

The story of *Dreissena polymorpha* (Pallas, 1771) (Mollusca Bivalvia) in Europe and Italy and observations on the origin of these populations

Mauro Grano

Via Valcenischia 24, 00141 Rome, Italy; ORCID: 0000-0001-8188-6234 - e-mail: elaphe58@yahoo.it

ABSTRACT

Currently the zebra mussel *Dreissena polymorpha* (Pallas, 1771) is considered an allochthonous species in Italy with a great potential for invasiveness. However, archaeological studies show that this species was present in our territory since ancient times.

KEY WORDS

Dreissena polymorpha; invasive alien species; archaeozoology.

Received 05.12.2022; accepted 29.01.2023; published online 06.03.2023

INTRODUCTION

Dreissena polymorpha was found in 1769 in an oxbow lake in the lower Yaik River (later re-named as Ural River) by Peter Pallas (Pallas, 1771 sub *Mytilus polymorphus*), a German zoologist and botanist who worked in Russia from 1767 to 1810 (Karatajev & Burlakova, 2022). Pallas (1771) reported to have found it only in the rivers Volga, Ural, and in the Caspian Sea (Pallas, 1771, 1773; Çağlar, 1952). Dreissens (1834), a Belgian pharmacist, discovered this species in a canal of the Meuse in Belgium. Subsequently, Van Beneden (1835) described the new genus *Dreissena* through these specimens (Giusti & Oppi, 1972). Before the 19th century, *D. polymorpha* was found in the Black, Caspian, and Azov Seas (Stanczykowska, 1977). Between 1800 and 1900, *D. polymorpha* more than doubled its range in Europe (Schloesser, 1995) and later was introduced to north-west Russia, central and western Europe, southern Scandinavia, Britain, Ireland and North America (Gollasch, 1996; Minchin et al., 2002). Within a month, they were

detected in the western basin of Lake Erie (Leach, 1993) and have subsequently spread throughout much of North America: along the Mississippi River (Cope et al., 1997; Benson, 2014) and in Minnesota and Louisiana (Benson, 2014). Zebra mussels are currently found in 31 states of United States (Vanderbusch et al., 2021). Over the last 200 years, zebra mussels spread to most lakes, rivers and waterways in Europe thanks to a combination of natural and anthropogenic dispersal mechanisms (Carlton, 1993; Johnson & Carlton, 1996; Rajagopal et al., 2009). It was above all the construction of the canals during the 1800s that facilitated their spread throughout Western Europe (Mackie et al., 1989; Morton, 1993; Benson, 2014; Vanderbusch et al., 2021). Ballast tanks transport of large commercial vessels was probably a further mechanism by which the *D. polymorpha* was successfully introduced in many areas (Minchin et al., 2002). Carlton (1993) suggested that transport through ballast water from a European port is considered the route by which zebra mussels (most likely as veliger larvae) were introduced into the Great Lakes

of North America (Hebert et al., 1989). Similarly, Bij de Vaate et al. (2002) discussed the role of ballast-water transport in the spread of a number of Ponto-Caspian species through the mainland of Europe, including the zebra mussel (Rajagopal et al., 2009). The increasing popularity of recreational water sports after the World War II led to the spread of zebra mussels, attached to recreational craft transported on trailers, to high alpine lakes (e.g., Lakes Geneva, Zurich and Constance in Switzerland) around 1960s (Kinzelbach, 1992). In 1824 Sowerby (Gray, 1840) reports this species for the first time in Western Europe and precisely in England where it seems to have arrived together with construction timber loaded on the Volga River. These specimens would have managed to survive a long period of life out of the water and then quickly take root on the rocks and submerged poles of the banks of the Thames River in front of the commercial docks (Giusti & Oppi, 1972). In the state of Yugoslavia, this species occurs since the 70s (Ludyanskiy et al., 1993). During the 19th century the zebra mussel colonized large parts of North and Central Europe, including many of France's major river systems e.g., Seine River 1855, Loire River 1863, Rhône River 1865 and Garonne River 1866 (Kinzelbach, 1992). In 1990, it was detected in brackish water in the eastern part of the Gulf of Finland after having been present for 150 years in the nearby freshwater Lake Ladoga (Valovirta & Porkka, 1996; Gollasch & Leppäkoski, 1999; Orlova et al., 2000; Minchin et al., 2002). Zebra mussel was presumably introduced to Germany during the extension of the inland waterway network in the early 1800s and, later, it reached the Netherlands in 1826, being in the Rhine at Rotterdam, most likely carried with imported timber from the Baltic (Kearney & Morton, 1970; Minchin et al., 2002). Around 1990 this species is starting to be reported for Greece (Economou et al., 1991; Koussouri et al., 1993a, 1993b; Petridis & Sims, 1993; Conides et al., 1995). The first introduction of the species in Estonia occurred in the Põlula Brook estuary in the Gulf of Finland and in the Pärnu Bay in the Gulf of Riga in the mid-1800s. A second introduction occurred in the 1930s through Lake Peipsi in the easternmost part of the Gulf of Finland. In Poland, *D. polymorpha* was first identified in the late of 1800s (Birnbaum, 2011). In Austria, the species was introduced in the 1860s or

