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# First record of the invasive Asian clam *Corbicula fluminea* (O.F. Müller, 1774) (Bivalvia: Corbiculidae) in Slovenia

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**Abstract.** The Asian clam (*Corbicula fluminea*) is considered one of the most invasive freshwater bivalves in the world. It has been introduced to several European countries. During the field surveys conducted in August 2018, a total of 61 specimens of the Asian clam were found along the Drava River between Ormož and Središče ob Dravi in Northeast Slovenia. These are the first records of this invasive species' occurrence in Slovenia.

Key words: invasive species, *Corbicula fluminea*, Slovenia, Drava River

**Izvleček. Prva najdba invazivne vrste azijske školjke *Corbicula fluminea* (O.F. Müller, 1774) (Bivalvia: Corbiculidae) v Sloveniji –** *Corbicula fluminea* je ena najbolj invazivnih školjk celinskih voda. Zanešena je bila v številne evropske države. Med terenskim popisom avgusta 2018 smo na odseku reke Drave med Ormožem in Središčem ob Dravi skupno našli 61 primerkov te školjke. To so hkrati tudi prvi podatki o pojavljanju te invazivne vrste v Sloveniji.

Ključne besede: invazivne vrste, *Corbicula fluminea*, Slovenija, Drava

## Introduction

The Asian clam (*Corbicula fluminea*) is a small (usually up to 30 mm long) freshwater bivalve inhabiting rivers, canals or lake sediments. It can tolerate low salt concentrations (Franco et al. 2012), thus it can be also found in brackish waters. It is native to Southeast Asia, but at the beginning of 20$^{th}$ century it started to spread to other continents (Sousa et al. 2008, Basen et al. 2017). In Europe, it is hard to track the defined invasion pathways. The first records of the species' introduction were received from a number of different locations (Crespo et al. 2015). The species was first found in the Tagus Estuary in Portugal and the Garrone Estuary in France in 1980, followed by the River Rhine, near Rotterdam in 1985 (Crespo et al. 2015). It disperses through passive transport of juveniles by fluvial navigation or tidal currents (Sousa et al. 2008). It can actively secrete long mucous threads that enable its flotation (Prezant & Chalermwat 1984), which germinates its dispersion in lakes. Unaided

upstream movement may be an important dispersal mechanism in free running rivers (Voelz et al. 1998). Rapid dispersion is caused mostly due to different human activities such as: ballast water transport, use as fish bait or as a food resource, use by aquarium hobbyists and juveniles' byssal attachment to boat hulls (Sousa et al. 2008, Franco et al. 2012, Crespo et al. 2015). Ectozoochorous dispersal by birds or endozoochorous dispersal by birds or fish is also possible, although most likely a rare occurrence (Coughlan et al. 2017). Today it is present in almost all European river basins, from the Iberian Peninsula to Ireland and the UK, and Bulgaria and Romania in the east (Ferreira-Rodriguez et al. 2018). In less than 100 years, it has invaded all continents, except Antarctica. Accordingly, this species is one of the most successful invasive species in aquatic ecosystems (Crespo et al. 2015).

The rapid spread and the invasion success is related to its biological characteristics (rapid growth, early sexual maturity, high fecundity, hermaphroditism, planktonic larvae, and the potential to reach high population density levels), extensive dispersal capacities, its physiological tolerance and its association to human activity. The Asian clam reaches sexual maturity within the first 3 to 6 months (Sousa et al. 2008). It reproduces twice per year (Crespo et al. 2015) – the majority of population is hermaphrodite, capable of androgenic self-fertilization (Pigneur et al. 2012). It releases pediveligers with reduced mobility to the water column, which rapidly settle into sediment. All this may result in an annual fecundity rate as many as 68,000 juveniles per individual (Denton et al. 2012). A single individual in optimal environmental conditions has the potential to start a new population (Crespo et al. 2015). It can also tolerate temperatures up to 36 °C (Basen et al. 2017). The Asian clam grows rapidly due to its high filtration and assimilation rates (Sousa et al. 2008). The major part of its energy is allocated to growth and reproduction and only a small proportion is devoted to respiration (Sousa et al. 2008). Where habitat conditions are favourable (fine sediment), the Asian clam can build up massive stocks and dominate the local community comprising up to 90% of total benthic biomass (Basen et al. 2017). Franco et al. (2012) report on densities up to 11,142 individuals $m^{-2}$. Specimens of the Asian clam spend much of their life burrowed into substrate at depths up to tens of centimetres. Juvenile and adult individuals migrate to the substrate surface when exposed to environmental stressors such as low dissolved oxygen levels (Forrest et al. 2017). The species has a short life span ranging from 1 to 5 years (Sousa et al. 2008).

