

Following the river's flow: first record of the invasive freshwater mollusc *Dreissena polymorpha* (Pallas, 1771) (Bivalvia Dreissenidae) in the upper course of the Tiber River (Umbria, Italy)

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ABSTRACT

In this contribution, the presence of *Dreissena polymorpha* (Pallas, 1771) (Bivalvia Dreissenidae) in the upper course of the Tiber River, in the province of Terni in Umbria (Italy), is reported for the first time during a citizen science project. The only other record of the species in this river is downstream at 40 km from the sea. This alien species with high invasive potential causes serious damage to the entire ecosystem and its distribution must be continuously monitored and contained. Involving local communities through citizen science projects can increase the capacity of early detection plans and possible actions to reduce spread of the species.

KEY WORDS

Dreissena polymorpha; Tiber river; Umbria; Terni; Citizen Science.

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INTRODUCTION

The zebra mussel *Dreissena polymorpha* (Pallas, 1771) (Bivalvia Dreissenidae) was found in 1769 in an oxbow lake in the lower Yaik River (later re-named as Ural River) by Peter Pallas (Pallas, 1771), a German zoologist and botanist who worked in Russia from 1767 to 1810 (Karatayev & Burlakova, 2022). Pallas (1771) described *D. polymorpha* as *Mytilus polymorphus* since its resemblance to the marine mussel of the genus *Mytilus* Linnaeus, 1758 and reported to have found it only in the rivers Volga (Ural region) and in the Caspian Sea (Pallas, 1773; Çağlar, 1952). Subsequently, Van Beneden (1835) described the new genus *Dreissena* on the specimens of this species

found in 1834 in a canal of the Meuse in Belgium by J.H. Dreissens, a Belgian pharmacist (Giusti & Oppi, 1972).

The zebra mussel is one of the most aggressive and actively spreading freshwater species worldwide (Karatayev & Burlakova, 2022). This species is considered one of the European's 100 worst invasive alien species (Nentwig et al., 2018); it is now widely distributed in various parts of the world, due to its ability to invade and colonize new environments, and its likely to enhance is invasion rates especially in absence of management actions (Haubrock et al., 2024).

DISTRIBUTION OF *DREISSENA POLYMORPHA* IN ITALY

The first report of alive *D. polymorpha* in Italy was by Giusti & Oppi (1972) who published a finding at Lake Garda on 7th December 1971, indicating pleasure boats from central Europe as possible vector. Actually, the earliest data of introduction into Italy is that of Franchini (1976), who reported that some specimens were collected in 1970 in the Venetian part of Lake Garda. In other articles (Castagnolo et al., 1980; Franchini, 1980, 1981; Campaioli et al., 1994; Binelli et al., 1996, 1997, 2001; Provini et al., 1997; Bacchetta et al., 2000, 2001; Camusso et al., 2001; Binelli & Provini, 2003; Colombi, 2003; Mantecchia et al., 2003), we find 1969 as the year of introduction in Italy, but these dates were probably estimated from the size of specimens collected in the early seventies. Since 1970, the species has become a stable component of the malacocoenosis of this lake (Bianchi et al., 1974; Franchini, 1976, 1978, 1980, 1981; Boscaini, 1977; Bignami et al., 1978; Annoni et al., 1978; Mariani et al., 1981; Cianfanelli et al., 1991, 2010; Borsani et al., 1992; Nardi & Braccia, 2004).

After colonising the whole Lake Garda, *D. polymorpha* proceeded to spread up the tributary Mincio River (first report in 1973 in Bianchi et al., 1974), reaching the Mantova lakes (1977-1978), the Po River as far as the mouth (Bedulli & Franchini, 1980) and the Sacca del Canarin in the Po delta (Relini et al., 1981) and the Laguna of Comacchio in 1991 (Bodon et al., 2005). Basins near Lake Garda were soon infested by the zebra mussel: Lake Ledro in 1973 (Bianchi et al., 1974), Lake Valvestino in 1976 (Bianchi et al., 1976) and Lake Iseo in 1985 (Bodon et al., 2005). The first report from the Adige River was in 1980 (Franchini, 1980) but the exact collection sites are not known. The first findings in the central western Prealps sector date back to 1992, when *D. polymorpha* was found in Lake Lugano (Borsani et al., 1992); a few years later it had colonised other major lakes: Lake Maggiore (Cossignani & Cossignani, 1995), Lake Como (Galassi et al., 1997) and Lake Lecco (Bacchetta et al., 2001). At the same time, it was spreading southward, with reports from the Po system, including the Seriola Fuga, Oglio River (Bodon et al., 2005) and the Emiliano-Romagnolo canal near Bologna in 1990 (Borsani et al., 1992), as well as northeastward with the first report (1992) from Lake Caldona in Trentino (Borsani et al., 1992; Cantonati et al., 1999). Other basins in Trentino were colonized

