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Rapid Communication**First record of the large-scale loach *Misgurnus dabryanus* (Guichenot, 1872) (Teleostei, Cobitidae) in France**Alain Cuinet¹, Gaël P.J. Denys^{2,3}, Sylvain Besson⁴, Yves Marchiset⁵ and Julien Bouchard⁴¹Eaux Continentales, 29 rue Principale, 25440 Chay, France²UAR Patrimoine Naturel – Centre d'expertise et de données (2006 OFB – CNRS – MNHN – IRD), Muséum national d'Histoire naturelle, 36 rue Geoffroy-Saint-Hilaire CP 41, 75005 Paris, France³UMR Biologie des organismes et écosystèmes aquatiques (BOREA 8067), MNHN, CNRS, IRD, SU, UCN, UA, 57 rue Cuvier CP26, 75005 Paris, France⁴Office Français de la Biodiversité, Direction Régionale Bourgogne / Franche-Comté, 57 rue de Mulhouse, 21000 Dijon, France⁵Syndicat Mixte d'Aménagement de la Basse et Moyenne Vallée de l'Ognon, 8 Rue Fred Lipmann, 70190 Boulot, FranceCorresponding author: Gaël P.J. Denys (gael.denys@mnhn.fr)

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Received: 22 September 2023**Accepted:** 19 December 2023**Published:** 21 April 2024**Handling editor:** Tatenda Dalu**Thematic editor:** Kenneth Hayes**Copyright:** © Cuinet et al.This is an open access article distributed under terms of the Creative Commons Attribution License ([Attribution 4.0 International - CC BY 4.0](https://creativecommons.org/licenses/by/4.0/)).**OPEN ACCESS****Abstract**

A specimen of weatherloach was caught in the Lanterne stream at Chevigny-sur-l'Ognon (Rhône catchment, Doubs department, eastern France) on the 22nd of July 2020. It was photographed and initially identified as European weatherloach *Misgurnus fossilis* before being released. Upon further examination of the photographs, looking at the adipose crests on the caudal peduncle, the coloration pattern and morphometric data of the head, the specimen was then correctly identified as a non-native large-scale loach *Misgurnus dabryanus*, thus being the first record of this species in France. Monitoring must be put in place to know if there is an established population and to follow its possible propagation.

Key words: weatherloach, Rhône drainage, invasive freshwater fish species, morphology**Introduction**

The last decades have seen a steadily increasing number of introductions—intentional or not—in natural habitats of alien, and potentially invasive, freshwater fish species (Leprieur et al. 2008; Thomaz et al. 2015; Turbelin et al. 2017). One of the causes is the ornamental fish trade, which has allowed to disperse many exotic fish species all over the world (Padilla and Williams 2004; Strecker et al. 2011; Maceda-Veiga et al. 2013; Chan et al. 2019), thus having numerous impacts on the native aquatic fauna (Gozlan et al. 2010; Cucherousset and Olden 2011).

Asian weatherloaches *Misgurnus* spp. are among the most frequently introduced ornamental fish species in Europe (Kottelat and Freyhof 2007; Franch et al. 2008; Belle et al. 2017; Clavero et al. 2023). In addition to the native European weatherloach *Misgurnus fossilis* (Linnaeus, 1758), a species of international conservation concern, listed in the Annex II of the European Habitat Directive (Council of the European Union 1992), we see three

introduced Asian weatherloach species: (i) the dojo weatherloach *Misgurnus anguillicaudatus* (Cantor, 1842) in Italy (Razzetti et al. 2001; Geiger et al. 2014), Germany (Freyhof and Korte 2005), Spain (Franch et al. 2008; Aparicio et al. 2016; Clavero et al. 2023), England (Zięba et al. 2010), France (Chauvigné 2011; Denys and Manné 2024), and Netherlands (van Kessel et al. 2013); (ii) the large-scale loach *Misgurnus dabryanus* (Guichenot, 1872) – also known as *Paramisgurnus dabryanus* Guichenot in Dabry de Thiersant, 1872 before the taxonomic revision of Zhang H et al. (2021) – in Germany (Riffel et al. 1994; Stoeckle et al. 2019), Switzerland (Marchesi 2010), and Catalonia (Clavero et al. 2023); (iii) *Misgurnus bipartitus* (Sauvage & Dabry de Thiersant, 1874) in Austria (Zangl et al. 2020), and Catalonia (Clavero et al. 2023). The alien invasive weatherloaches may hybridize with the native species and therefore have an impact on its populations (Wanzenböck et al. 2021).