1870s, presumably with diggers from excavation works of the Suez Channel (Suess, 1916). Remote lakes and other standing waters have also recently been colonized, most likely due to translocation with sport boats (Reischütz, 2005). At the end of the 19th century, it was discovered in the Labe River in the Czech Republic (Birnbaum, 2011). In Ireland, it was introduced to the Shannon-erne system in the early-mid 1990s (Minchin, 2000). In Denmark (Birnbaum, 2011), the species was first recorded in 1843 in a channel in Copenhagen, where after it spread to local lakes, to Lake Fure (1915), Lakes Esrum (1922–23), and Susaa River system on the Island of Zealand (1939). It has now spread to Jutland, occurring in Lakes Jels, Lake Faarup, and most recently in the Guden River system. The zebra mussel has been sighted from Bulgarian relic lakes: Varnensko, Beloslavsko, Mandrensko, Bourgasko, and also in the Kamchia and Veleca Rivers (Hubenov, 2005). In eastern Bulgarian lakes, the zebra mussel has been detected within the Sinoie-Razim lagoonal complex (Romania) connected with Danube Delta (Son, 2007). The zebra mussel arrived in Ireland in 1994 or earlier (Minchin & Moriarty, 1998a, 1998b) and has since spread to most interconnected waterways with recreational boating. Ireland remained uninvaded for almost 150 years after its establishment in Britain and north-western Europe and the reason for the sudden mussel invasion, the vector of introduction and the source region remained unknown (Pollux et al., 2003). *Dreissena polymorpha* spread to Spain around 2001, having been first found in the Ribarroja Reservoir at the lower part of the Ebro River, Northeast Spain (Araujo & Álvarez, 2001; Bij de Vaate et al., 2002; (Rajagopal et al., 2009). In 2018 and 2019, zebra mussel was found on the Urals (Eremkina et al., 2021; Kolozin et al., 2021). The first discovery of *D. polymorpha* in Siberia was made during the survey of the Pyshma River close to the village of Malye Akiyary, Tyumensky district of Tyumen Region (Babushkin et al., 2022).

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., 2000b, 2001; Camusso et al., 2001; Binelli & Provini, 2003; Colombi, 2003; Mantecca et al., 2003), we find 1969 as the year of introduction in Italy. 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). Specimens were found in channels of the Laguna of Comacchio in 1991 (Bodon et al., 2005a). 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., 2005a). The first report from the Adige River was in 1980 (Franchini, 1980); it was also found in Lake Lugano (Borsani et al., 1992), 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., 2005a) and the Emiliano-Romagnolo canal near Bologna in 1990 (Borsani et al., 1992), as well as northeastward with the first report (1992) from Lake Caldonna 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., 2005a) in Pavia Province and in the Adda River in the provinces of Lecco, Lodi and Cremona (Bodon et al., 2005a). 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 Pavana (Lori & Cianfanelli, 2006) and in 2006 in the Lake Bilancino in province of Florence, where a very consistent population occurs (Lori & Cianfanelli, 2006). 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). In 2020, two first reports were also made for Lazio. The first discovery took place in the Tiber River in the historic center of Rome (Grano et al., 2020) and the second in Lake Turano in the province of Rieti (Grano, 2022).

DISCUSSION

Although *D. polymorpha* has always been considered an allochthonous in Europe and in Italy, various considerations can be made on its real presence in Europe, probably starting from an ancient nucleus of origin in Central Europe and North-Eastern Asia. During the quaternary glacial epochs, the area was reduced to small pockets in the Ponto-Caspian area (Bobat et al., 2004), from which *D. polymorpha* has re-colonized much of its original habitat and spread throughout the Europe (Lancioni & Gaino, 2006).

