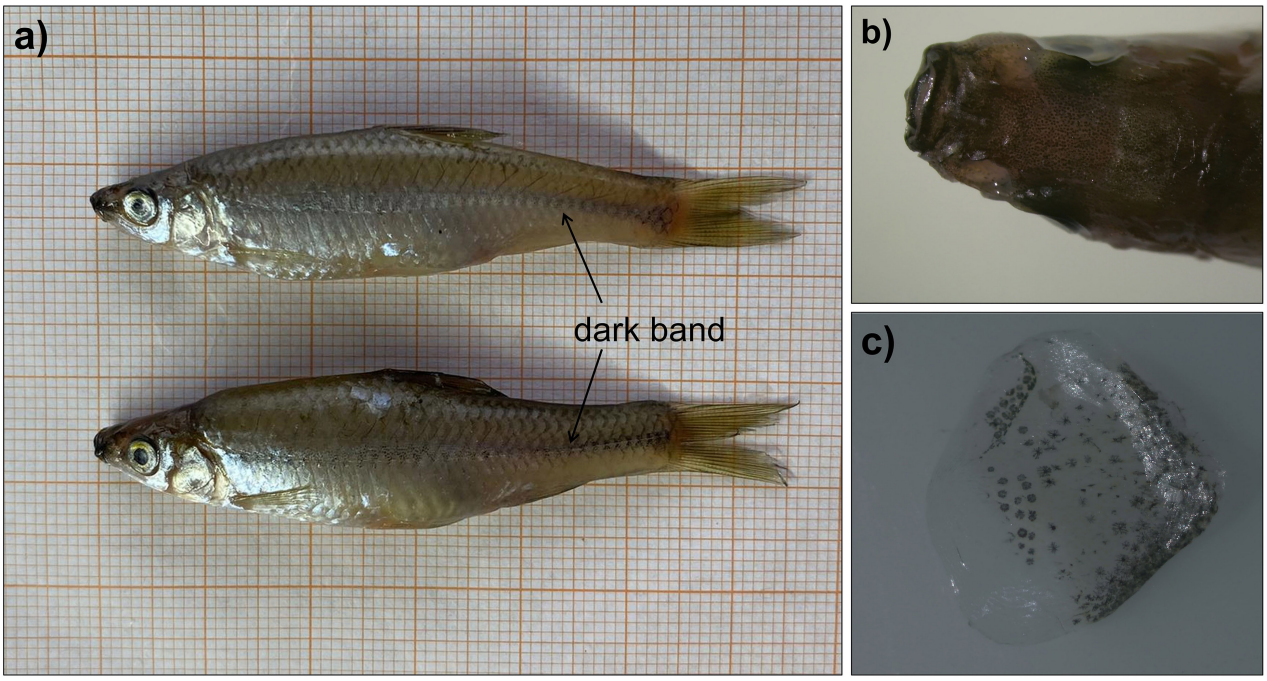


**Figure 3.** Photographic report of two specimens of *Pseudorasbora parva* caught in Lake Bracciano in August 2022. a) Specimens on graph paper; arrows indicate the distinctive dark longitudinal bands running along the lateral line, from the posterior margin of the orbit to the origin of the caudal fin. b) Detail of the mouth. c) Dorsal scale, strongly pigmented on the posterior edge. Photo credit: authors.

**Table 1.** Body parameters of the two specimens of *Pseudorasbora parva* caught in Lake Bracciano in August 2022.

| Body parameters | Specimen 1 | Specimen 2 |
|---|---|---|
| Body weight (g) | 2.93 | 3.19 |
| Total length (mm) | 66 | 65 |
| Standard length (mm) | 54 | 53.5 |
| Fork length (mm) | 61 | 57 |
| Body depth (mm) | 13 | 13 |
| Body width (mm) | 8 | 8.5 |
| Number of scales in lateral line | 38 | 37 |

(Gozlan et al. 2005) and a strong competitor of native species for food and habitat (Britton et al. 2007, 2010). It has successfully invaded lakes with different trophic conditions, from oligotrophic to hypereutrophic (Ciutti et al. 2011; Traczuk et al. 2023). Furthermore, although small invertebrates are the species' preferred prey (Hliwa et al. 2002; Yalcin-Ozdilek et al. 2013), *P. parva* can also feed on the eggs of other fish, thus hindering their recruitment (Britton et al. 2007; Yalcin-Ozdilek et al. 2013). In other words, *P. parva* being an alien fish, can affect the local aquatic fauna living in Lake Bracciano. It can have potential cascading effects on the entire food web, which is already endangered by the presence of many other allochthonous species introduced in recent decades (Costantini et al. 2018; Ventura et al. 2023).

*Pseudorasbora parva* specimens caught in Lake Bracciano in 2017 were mainly small individuals (< 40 mm total length or < 1 g body weight) and constituted a low percentage of total fish biomass compared to other ecosystems where populations were found to be well-established, in Italy (Ciuffardi et al. 2014; Nocita et al. 2022) and in other countries (Britton et al.

2007, 2010; Traczuk et al. 2023). This could indicate a recent introduction and a not-structured population by size. The small sample caught in 2022 (only 2 individuals) cannot be considered in terms of size structure nor compared with the 2017 sample due to the different sampling methods, which differ in terms of effectiveness in capturing *P. parva* (Kajgrová et al. 2023).

Although it is not currently possible to establish the circumstances and mode of the introduction, the present record represents an alarm bell. The measures implemented by European countries to resist invasion by *P. parva* (e.g. the ban on the transport of live specimens and the development of management plans; EU Regulation No. 1143/2014) have limited the spread of this species, which in recent years has been mainly due to riverine dispersal (Pinder et al. 2005; Gozlan et al. 2010). However, since Lake Bracciano is not connected to other water bodies, the detection of *P. parva* in this basin could be evidence of the persistence of translocation events, possibly connected to the restocking of other species but also to the use of *P. parva* by anglers as live bait for fishing pike, perch or black bass (Puzzi et al. 2021). These events may increase the genetic variability to non-native populations and further strengthen the harmful potential of this invasive species (Dlugosch and Parker 2008).

Further studies will be needed to understand the origin of the introduction of *P. parva* into Lake Bracciano and to investigate the extent and current trend of the invasion. Understanding the role of *P. parva* in lake food webs will be crucial for the management and protection of the lake's rich biodiversity, including native fish species of high commercial importance to the local economy (Calizza et al. 2021; Ventura et al. 2023).

## Acknowledgements

We thank the Regional Natural Park of Bracciano-Martignano for granting permission necessary for sampling activity. We thank two anonymous reviewers and the associate editor for their comments and suggestion, which greatly improved the manuscript.

## Funding declaration

Sampling activities were founded by Sapienza Starting Grants ("Avvio alla Ricerca" 2022 – Giulio Careddu) grant number 302_22_AVVIO RICERCA_G._CAREDDU. The APC was funded by Department of Environmental Biology, Sapienza University of Rome, 00185 Rome, Italy (PhD founding of Matteo Ventura) grant number 302_23_DOTTORATO_CTB_22_MANZI. The funders had no role in study design, data collection and analysis, decision to publish, or preparation of the manuscript.

## Authors' contribution

Conceptualization, M.V.; writing – original draft, M.V.; visualization, M.V., T.V., G.C., S.S.C., E.C.; writing – review and editing, M.V., T.V., M.S., G.C., S.S.C., E.C., L.R., M.L.C.; supervision, M.L.C.; funding acquisition, M.V, G.C. All authors have read and agreed to the published version of the manuscript.

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