During intense field sampling of the Lanterne stream at Chevigney-sur-l'Ognon (Rhône catchment, Doubs department, eastern France, about 10 km NW from Besançon), one weatherloach specimen was caught, photographed, and initially identified on-site as *M. fossilis* before being released. Given the risk of misidentification, the photographs were sent to the Muséum national d'Histoire naturelle (Paris, MNHN) for expert assessment. Without any preserved material nor tissue for molecular analysis, the aim of this study is to (i) identify which *Misgurnus* species was caught in the Lanterne stream, and (ii) to report the first record of the large-scale loach *Misgurnus dabryanus* in France, identified from photographs. The potential impact of the species on the native fauna will be discussed as well as some advices for riverine managers about its monitoring.

Materials and methods

The Lanterne stream (12.5 km long) is a tributary of the Ognon River in the middle valley sector of eastern France (Figure 1). Its source is immediately upstream of Pouilley-les-Vignes; it then crosses the villages of Pelousey and Chaucenne before its confluence with the Ognon river on the left bank, between Emagny and Chevigney-sur-l'Ognon. Both water and habitat qualities are negatively impacted by multiple human-induced alterations to this stream: the watercourse has historically undergone a general recalibration of its bed, as well as more localized suppressions of sinuosities and riparian forest. Its current state is characterized by very high (2 m in some places) and steep banks, and an abnormally high wetted width. Thus the flows are highly homogenous and the waters pretty shallow, with little to contact with riparian vegetation. Furthermore, the original alluvial mattress has almost completely disappeared so, leaving the river bed almost naked, with some muddy deposits instead of pebbles and gravel. This stream presents essentially lentic flows, flats and pits, and ends upstream on the apron of an agricultural bridge.