Species of the genus *Dreissena* are known as fossils from the Miocene to the Pleistocene of Europe (Germain 1931), including Italy (De Stefani 1876, 1877, 1880; Sacco, 1888; Esu, 1980; Biddittu & Celletti, 2001). The species *D. polymorpha* is reported in fossil-bearing Tertiary European terrains (Brusina, 1874; Ložek, 1964) and in Italy, it has been found in Quaternary terrains in some peninsular sites (Settepassi & Verdel, 1965; Esu & Girotti, 1991). The European origin of the genus and the cause of its disappearance in Italy (the Würmian glaciation) therefore seem certain (Giusti & Oppi, 1972). The fossil finds of *D. polymorpha* seem to appear in Italy at the beginning of the Upper Villafranchiano; in fact, there is no evidence of their presence in more ancient Italian sediments (Esu & Girotti, 1974; Conti & Esu, 1981; Ambrosetti et al., 1987). In Italy it is found in the Plio-Pleistocene series of the Torrente Stirone in Parma (Papani &

Peloso, 1962), it seems to become extinct at the end of the Mindel-Riss when we still find it in the Cassino Basin (Settepassi & Verdel, 1965) and in the Pleistocene of Liguria (Leonardi, 1933). In locality Tavernelle Basin (Umbria), belonging to a lateral branch of the Tiberino Basin, Esu & Girotti (1974), Conti & Esu (1981) and Ambrosetti et al. (1987) described the presence of *D. polymorpha* (Petronio et al., 2000–2002). In the Pleistocene lake reservoir near Canella, *D. polymorpha* appears particularly abundant, with specimens even of considerable size; this form, on the other hand, is absent in the one south of the Pietrafitta quarry, still in the province of Perugia (Conti & Esu, 1981). A Briziarelli quarry, just outside Bevagna, a little town of the “Umbrian Valley” (eastern branch of the Tiberino Basin) shows a good exposure of the Santa Maria di Ciciliano Formation, from which a rich assemblage of molluscs was collected, and *D. polymorpha* is among the most significant species (Petronio et al., 2000–2002). *Dreissena polymorpha* is quoted also in the Chiana Valley, Tuscany (Malatesta, 1964) and in the Gubbio Basin, Umbria (Esu & Girotti, 1991). In the case of the basins of central Italy, a subsequent climatic deterioration seems to be due to the extinction of the aforementioned archaic species and the disappearance of *D. polymorpha*, a species indicative of hot-humid periods in Czechoslovakia (Ložek, 1964) and therefore in our latitudes already tending to cool, a species that will reappear in a recent interglacial and then reappear in Italy in historical times by human work.

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). This species with dangerous invasive characteristics is

now considered an allochthonous species in Europe, but actually, it was very widespread in this area during the last interglacial period, as shown by fossil evidence. With the advance of the ice of the Würmian glaciation, it would have been progressively moved and forced to survive only in some areas of the Aralo-Caspian Basin (Giusti & Oppi, 1972). Only when the anthropogenic traffic now carried out with fast means and able to travel over large distances, made it possible, *D. polymorpha* manage to regain the original area and go even further.

ACKNOWLEDGEMENTS

The author wishes to express a special thanks to Cristina Cattaneo (Rome) for her constant presence in my life and in my research.

REFERENCES

- Ambrosetti P., Carboni M.G., Conti M.A., Esu D., Girotti O., La Monica G.B., Landini B. & Parisi G., 1987. Il Pliocene ed il Pleistocene Inferiore del bacino del Fiume Tevere nell’Umbria meridionale. *Geografia Fisica e Dinamica Quaternaria*, 10: 10–33.
- Annoni D., Bianchi I. & Girod A., 1978. Introduction of *Dreissena polymorpha* (Pallas) (Mollusca, Bivalvia) in the coastal mollusc beds of Lake Garda (North Italy). *Quaderni Civica Stazione Idrobiologica Milano*, 6: 77–84.
- Araujo R. & Álvarez R.M., 2001. El mejillón cebrá en el Ebro: un grave caso de riesgo ambiental en Aragón. *Naturaleza Aragonesa*, 8: 39–46.
- Babushkin E.S., Vinarski M.V., Gerasimova A.A., Ivanov S.N. & Sharapova T.A., 2022. First finding of *Dreissena polymorpha* (Pallas, 1771) (Mollusca, Bivalvia) in Siberia. *Russian Journal of Biological Invasions*, 13: 167–173.
<https://doi.org/10.35885/1996-1499-15-1-13-21>
- Bacchetta R., Mantecca P. & Vailati G., 2000. *Dreissena polymorpha* in Italy: first data on its reproductive behaviour. Primo congresso congiunto delle Società Malacologiche del Mediterraneo, Genova 13–15 novembre 2000. Abstract, 1 p.
- Bacchetta R., Mantecca P., Vailati G., 2001. Reproductive behavior of the freshwater mussel *Dreissena polymorpha* in Italy: a comparison between two populations. *Archiv für Hydrobiologie*, 151: 247–262.
- Bedulli D. & Franchini D.A., 1980. *Dreissena polymorpha* (Pallas): primi rinvenimenti nel fiume Po e