## Materials and methods

The survey was conducted between 15.8.2018 and 16.8.2018 after coincidental finding of one half of an empty shell of the Asian clam on 1.7.2018 on gravel bar of the Drava River near Središče ob Dravi in Northeast Slovenia. The sampling method used was the hand netting of live animals in the river sediments in the shallow water. Due to their small size and because they are totally anchored into the river sediment, it was harder to spot them with bathyscopes compared to the success this survey technique delivers for indigenous unionid species. All the potential locations along the short section of the Drava River in Slovenia between Ormož and Središče ob Dravi were surveyed. Only shallow sections (up to depth of about 1 m) of the river were sampled. Additionally, gravel bars in this section of Drava River were surveyed for empty

shells. All animals and empty shells were taken from the site and later on individual shell length and height were measured with an ESD Safe Dial Caliper (0.1 mm reading).

The species was identified by its external morphological characteristics such as pattern of shell sculpture, shape and concentric ridges. *Corbicula fluminea* can be easily misidentified with *C. fluminalis*. Collected specimens of *C. fluminea* had coarser ridges with a whitish inner surface compared to *C. fluminalis*, the shells of which develop finer ridges, with a violet inner surface (Ciutti & Cappelletti 2009). The height/length (<1) ratio was in favour of *C. fluminea* as well.

## Results and discussion

A total of 52 (min-max length: 7.2–23.1 mm) live specimens of the Asian clam and 9 empty shells (min-max length: 11.7–20.8 mm) were collected at four locations along the Drava River between Obrež and Središče ob Dravi (Fig. 1). The clams were found only in fine sediment in the shallow water next to the river bank. Various other studies report on the presence of Asian clams in fine sediment (Paunović et al. 2007). This fact corresponds to some references (Crespo et al. 2015, Gama et al. 2015), which state that the species is restricted only to well-oxygenated water. Empty shells were additionally found on the surface of fine sediment at the downstream end of gravel bars together with empty shells of the painter's mussel (*Unio pictorum*), thick shelled river mussel (*Unio crassus*), duck mussel (*Anodonta anatina*) and zebra mussel (*Dreissena polymorpha*). From the length frequency distribution (Fig. 2), all captured clams were considered sexually mature, which corresponds to Sousa et al. (2008). The largest shells suggest that the first generation of the Asian clam occurred in the Drava River at least 2 years earlier.

Due to the presence of Asian clams in the neighbouring countries, i.e. Italy (Ciutti & Cappelletti 2009, Kamburska et al. 2013), Croatia (Lajtner 2015, Lajtner et al. 2016) and Hungary (Csanyi 1999), its occurrence in Slovenia has been expected. In the Drava River the species was found as early as in 2016 in Ormož Lake on Croatian side and downstream in Lake Varaždin in 2018 (Lajtner J., personal information).

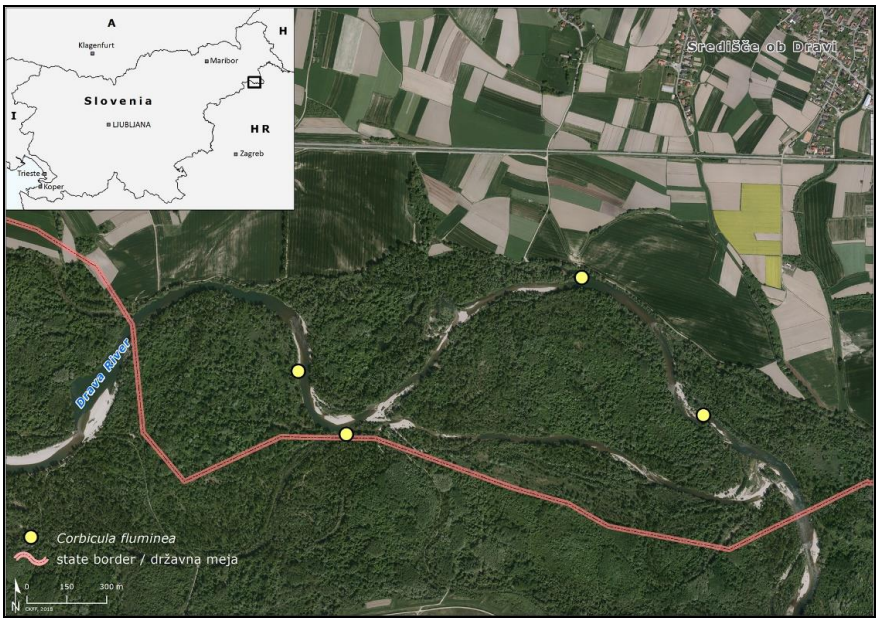


**Figure 1**. Records of the live Asian clam *Corbicula fluminea*.
**Slika 1.** Mesta najdbe živih školjk vrste *Corbicula fluminea*.