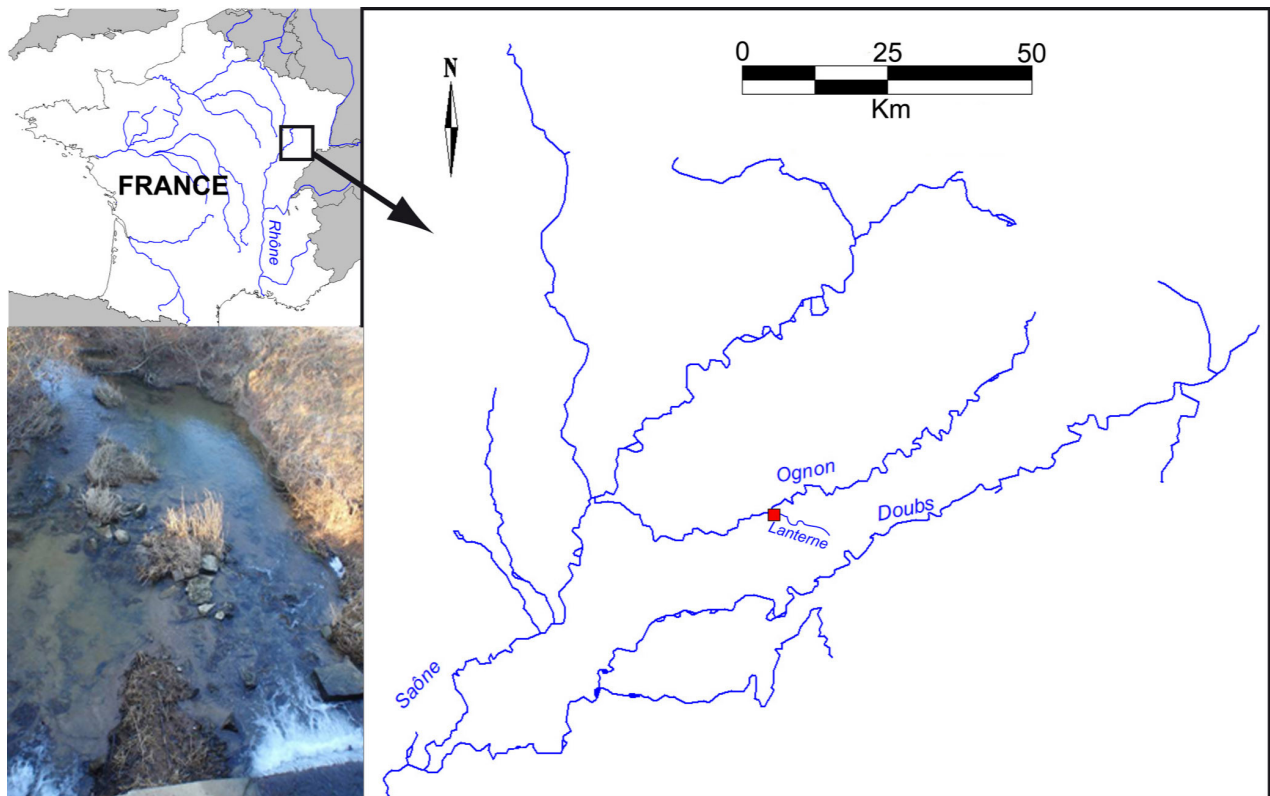


Figure 1. Location (red square) of the first occurrence in France of the large-scale loach *Misgurnus dabryanus* in the Lanterne stream at Chevigny-sur-l’Ognon, the 22nd July 2020, and a picture of the habitat where the specimen was caught.

This causes a small localized acceleration, so a minor oxygenation zone. Despite those high banks, there is also locally a connective riparian forest composed of willows. A natural berm has formed downstream of the station, at Chevigny-sur-l’Ognon (latitude: 47.30256N; longitude: 5.85356E) and is the subject of a restoration program for the Lantern stream by the “Syndicat Mixte d’Aménagement de la Moyenne et Basse Vallée de l’Ognon” (SMAMBVO).

On the 22nd of July 2020, the French consulting engineer firm Eaux Continentales inventoried the Lanterne stream at Chevigny-sur-l’Ognon (Rhône catchment, Doubs department, eastern France) for the French Biodiversity Agency (OFB). Fish were caught by complete electrofishing with a “Héron” device from Dream Electronique, using two anodes, following the protocol of Belliard et al. (2012). All individuals were measured in total lengths and weighted before being released, and a specimen of each species was photographed.

The weatherloach was measured, weighted and sex determined: the first and second pectoral fin rays are enlarged and include a *lamina circularis* in males (*vs.* slim first and second pectoral fin rays and no *lamina circularis* in females) (Kim 2009). The specimen was identified from photographs using external traits as well as morphometric character of the head. The general examination was made following Kottelat and Freyhof (2007) (coloration pattern, adipose crests of the caudal peduncle) and comparison with the holotype specimen of *Paramisgurnus dabryanus* Guichenot *in* Dabry de