- predazione su di essa da parte di *Rattus norvegicus* (Berk). Quaderni Civica Stazione Idrobiologia di Milano, 6: 85–92.
- Benson A.J., 2014. Chapter 1: Chronological History of Zebra and Quagga Mussels (Dreissenidae) in North America, 1988-2010. In: Nalepa T.F. & Schloesser D.W., Eds., Quagga and Zebra Mussels Biology, Impacts, and Control, 5th Edition, Taylor and Francis, Boca Raton, 7–30.
- Bianchi I., Girod A., Mariani M., 1974. Densità, strutture di popolazione e distribuzione di *Dreissena polymorpha* nel bacino idrografico del Benaco. Archiv für Molluskenkunde, 104: 97–105.
- Bianchi I., Girod A., Mariani M., 1976. Ritrovamento di *Dreissena polymorpha* Pallas nel Lago di Valvestino (Brescia). Natura Bresciana Annali del Museo Civico di Storia naturale di Brescia, 13: 115–116.
- Bignami S., Conti M., Spreafico E., 1978. Osservazioni sulla distribuzione di *Dreissena polymorpha* (Pallas) nel Lago di Garda. Natura Alpina, 29: 27–30.
- Bij de Vaate A., Jazdzewski K., Ketelaars H.A.M., 2002. Geographical patterns in range extension of Ponto-Caspian macro-invertebrate species in Europe. Canadian Journal of Fisheries and Aquatic Sciences, 59: 1159–1174.
- Binelli A. & Provini A., 2003. The PCB pollution of Lake Iseo (N-Italy) and the role of biomagnification in the pelagic food web. Chemosphere, 53: 143–151.
- Binelli A., Galassi S., Mariani M., 1996. Uso di un mollusco bivalve (*Dreissena polymorpha*) per il biomonitoraggio di composti organoclorurati nella parte terminale del fiume Po. Acqua & Aria, 7–8: 689–696.
- Binelli A., Provini A., Galassi S., 1997. Trophic modifications in Lake Como (N. Italy) caused by the zebra mussel (*Dreissena polymorpha*). Water Air Soil Pollution, 99: 633–640.
- Binelli A., Galassi S., Provini A., 2001. Factors affecting the use of *Dreissena polymorpha* as a bioindicator: the PCB pollution in Lake Como (N-Italy). Water Air Soil Pollution, 125: 19–32.
- Birnbaum C., 2011. NOBANIS-Invasive Alien Species Fact Sheet. *Dreissena polymorpha*. From: Online Database of the European Network on Invasive Species. NOBANIS www.nobanis.org Date of access 05.11.2022
- Bobat A., Hengirmen M.O. & Zapletal W., 2004. Zebra mussel and fouling problems in the Euphrates basin. Turkish Journal of Zoology, 28: 161–177.
- Bodon M., Cianfanelli S., Manganelli G., Castagnolo L., Pezzoli E. & Giusti F., 2005 Mollusca Bivalvia. In: Ruffo S., Stoch F. (eds) Checklist e distribuzione della fauna italiana. Memorie del Museo Civico di Storia Naturale di Verona, 2. Serie, Sezione Scienze della Vita, 16: 83–84.
- Borsani G., Mariani M. & Saronni G., 1992. The distribution of *Dreissena polymorpha* (Pallas, 1771) in northern Italy. Giusti F. & Manganelli G. (Eds.), Abstract 11 International Malacological Congress, Siena, pp. 19–22.
- Boscaini E., 1977. La presenza della folaga (*Fulica atra*) nell’Alto Garda (1968–76) e i suoi rapporti coi popolamenti della “*Dreissena polymorpha*”. Natura Alpina, 28: 198–204.
- Campaioli S., Ghetti P.F., Minelli A. & Ruffo S., 1994: Manuale per il riconoscimento dei macroinvertebrati delle acque dolci italiane. Vol. 1. Provincia Autonoma di Trento, 357 pp.
- Camusso M., Balestrini R. & Binelli A., 2001. Use of zebra mussel (*Dreissena polymorpha*) to assess trace metal contamination in the largest Italian subalpine lakes. Chemosphere, 44: 263–270.
- Cantonati M., Maiolini B., Boscaini A., Del Prete B., Del Prete M.C., Franceschini A., Giordani V., Gruber E., Lencioni V., Mott D., Pozzi S. & Tolotti M., 1999. *Dreissena polymorpha*. Ricerca sulla presenza e diffusione del “nuovo” bivalve nel Lago di Caldonazzo. Natura Alpina, 50: 115–116.
- Carlton J.T., 1993. Dispersal mechanisms of the zebra mussel (*Dreissena polymorpha*). In: Nalepa T.F. & Schloesser D.W. (Eds.), Zebra mussels: biology, impacts, and control. Lewis Publishers, CRC Press, Boca Raton, USA, pp. 677–698.
- Castagnolo L., Franchini D. & Giusti F., 1980: Bivalvi (Bivalvia). Guide per il riconoscimento delle specie animali delle acque interne italiane. Consiglio Nazionale delle Ricerche AQ/1/49, 64 pp.
- Cianfanelli S., Calcagno M. & Talenti E., 1991. *Emmericia patula* (Brumati, 1838), nuovi dati sulla distribuzione in Italia. Bollettino Malacologico, 27: 15–20.
- Cianfanelli S., Lori E. & Bodon M., 2007. Non-indigenous freshwater molluscs and their distribution in Italy. In: Gherardi F. (Ed.), Biological invader in inland waters: profiles, distribution, and threats. Springer, Dordrecht. Chapter 5: 103–121.
- Cianfanelli S., Lori E. & Bodon M., 2010. *Dreissena polymorpha*: current status of knowledge about the distribution in Italy. In: van der Veld G., Rajagopal S. & bij de Vaate A. (Eds), The Zebra Mussel in Europe, Margraf Publishers GmbH, pp. 93–100.
- Colomba M.S., Liberto F., Reitano A., Di Franco D. & Sparacio I., 2013. On the presence of *Dreissena polymorpha* Pallas, 1771 and *Sinanodonta woodiana woodiana* (Lea, 1834) in Sicily (Bivalvia). Biodiversity Journal, 4: 571–580.
- Colombi L., 2003. Biomonitoraggio del Lago d’Iseo mediante lo studio del ciclo riproduttivo di *Dreissena polymorpha*. Atti dell’Ateneo di Scienze, Lettere ed Arti di Bergamo Anno Accademico 2001–2002, 65: 199–211.