between 2001 and 2002: Lake Levico (Dalfreddo & Maiolini, 2004), Lake Tenno and Lake Lases (Bodon et al., 2005) and Lake Grande di Monticolo in Alto Adige (Morpurgo & Thaler, 2002). There have been recent findings in the north-west of Italy in 2002 and in 2003 in the Ticino River in the Novara Province (Bodon et al., 2005) in Pavia Province and in the Adda River in the provinces of Lecco, Lodi and Cremona (Bodon et al., 2005).

The first finding took place on the Apennines in 1994, from the Biferno River in Molise (Bodon et al., 2005). During the summer 1999 it was reported for the Lake Trasimeno in Umbria (Spilinga et al., 2000) and for the artificial Lake Suviana from the Emilia-Romagna Apennines and later in the nearby artificial Lakes Brasimone and San Damiano (Bodon et al., 2005). In 2003, it was also found in Tuscany, in the artificial Lake Pavano (Lori & Cianfanelli, 2006) and in 2006 in the Lake Bilancino in province of Florence, where a very consistent population occurs (Lori & Cianfanelli, 2006). Lori & Cianfanelli, (2006) also predicted that the species would spread along the Arno River following its confluence with the Sieve River, which originates from Bilancino Lake and flows into the Arno (Mari et al. 2009 modelled the spatio-temporal scenario on invasion from the Lake to Florence); the species, in fact, was observed and collected in Pisa in 2023 (authors' personal observation). In September 2013, a zebra mussel population was detected in the artificial Lake Santa Rosalia (Ragusa), which is the first record of *D. polymorpha* in Sicily (Colomba et al., 2013). The first report for Abruzzo refers to Lake Bomba (Bosso et al., 2017). Finally, the species has recently been reported also in Lazio in the final urban stretch of the Tiber River in Rome (Grano et al., 2020; Grano, 2022).

DREISSENA POLYMORPHA IN THE UPPER COURSE OF THE TIBER RIVER

In April 2024, several empty shells of dead specimens were collected (Fig. 1, 2) from two sections of the Tiber River (Umbria). The first section was located just downstream of the Alviano Hydroelectric Dam (42.584428, 12.251023) in the province of Terni, while the second was four kilometers further downstream, near the border between Umbria and Latium (42.558462, 12.265971).

The specimens from the first site were found on a gravel and cobble substrate that is regularly flooded due to periodic, sudden water releases from the dam. The density on the riverbank was approximately 0.2 per square meter, and the samples consisted of single valves measuring between 27 and 30 mm in length.

At the second site, which had a similar substrate but was influenced by the dam's water releases in a less sudden manner, the density was about 0.1 per square meter. Some samples there included valves still hinged together and attached by byssus threads, with valves measuring between 30 and 40 mm in length.

The only other record of the species in the Tiber River (Grano et al., 2022) was in the city of Rome, 40 km away from the sea, with a distance between the two records of 150 km.

DISCUSSION

Dreissena polymorpha has a greater probability of occurring at low to medium altitudes in areas characterised by fluvial deposits of major streams. Northern and central Italy appear more at risk. Some hydroelectric power dams are at high risk, while most dams for irrigation, drinkable water reservoirs and other dam types are at medium to low risk. Lakes and rivers (representing likely expansion pathways) at medium-high or high risk

mostly occur in northern and central Italy (Bosso et al., 2017). The Umbria region is among those at high risk concerning the degree of invasiveness of *D. polymorpha* (Bosso et al., 2017). In this region, the species was already known from Lake Trasimeno (Spilinga et al. 2000; Padula & Predicatori 2023) in the province of Perugia. The species was collected during the citizen science project ‘#teveremolluschifantastici...e dove trovarli’ (Isprambiente, 2023), specifically during a canoe descent along the river; the information was validated by a local moderator and the species was verified by one of the malacologists of the citizen science project. The citizen science database, hosted by the National Network on Biodiversity (NNB), comprise more than 150 records of molluscs along most of the river, from the Montedoglio Lake to the river mouth (380 km), and this was the first record collected of *D. polymorpha*. Although the citizen science project lacks a stratified design for data collection - resulting in sampling effort that is unevenly distributed across space and time and therefore considered opportunistic - it is noteworthy that zebra mussel shells were found only downstream of a dam, notwithstanding that there are in the database records of several other molluscs species in the reservoir originated from the dam. Multiple studies have shown that altered hydrological conditions caused by dams can facilitate the establishment of invasive species like *D. polymorpha* (Watters & Flaute, 2010; Bosso et al., 2017; Paganelli et al.,



Figure 1. The first site of *Dreissena polymorpha*: Terni (Umbria, Italy), downstream of the Alviano Hydroelectric Dam.