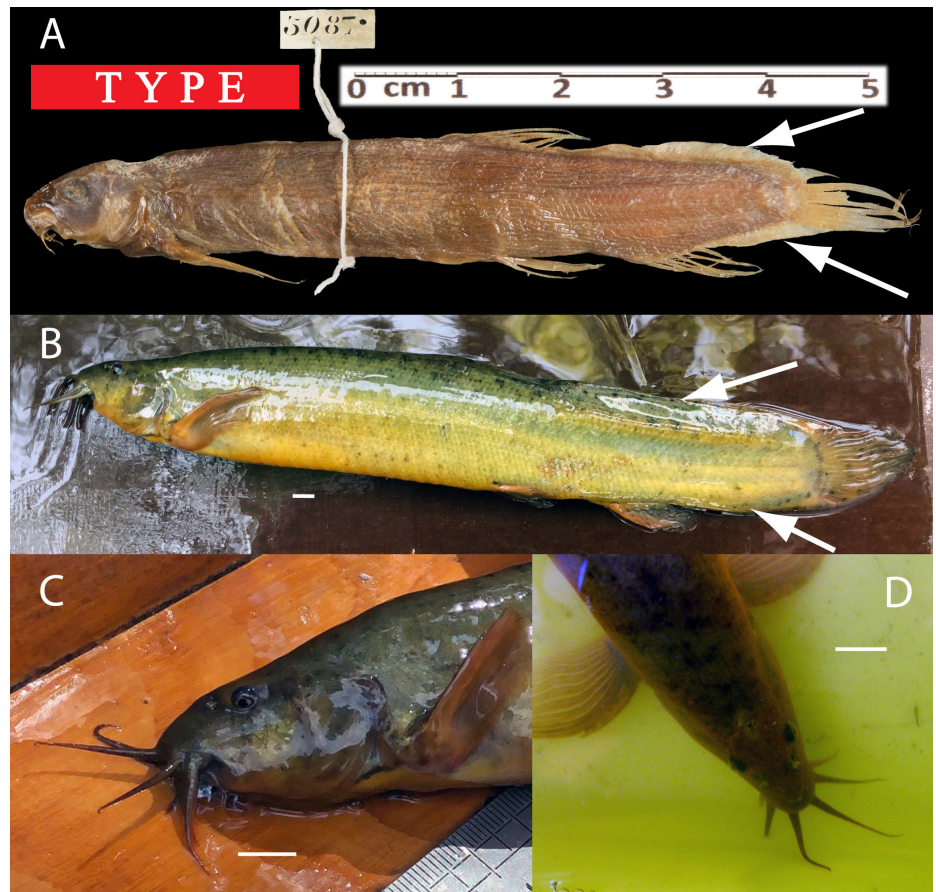


Figure 2. Holotype specimen of *Paramisgurnus dabryanus* Guichenot in Dabry de Thiersant 1872 (MNHN IC A-5087) (A); photo credit: L. Randrihasipara/MNHN. Asian weather loach identified as *Misgurnus dabryanus* (Guichenot, 1872) caught in the Lanterne stream at Chevigney-sur-l'Ognon the 22 of July 2020: caught specimen in lateral view (B), head in lateral view (C) and in dorsal view (D); scale bars represent 1 cm; white arrows indicate high adipose crests on the caudal peduncle, typical of the species; photos credit: A. Cuinet/Eaux Continentales.

Thiersant, 1872 (MNHN IC A-5087; Figure 2A) according to Bertin and Estève (1948); the morphometric measurements (head depth, head width, snout length, postorbital length, eye diameter, interorbital with, inner rostral barbel length, outer rostral barbel length and maxillary barbel length) were done using pixels numbers counted on photographs (Figure 2C–D) with the GIMP software (<https://www.gimp.org/>); their ratio with the pixels number of the head length were then compared with the data on male specimens from Zhang H et al. (2021) (Table 1).

Results

One male Asian weatherloach (Figure 2B–D) (25 cm TL, 102 g) was caught with 19 other fish and crayfish species, including native rheophilic species *Alburnoides bipunctatus* (Bloch, 1782), *Leuciscus leuciscus* (Linnaeus, 1758), *Squalius cephalus* (Linnaeus, 1758), *Gobio gobio* (Linnaeus, 1758), *Barbus barbus* (Linnaeus, 1758), *Barbatula* sp., *Cottus gobio* Linnaeus, 1758, some limnophylic species *Rutilus rutilus* (Linnaeus, 1758), *Tinca tinca* (Linnaeus, 1758) and *Perca fluviatilis* Linnaeus, 1758, as well as introduced species

Table 1. Morphometric measurements in percentage of the head length taken on photographs (Figure 2C and 2D; in pixel numbers) of the male Asian weatherloach caught in the Lanterne Stream at Chevigney-sur-l'Ognon the 22nd July 2020 compared to data on male specimens from Zhang H et al. (2021) on the three *Misgurnus* species introduced in Europe; * and \$ mean that measurements were made respectively on the Figure 2C and D; diagnostic characters are in bold.