- Conides A., Koussorius T. & Gritzalis K., 1995. Zebra mussel, *Dreissena polymorpha*: population dynamics and notes on control strategies in a reservoir in Western Greece. *Lake and Reservoir Management*, 11: 329–336.
<https://doi.org/10.1080/07438149509354214>
- Conti M.A. & Esu D., 1981. Considerazioni sul significato paleoclimatico e geodinamico di una serie lacustre pleistocenica inferiore presso Tavernelle (Perugia, Umbria). *Geografia Fisica e Dinamica Quaternaria*, 4: 3–10.
- Cope W.G., Bartsch M.R. & Hayden R.R., 1997. Longitudinal Patterns in Abundance of the Zebra Mussel (*Dreissena polymorpha*) in the Upper Mississippi River. *Journal of Freshwater Ecology*, 12: 235–238.
<https://doi.org/10.1080/02705060.1997.9663531>
- Cossignani T. & Cossignani V., 1995. Atlante delle conchiglie terrestri e dulciacquicole italiane. L'Informatore Piceno, Ancona, Italy, 208 pp.
- Çağlar M., 1952. Omurgasız Hayvanlar, Anatomi ve Sistematiği, 2, İstanbul.
- Dalfreddo C. & Maiolini B., 2004. Il popolamento malacologico di alcuni laghi trentini a confronto 70 anni dopo. *Stud Trentini di Scienze Naturali, Acta Biologica*, 80: 175–177.
- Economou A.N., Daoulas C. & Economidis P., 1991. Observations on the biology of *Leuciscus 'svallize'* in the Kremasta reservoir (Greece). *Hydrobiologia* 213: 99–111.
<http://dx.doi.org/10.1007/BF00014996>
- Eremkina T.V., Tsurikhin E.A., Chechulina N.V., Klimova N.B. & Izimetova M.P., 2021. Changes in the ecosystem of the Beloyarskoe Reservoir (Middle Ural) in the conditions of formation of the population of the invasive species *Dreissena polymorpha* (Pallas, 1771). In: Dgebuadze Y.Y., Krylov A.V., Petrosyan V.G., & Karabanov D.P. (Eds.), *Invasion of Alien Species in Holarctic*. Borok–VI: Abstr. Sixth Int. Symp., Kazan: Buk, 2021, p. 67.
- Esu D. & Girotti O., 1974. La malacofauna continentale del Plio-Pleistocene dell'Italia Centrale. I: Paleontologia. *Geologica Romana*, 13: 203–293.
- Esu D. & Girotti O., 1991. Late Pliocene and Pleistocene assemblages of continental molluscs in Italy. A survey. *Il Quaternario*, 4: 137–150.
- Franchini D.A., 1976. Sostituzione degli insediamenti malacologici autoctoni ad opera della *Dreissena polymorpha* (Pallas) in una stazione del Benaco (Torri del Benaco, VR). *Lavori del Simposio sui Molluschi terrestri e dulcicoli dell'Italia Settentrionale*, Mantova, 10–11/5/1975, *Lavori della Società Malacologica Italiana*, 13: 89–95.
- Franchini D.A., 1978. Distribuzione verticale di *Dreissena polymorpha* (Pallas) nel lago di Garda. *Bollettino Zoologico*, 45: 257–260.