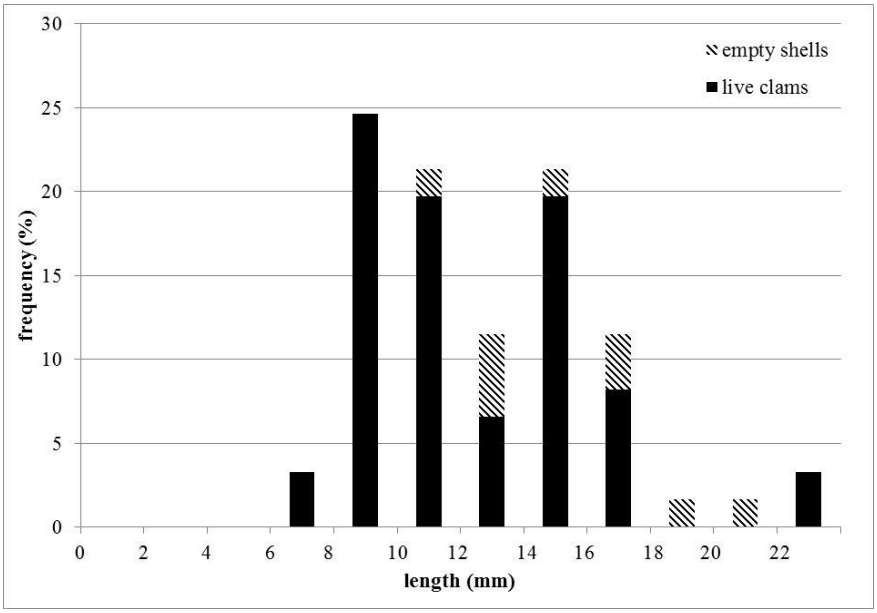


**Figure 2.** Length frequency distribution of Asian clam *Corbicula fluminea* in the Drava River between Obrež and Središče ob Dravi.
**Slika 2.** Frekvenčna distribucija dolžine lupin vrste *Corbicula fluminea* iz reke Drave od Obreža do Središča ob Dravi.

Invasive bivalves cause serious ecological and economic impact due to their effects on natural ecosystems and the damaging impacts on man-made structures (Rosa et al. 2011). The Asian clam can have a detrimental impact on native bivalves due to its burrowing and bioturbation activity, high abundances, displacing and/or reducing available habitats for juvenile unionids (Unionidae) and sphaeriids (Sphaeriidae). Dense populations of the Asian clam may also ingest large numbers of unionids sperm, glochidia and newly metamorphosed juveniles (Sousa et al. 2008). It may also compete for food resources with sphaeriids and unionids and consequently has the potential to limit planktonic food available to native bivalves (Pigneur et al. 2014, Ferreira-Rodriguez et al. 2018). Contrary to Asian clams, unionids are slow-growing species with a long lifespan and life-cycles that are dependent on fish hosts (Lopes-Lima et al. 2014). Additionally, this invasive species can be a vector for the introduction of new parasites and diseases to the biotic components of invaded ecosystems (Sousa et al. 2008).

In lowland parts of Slovenia and Croatia, relatively large and shallow reservoirs were built, whereas hydroelectric power stations have been constructed on side channels. This completely altered the hydrological and ecological regimes of the Drava River. In the stretch of the Drava River where the Asian clam was found, the hydrological regime is controlled. The discharge is set at 8 $m^3$ $s^{-1}$ during the summer and winter. There are no water level oscillations after regular rainy days. Most of the sediment is deposited in the accumulation lakes. The river substrate contains mainly gravel with only a small amount of deposited fine sediment. During high discharges, the greater part of fine sediment is deposited in a flood zone outside the main river channel. Only small patches of fine sediment are deposited at the inside of the meander bends, where the water velocity locally drops. Thus fine sediment may be found after meander bends as well as at the bottom of the deeper sections. Since we sampled only shallow and accessible sections of the Drava River, we do not know whether the Asian clam lives in the deeper sections as well. The amount of empty shells on gravel bars will reveal this in the future. The accumulation lakes where large amounts of fine sediment occur have big potential for the Asian clam to develop big populations. The Asian clam is so far the third (together with Chinese pond mussel and zebra mussel) invasive bivalve species discovered in the Drava River in Slovenia. Time will reveal if all three invasive bivalve species will remain here and whether they will affect the three indigenous bivalve species (painter's mussel, thick shelled river mussel, duck mussel). Due to the Asian clam's biology we assume that the competition for habitat (fine sediment) and food between the Asian clam, Chinese pond mussel and all three indigenous species will be the main driver.

As the species is spreading fast upstream the Drava River, it is expected to occur also in Ptuj Lake. There it may establish a large population, since the Asian clam can reach high density in similar habitats; up to 3,206 individuals $m^{-2}$ in rivers, up to 1,278 individuals $m^{-2}$ in lakes and up to 796 individuals $m^{-2}$ in reservoirs (Lucy et al. 2012). Preventive measures have to be taken immediately to stop the species from spreading out of the Drava River. Due to the popular use of Ptuj Lake for water sports it may spread fast around Slovenia.

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