	<i>Misgurnus</i> sp. from the Lanterne stream	<i>Misgurnus dabryanus</i>	<i>Misgurnus anguillicaudatus</i>	<i>Misgurnus bipartitus</i>
Head depth *	63.8	57.7–70.8	52.1–57.7	47.3–54.9
Head width \$	53.8	43.3–55.1	42.6–49.9	39.6–46.6
Snout length *	33.0	26.4–55.8	30.1–37.6	33.4–41.8
Postorbital length *	58.3	11.3–61.1	45–58.3	46.4–57.2
Eye diameter *	11.9	8.8–25.6	8.3–17.5	7.4–12.7
Interorbital width \$	25.8	21.2–55.4	14.6–23.3	16.2–21
Inner rostral barbel length \$	55.8	44–56.6	30.5–39.8	15.8–29.9
Outer rostral barbel length \$	44.6	44.6–55.4	34–38.5	17.1–30.4
Maxillary barbel length \$	51.7	44.5–62.8	30.5–44.9	17.9–30.6

Rhodeus amarus (Linnaeus, 1758), *Carassius* sp., *Alburnus alburnus* (Linnaeus, 1758), *Chondrostoma nasus* (Linnaeus, 1758), *Silurus glanis* Linnaeus, 1758, *Gymnocephalus cernua* (Linnaeus, 1758) and *Faxonius limosus* (Rafinesque, 1817) and three invasive alien species *Pseudorasbora parva* (Temminck & Schlegel, 1846), *Ameiurus melas* (Rafinesque, 1820) and *Lepomis gibbosus* (Linnaeus, 1758).

The specimen was encountered on a flat-type facies 20 cm deep, with a stony substrate including multi-centimeter clogging of silt and clay, downstream of a small stony pit sheltering sculpins *C. gobio* (Figure 1).

The following morphological data support its identification as *Misgurnus dabryanus*: no distinct coat coloration pattern (vs. bands for *M. fossilis*, dark spotted coat for *M. anguillicaudatus* or marbled coat for the other species), a caudal peduncle with high adipose crests (vs. low adipose crests for the other *Misgurnus* species), and no black spot at the upper caudal base (vs. presence of a black spot for *M. anguillicaudatus* and *M. bipartitus*) (Figure 2B). Morphometric data on the head (head depth, head width, interorbital with, inner rostral barbel length, outer rostral barbel length and maxillary barbel length) (Table 1, indicated in bold) also support this identification.

Discussion

The large-scale loach *Misgurnus dabryanus* is native to the Yangtze and Pearl drainages (central and southern China) as well as inland waters of Taiwan (Kottelat 2001; Shedko and Vasil'eva 2022). However, it was also introduced in other Asian countries such as Japan (Kanou et al. 2007) and Russia (Dyldin et al. 2023), as well as California (Kirsch et al. 2018) and in Europe: Germany (Riffel et al. 1994; Stoeckle et al. 2019), Switzerland (Marchesi 2010), and Catalonia (Clavero et al. 2023). This species will be integrated into the French taxonomic register TAXREF (Gargominy et al. 2022) of the National Inventory of Natural Heritage (*Inventaire du Patrimoine Naturel* – INPN). This record is then the fourth in Europe and the second Asian weatherloach species encountered in France, following the earlier

records of the dojo weatherloach *M. anguillicaudatus* (Chauvigné 2011; Denys and Manné 2024).

This specimen was morphologically identified from photographs, using the following criteria: coloration pattern and the presence of high adipose crests on the caudal peduncle (Marchesi 2010; Kirsch et al. 2018). We demonstrated that morphometric data on the head (head depth and width, interorbital width, barbel lengths) were also diagnostic (see Zhang H et al. 2021). The use of the comparison with the holotype specimen of *Paramisgurnus dabryanus* Guichenot in Dabry de Thiersant, 1872 in the expertise also supports our morphometric identification (e.g., Sluys 2021). Unfortunately, the specimen was released and we were not able to support our species identification with molecular data from other authors (e.g., Riffel et al. 1994; Kirsch et al. 2018; Stoeckle et al. 2019; Clavero et al. 2023). The additional use of a nuclear marker could have also flagged a potential hybrid with *M. anguillicaudatus* (Belle et al. 2021). Nevertheless, morphological identification is still feasible, as the morphological diagnostic characters (morphometry, coloration pattern, and the adipose crests on the caudal peduncle) are easy to observe, even for inexperienced riverine managers, if appropriately trained. This should prevent future confusion with the native and endangered European weatherloach *M. fossilis*, a misidentification that could adversely impact the riverine management (Bortolus 2008).