- Franchini D.A., 1980. Dreissenoida. In: Castagnolo L., Franchini D. & Giusti F., *Bivalvi (Bivalvia)*. Consiglio Nazionale delle Ricerche. Collana del progetto finalizzato "Promozione della qualità dell'ambiente". Pubblicazione AQ/1/49. Guide per il riconoscimento delle specie animali delle acque interne italiane, 10: 56–59.
- Franchini D.A., 1981. Un inquinamento di origine naturale: *Dreissena polymorpha* nei laghi di Mantova. *Acqua & Aria*, 2: 153–155.
- Galassi S., Binelli A. & Provini A., 1997. *Dreissena polymorpha* come bioindicatore della contaminazione da PCB nelle acque lacustri. *Acqua & Aria*, 2: 61–65.
- Garton D.W. & Haag W.R., 1993. Seasonal Reproductive Cycles and Settlement Patterns of *Dreissena polymorpha* in Western Lake Erie. In: Nalepa T.F. & Schloesser D.W. (Eds.), *Zebra Mussels Biology, Impacts, and Control*, Lewis Publishers, Boca Raton, 111–128.
- Giusti F. & Oppi E., 1972. *Dreissena polymorpha* (Pallas) nuovamente in Italia (Bivalvia, Dreissenidae). *Memorie del Museo Civico di Storia Naturale di Verona*, 20: 45–49.
- Gollasch S., 1996. Untersuchungen des Arteintrages durch den internationalen Schiffsverkehr unter besonderer Berücksichtigung nichteinheimischer Arten. Hamburg.
- Gollasch S. & Leppäkoski E., 1999. Initial Risk Assessment of Alien Species in Nordic Coastal Waters. Nordic Council of Ministers, Copenhagen
- Gray J.E., 1840. *Manual of the land and fresh-water shells of the British Islands*, London.
- Grano M., 2022. Prima segnalazione di *Dreissena polymorpha* (Pallas, 1771) (Bivalvia: Dreissenidae) nel Lago del Turano e per la provincia di Rieti (Lazio). *Alleryana*, 40: 12–15.
- Grano M., Nistri R. & Di Giuseppe R., 2020. Aggiornamento sui molluschi alloctoni nel Tevere a Roma (Bivalvia). *Alleryana*, 38: 117–121.
- Griffiths R.W., Schloesser D.W., Leach J.H. & Kovalak W.P., 1991. Distribution and Dispersal of the zebra Mussels (*Dreissena polymorpha*) in the Great Lakes Region. *Canadian Journal of Fisheries and Aquatic Sciences*, 48: 1381–1388.
<https://doi.org/10.1139/f91-165>
- Hebert P.D., Muncaster B.W. & Mackie G.L., 1989. Ecological and Genetic Studies of *Dreissena polymorpha* (Pallas): A New Mollusk in the Great Lakes. *Canadian Journal of Fisheries and Aquatic Sciences*, 46: 1587–1591. <https://doi.org/10.1139/f89-202>
- Hubenov Z., 2005. *Dreissena* (Bivalvia: Dreissenidae) - systematics, autochthonous and anthropogenic areas. *Acta Zoologica Bulgarica*, 57: 259–268.
- Johnson L.E. & Carlton J.T., 1996. Post-establishment spread in large-scale invasions: dispersal mechanisms