Figure 2. *Dreissena polymorpha* at the second site, near the border between Umbria and Lazio.

2021; Zieritz et al., 2022). Such environments may also offer the species suitable refuges, including protection from predators (Haubrock et al., 2024). The Alviano Dam reservoir, however, is heavily silted and experiences anoxic conditions, making it an unfavourable habitat for the species. Additionally, due to restricted access within the interdiction zone, the citizen science project is unable to survey dam structures with flowing water - such as pipes, tunnels, or walls. Despite these circumstances, it is important to note that at the second site, the discovered specimens had valves still hinged together and retained byssus threads, suggesting that the samples had not travelled far and that the colony may be nearby.

CONCLUSIONS

The zebra mussel is the most widely studied and monitored non-indigenous mollusc (Cianfanelli et al., 2007). This species is included in the well-known list of “100 most harmful invasive species” compiled by experts from the International Union for Conservation of Nature (Marsden, 2021), and its negative impacts on the ecosystem and especially its economic damage are well known. The ability to attach to solid substrates and the free-swimming larval stage, along with the ability to exist in a wide range of environmental conditions and high fertility, made zebra mussel an extremely successful invader (Orlova & Feneva, 2018). The presence of *D. polymorpha* can modify habitats and affect biodiversity, sometimes radically, at different levels (Meier-Brook, 2002; Charavgis & Cingolani, 2004; Lancioni & Gaino, 2005; Cianfanelli et al., 2010; Bosso et al., 2017).

The new report for the Tiber River creates further strong concerns for the environmental damage that this alien and invasive mollusc causes.

Notwithstanding that the species seems to be still in a latent stage as not yet causing noticeable harm or spreading aggressively, there is a pressing need to enhance monitoring of freshwater aquatic invasive species, also through citizen science projects, especially in the context of rising temperatures, in a climate change scenario. As evidence of the importance of continuous surveillance for early warning - also through citizen science projects - in the Umbria region, the mentioned citizen science initiative on

the Tiber River recorded, for the first time in 2023, the presence of *Corbicula fluminea* (O.F. Müller, 1774), another invasive bivalve species (Grano et al., 2023). In addition, there is a growing need to raise awareness and promote the implementation of the “Check, Clean & Dry” protocols across continental Europe (Grano & Crosti, 2024). These protocols are essential for preventing the unintentional spread of invasive and noxious species between freshwater basins, particularly as human activities, such as fishing, water sports, water land drainage and reclamation works, increase the risk of biological spread and contamination. The two different known records of the *D. polymorpha*, in the Tiber River, are 150 km apart one from each other (downstream of the Alviano dam and in the city of Rome). Consequently, to prevent the spread of the species, upstream or in other water basin in the wide region, it is important to drain and clean any type of gear which gets into the water before moving it among basins (Goretti et al., 2019). Early detection systems and rapid response efforts are crucial to minimizing the spread of invasive species. Engaging the public through citizen science initiatives can significantly enhance surveillance capabilities. The eradication of invasive species, particularly during dam dredging operations or the removal of biological fouling, can be more effective when overseen by expert environmental officers, helping to contain the spread of invasive molluscs. In the case of *D. polymorpha*, effective large-scale management tools for population control are currently limited or impractical, especially in natural environments (Wimbush et al., 2009; Coughlan et al., 2020). Nevertheless, advancing our understanding of the species’ invasion dynamics and the environmental factors contributing to its success remains critical. Such knowledge can inform targeted prevention and management strategies, reducing the risk of widespread infestations and the associated economic and ecological impacts (Adams & Lee, 2012; Haubrock et al., 2024). The investigations carried out so far have allowed us to build an important understanding of the current presence and distribution of molluscs in the Tiber River. Through the “river sentinel” initiative of the citizen science project, we have also been able to identify new records, including those of invasive species. Currently, the spread of *D. polymorpha* raises concerns, as the long-term impact of its proliferation on native fauna remains unclear.

Known for forming dense colonies that cover virtually all available surfaces, this species effectively monopolizes habitat space and this poses serious threats to native molluscs, such as those in the Lymnaeidae and Physidae families.

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