Knowledge about this species' potential invasiveness and its impact on the native European ichthyofauna is scarce. Some of its biological features are known, though: it lives in lentic and lotic environments, with muddy substrate with low gradient, slack water and high turbidity (Gao et al. 2010; Sato et al. 2011; Huang et al. 2013); it can adapt to hypoxic environments, breathing through its skin and intestines (Zhang et al. 2012; Wang et al. 2020; Liu et al. 2021) that have anatomical and physiological adaptations for air-breathing (Liu and Wang 2021); it tolerates a high range of water temperature (10 °C to 30 °C), burrowing into the sediment at a depth of 20–30 cm if the temperatures were to be too high or too low (Wang and Li 2005; Zhang et al. 2012); it also has a rapid growth, reaching its maximal length of about 30 cm in a few years (Wang et al. 2001; Gao et al. 2017). Moreover, considering its high reproductive potential (Chu et al. 2012), and its large range of diet, from zooplankton to macroinvertebrates and algae (Wang and Li 2005; Kanou et al. 2007), *M. dabryanus* fulfils all criteria to be considered an invasive species (e.g., Keller et al. 2011). Furthermore, this species is able to reproduce by asexual gynogenesis (You et al. 2008), which may accentuate its invasive potential (Fuad et al. 2021). In addition to a possible risk of competition with native benthic fish species (e.g., Mills et al. 2004), *M. dabryanus* may have a sanitary impact, for it is the intermediate host of nematodes *Contracaecum* spp. that might infect native fish species, as well as piscivorous birds and humans (Zhang C et al. 2021). However, unlike the Bavarian

record (Stoeckle et al. 2019), there would be no threat to the population of *M. fossilis*. Its closest known population is located more than 100 km aerial away in another catchment system, the Savoureuse stream, belonging to the Doubs sub-drainage. However, *M. fossilis* is not native in the Rhône drainage and its presence is certainly due to accidental introduction with restocking events (Keith et al. 2020). The two occurrences of *M. anguillicaudatus* known in France are located in the Orge river (Seine drainage), in the south suburb of Paris at Sainte-Geneviève-des-Bois in 2010 with only one fish, and an established population in the Schadgraben stream at Geispolsheim, near Strasbourg (Rhine catchment, eastern France) in autumn 2021 (Chauvigné 2011; Denys and Manné 2024). Their presences—and that of our large-scale weatherloach in the Lantern stream—are probably due to aquarium releasements (Chan et al. 2019). However, the presence of a lonely specimen in an isolated location from any urban environment lets us to suggest potential other specimens in a widespread area in the catchment.

Surveys must be set up in this region to assess the situation, especially to verify if our record indicates the presence of an established population, or if it was a lonely individual. Thus, regular electrofishing operations must be undertaken, as well as molecular sampling, like measuring eDNA (Beng and Corlett 2020; Feng et al. 2023), but see Jerde (2020) about the risk of results misinterpretation. Furthermore, initiatives at the national scale must also be initiated to detect eventual cryptic populations of the large scale-loach in the French hydrosystems.

Authors' contribution

AC conceptualized research, designed sample and methodology, investigated and collected data. Data analysis and interpretation were performed by GPJD, SB and JB. YM provided funding. AC and GPJD wrote the original draft. All authors reviewed and edited the manuscript.

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Ethics and permits

Electrofishing permit was provided according to the prefectural decree of the Doubs department (DDT25-ERNF-2020-06-18-003). No ethics agreement was required.

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