- of the zebra mussel *Dreissena polymorpha*. Ecology 77: 1686–1690.
- Karatayev A.Y. & Burlakova L.E., 2022. What we know and don't know about the invasive zebra (*Dreissena polymorpha*) and quagga (*Dreissena rostriformis bugensis*) mussels. Hydrobiologia, 2022. <https://doi.org/10.1007/s10750-022-04950-5>
- Kearney M.P. & Morton B.S., 1970. The distribution of *Dreissena polymorpha* (Pallas) in Britain. Journal of Conchology 27: 97–100.
- Kinzelbach R., 1992. The main features of the phylogeny and dispersal of the Zebra mussel *Dreissena polymorpha*. In: Neumann D. & Jenner H.A. (Eds.), The Zebra mussel *Dreissena polymorpha*. Gustav Fisher Verlag, Stuttgart, pp. 5–17.
- Kolozin V.A., Filinova E.I. & Meleshin D.I., 2021. First findings of *Dreissena polymorpha* (Pallas, 1771) in the Irikinsky Reservoir. Russian Journal of Biological Invasions, 12: 283–288. <https://doi.org/10.1134/S2075111721030097>
- Koussouris T., Berthas I., Fotis G., Diapoulis A., Pakos V., Nikolaidis N., Gritzalis K. & Koritsoglou-Moshovakou A., 1993a. Control of the freshwater mussel (*Dreissena polymorpha*, Pallas) in the water supply system of Agrinion city. Greek Geotechnical Science Issues, 4: 62–83.
- Koussouris T., Diapoulis A., Berthas I., Nikolaidis N., Pakos V., 1993b. Disinfection effectiveness of chlorine to control zebra mussel in water supply system in Greece. Prot. Ist. SETAC World Congress Ecotoxicology and Environmental Chemistry, Portugal, 228 pp.
- IUCN, 2006. Global Invasive Species Database. www.issg.org (Accessed 30 September 2022).
- Lancioni T. & Gaino E., 2006. The invasive zebra mussel *Dreissena polymorpha* in Lake Trasimeno (Central Italy): Distribution and reproduction, Italian Journal of Zoology, 73: 335–346. <https://doi.org/10.1080/11250000600918001>
- Leach J.H., 1993. Impacts of Zebra Mussel (*Dreissena polymorpha*) on Water Quality and Fish Spawning Reefs in Western Lake Erie. In: Nalepa T.F. & Schloesser D.W. (Eds.) Zebra Mussels Biology, Impacts, and Control, Lewis Publishers, Boca Raton, pp. 381–398.
- Leonardi P., 1933. La formazione a Strombi e la cronologia pleistocenica. Bollettino della Società Venetiana di Storia Naturale, 1: 1–72.
- Lori E. & Cianfanelli S., 2006. New records of *Dreissena polymorpha* (Pallas, 1771) (Mollusca: Bivalvia: Dreissenidae) from Central Italy. Aquatic Invasions, 1: 281–283.
- Ložek V., 1964. Quartärmollusken der Tschechoslovakei. Verlag Tschechosl. Akad. Wiss., Praha, 374 pp.
- Ludyanskiy M.L., McDonald D. & MacNeill D., 1993. Impact of the zebra mussel, a bivalve invader. BioScience, 43: 533–544. <https://doi.org/10.2307/1311948>
- Mackie G.L., Gibbons W.N., Muncaster B.W. & Gray I.M., 1989. The Zebra Mussel, *Dreissena polymorpha*: A Synthesis of European Experiences and a Preview for North America. Ontario Ministry of Environment, Ontario.
- Malatesta A., 1964. Über einige pleistozäne Süßwassermollusken aus Mittel-Italien. I. Archiv für Molluskenkunde, 93: 151–162.
- Mantecca P., Vailati G., Garibaldi L. & Bacchetta R., 2003. Depth effects on zebra mussels reproduction. Malacologia, 45: 109–120.
- Mariani M., Girod A., Bianchi I. & Annoni D., 1981. I molluschi del bacino meridionale del lago di Garda con particolare riferimento a *Theodoxus fluviatilis* (L.). Atti IV Congresso S.M.I., 6–9/10/1978, Siena, Lavori della Società Malacologica Italiana, 17–18: 215–238.
- Marsden J.E., 2021. *Dreissena polymorpha* (Pallas, 1771). Global Invasive Species Database, 2021. <http://www.iucngisd.org/gisd/species.php?sc=50>. Accessed October 28, 2022.
- Minchin D., 2000. Dispersal of zebra mussel in Ireland. Verhandlungen Internationale Vereinigung für theoretische und angewandte. Limnologie, 27: 1576–1579.
- Minchin D. & Moriarty C., 1998a. Distribution of the zebra mussel *Dreissena polymorpha* (Pallas, 1771) in Ireland, 1997. Irish Naturalists' Journal, 26: 38–42.
- Minchin D. & Moriarty C., 1998b. Zebra mussels in Ireland. Fisheries Leaflet, 177: 1–11.
- Minchin D., Lucy F. & Sullivan M., 2002. Zebra mussel: impacts and spread. In: Leppakoski E., Gollasch S. & Olenin S. (Eds.), Invasive aquatic species of Europe: distribution, impacts and management. Kluwer Academic Publishers, Dordrecht, The Netherlands, pp. 135–146.
- Morpurgo M. & Thaler B., 2002. Ritrovamento di *Dreissena polymorpha* (Pallas) (Mollusca, Bivalvia) nel Lago Grande di Monticolo (Alto Adige, Italia). Gredleriana, 2: 219–222.
- Morton B., 1993. The Anatomy of *Dreissena polymorpha* and the Evolution and Success of the Heteromyarian Form in the Dreissenoidae. In: Nalepa T.F. & Schloesser D.W. (Eds.), Zebra Mussels Biology, Impacts, and Control, Lewis Publishers, Boca Raton, PP. 185–215.
- Nardi G. & Braccia A., 2004. Prima segnalazione di *Corbicula fluminea* (O.F. Müller, 1774) per il Lago di Garda (provincia di Brescia) (Mollusca, Bivalvia, Corbiculidae). Bollettino Malacologico, 39: 181–184.

- Orlova M.I. & Feneva I.Y., 2018. *Dreissena polymorpha* (Pallas, 1771): Riverine zebra mussel, in *Samye opasnye invazionnye vidy Rossii (TOP 100) (TOP 100: The Most Dangerous Invasive Species in Russia)*, Dgebuadze Y.Y., Petrosyan V.G., & Khlyap L.A., Eds., Moscow: KMK, pp. 299–311.
- Pallas P.S., 1771. *Reise durch verschiedene Provinzen des Russischen Reichs. Theil 1. Physicalische Reise durch verschiedene Provinzen des Russischen Reichs im 1768 und 1769 sten Jahren. Kayserliche Akademie der Wissenschaften. St. Petersburg*, 505 pp.
- Pallas P.S., 1773. *Travels Through Various Provinces of the Russian Empire. St. Petersburg. Part 1. Supplement*.
- Papani G. & Pelosio G., 1962. La serie plio-pleistocenica del T. Stirone (Parmense occidentale). *Bollettino della Società Geologica Italiana*, 81: 293–335.
- Petridis D. & Sims A., 1993. Benthic macrofauna of Tavropos reservoir (central Greece). *Hydrobiologia* (262): 1–12. <http://dx.doi.org/10.1007/BF00010985>
- Petronio C., Argenti P., Caloi L., Esu D., Girotti O. & Sardella R., 2000–2002. Updating Villafranchian mollusc and mammal faunas of Umbria and Latium (Central Italy). *Geologica Romana*, 36: 369–387.
- Pollux B., Minchin D., Van der Velde G., Van Alen T., Moon-Van der Staay S.Y. & Hackstein J., 2003. Zebra mussels (*Dreissena polymorpha*) in Ireland, AFLP-fingerprinting and boat traffic both indicate an origin from Britain. *Freshwater Biology*, 48: 1127–1139.
- Provini A., Binelli A. & Galassi S., 1997. Ruolo di *Dreissena polymorpha* nel ciclo dei nutrienti e dei PCB nel bacino occidentale del Lago di Como. In: Mosello R. & Giussani G. (Eds), *Evoluzione recente della qualità delle acque dei laghi profondi subalpini*. Documenti Istituto italiano di Idrobiologia, 61: 117–133.
- Rajagopal S., Pollux B.J.A., Peters J.L., Cremers G., Moon-van der Staay S.Y., van Alen T., Eygensteyn J., van Hoek A.H.A.M., Palau A., de Vaate A.B. & van der Velde G., 2009. Origin of Spanish invasion by the zebra mussel, *Dreissena polymorpha* (Pallas, 1771) revealed by amplified fragment length polymorphism (AFLP) fingerprinting. *Biol Invasions* 11: 2147–2159. <https://doi.org/10.1007/s10530-009-9495-3>
- Reischütz P.L., 2005. Weichtiere (Schnecken und Muscheln). *Grüne Reihe des Lebensministeriums (Wien)*, 15: 157–170.
- Relini G., Matricardi G., Bianchi C.N., 1981. Organismi di substrato duro in un ambiente salmastro padano. *Quaderni dei Laboratori Tecnologia Pesca Ancona*, 3 (S1): 293–303.
- Schloesser D.W., 1995. Introduced Species, Zebra Mussels In North America. In: *Encyclopedia of Environmental Biology*, Academic Press, Inc., San Diego, California, pp. 337–356.
- Settepassi F. & Verdel U., 1965. Continental Quaternary Mollusca of lower Liri Valley (S Latium). *Geologica Romana*, 4: 369–452.
- Son M.O., 2007. Native range of the zebra mussel and quagga mussel and new data on their invasions within the Ponto-Caspian Region. *Aquatic Invasions*, 2: 174–184.
- Spilinga C., Chiappafreddo U. & Pirisinu Q., 2000. *Dreissena polymorpha* (Pallas) al Lago Trasimeno. *Rivista di Idrobiologia*, 39: 145–152.
- Stanczykowska A., 1977. Ecology of *Dreissena polymorpha* (Pallas) (Bivalvia) in lakes. *Polish Archives of Hydrobiology*, 24: 461–530.
- Suess E., 1916. *Erinnerungen*. Hirzel, Leipzig, 215 pp.
- Valovirta I. & Porkka M., 1996. The distribution and abundance of *Dreissena polymorpha* (Pallas) in the eastern Gulf of Finland. *Memoranda Societatis Pro Fauna et Flora Fennica*, 72: 63–78.
- Vanderbush B., Longhenry C., Lucchesi D.O. & Barnes M.E., 2021. A Review of Zebra Mussel Biology, Distribution, Aquatic Ecosystem Impacts, and Control with Specific Emphasis on South Dakota, USA. *Open Journal of Ecology*, 11: 163–182. <https://doi.org/10.4236/oje.2021.112014>