Invasion of *Corbicula fluminea* (Müller, 1774) (Bivalvia:Corbiculidae) in water bodies from the East Aegean River Basin in Bulgaria

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Abstract

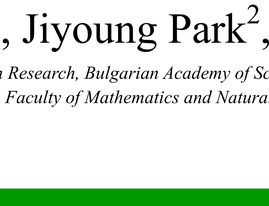
Since the first record of the invasive *Corbicula fluminea* (Müller, 1774) in Bulgaria in 2001 (Danube River at Vetren village), the Asian clam spread in a relatively short time to most of the Bulgarian Danube tributaries. For almost a decade after, the mussel was registered in many surface freshwaters in Bulgarian Danube River Basin, including rivers, lakes and reservoirs.

The aim of the current study is to report the finding of *C. fluminea* at the East Aegean water basin in Bulgaria. As a result of large-scale research of macroinvertebrate communities in different types of water bodies, 6 new localities of this species were registered - two in Tundzha River, four in Maritsa River - all situated in their lower stretches of the rivers. Considering the current known distribution of the species, we discussed the possible path for invasion of the largest rivers in South-Eastern part of Balkan Peninsula and the probability of rapid spread of *Corbicula* in their tributary systems.

Key words:
Asian clam, invasion, dispersal, East Aegean River Basin, Bulgaria.

Introduction

The Asian clam *Corbicula fluminea* (Müller, 1774) is one of the most success invasive mussel species globally due to the its very high colonization potential and the abundant populations (Stites *et al.,* 1995; Morgan *et al.,* 2003). The first record of the *C. fluminea* (Müller, 1774) in Bulgaria was in 2001 when it was found in the Danube River at Vetren village (Hubenov, 2001).



Corbicula fluminea (Müller, 1774)

In a relatively short time the Asian clam spread into the most of the Bulgarian Danube tributaries and adjacent standing water bodies (Hubenov *et al.,* 2013; Vidinova *et al.,* 2016). During the hydrobiological studies in 2013 related to the preparation of management plans of two NATURA 2000 protected zones, the invasive mussel was found at one sampling site in Ovcharitsa Reservoir (Uzunov, 2013), which was the first finding of *C. fluminea* in a water body within the Aegean water basin in Bulgaria.

Acknowledgement
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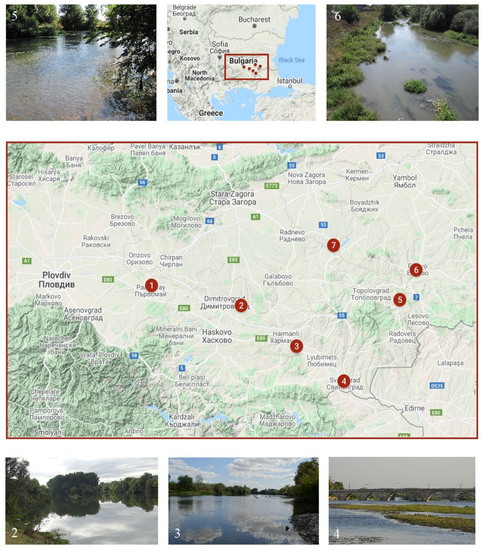
Material and methods

Study area



The location and general view of the sampling sites

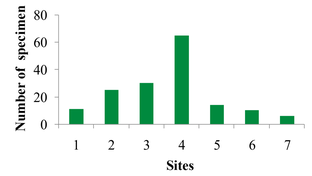
Site 1. Maritsa River - Parvomay town (42.11543, 25.22290); Altitude - 158 m
Site 2. Maritsa River - Brod village (42.04295, 25.67528); Altitude – 90 m
Site 3. Maritsa River – Downstream Harmanli town (41.89918, 25.95537); Altitude - 66 m
Site 4. Maritsa River – Svilengrad town (41.77239, 26.19361); Altitude - 54 m
Site 5. Tundzha River - Srem village (42.06263, 26.47655); Altitude - 89 m
Site 6. Tundzha River - Elhovo town (42.17043, 26.55885); Altitude - 102 m
Site 7. Ovcharitsa Dam - near Fish farm (42.25659, 26.14289); Altitude – 135m

Sampling

The sampling was conducted in the lower reaches of the Maritsa and Tundzha Rivers in East Aegean River Basin (EARB) in August and September 2020. The sampling of macroinvertebrates followed the pro-rata multi-habitat sampling strategy, using a hand net (mesh size 500 μm) and set of hydro-biological sieves for sandy and silt substrata (Cheshmedjiev *et al.*, 2011). The laboratory processing included the separation, determination and enumeration of specimens of *C. fluminea.* The physical and chemical parameters of water quality were also measured *in situ* using portable Windaus Labortechnik Package and HANNA multi-parameter instruments for temperature (WT), alkalinity (pH), conductivity (Cond., $\mu S.cm^{-1}$), dissolved oxygen concentration (DO; mg/l) and saturation (O Sat, %). A description of the relative proportion of bottom substrates (in %) at the localities was also performed before sampling.

Results

Number of collected specimen



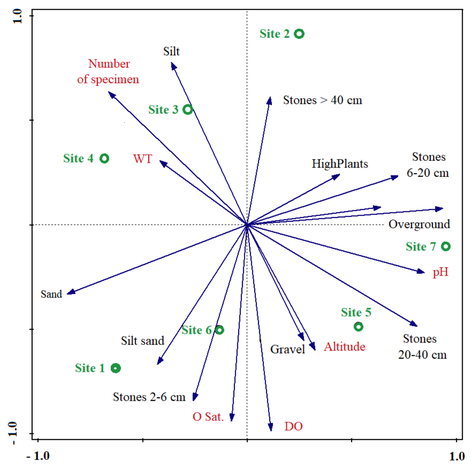
The specimens of *C. fluminea* were found serially in abundance from the lower sections to upstream of the rivers. It was the richest at the Svilengrad area (Site 4) and was gradually decreasing to upstream.

Physical and chemical water parameters

Site	WT (°C)	pH	Cond. ($\mu S.cm^{-1}$)	DO (mg/l)	O sat. (%)
1	21.7	7.50	426	7.60	88.0
2	21.7	7.64	486	5.90	67.0
3	22.8	7.59	544	6.20	77.0
4	23.6	7.63	541	6.60	81.0
5	22.9	7.88	545	7.45	89.0
6	20.3	7.98	500	7.68	86.9
7	22.6	8.63	818	7.17	83.9

Principal Component Analysis (PCA) analysis

The PCA analysis demonstrated that the *C. fluminea* is adaptive and could be found in lakes and streams of all sizes with diverse substrate. It also showed WT, conductivity, overgrown and oxygen performance are the significant factors for the distribution. *C. fluminea* requires high levels of DO, and prefers fine, clean sand, clay, and coarse sand substrates. Other favorable conditions are neutral to alkaline pH, depth, relatively high oxygen concentrations. *C. fluminea* is generally intolerant of significant sources of contaminants, so can be used as a indicator species of pollutants.



Discussion

The passive upstream movement is an important dispersal mechanism for *C. fluminea* (Beran, 2006). Most clams showed a positive rheotaxis, some authors reported colonization of bigger rivers with upstream spread of 2.4 km per year (Beran, 2006; Schmidlin & Baur, 2007). In Bulgaria, it considered both passive upstream transport and human activities, such as fishing, fish stocking, recreational activities, sand and gravel extraction (Hubenov *et al.,* 2013).

C. fluminea was found in the Ovcharitsa Reservoir (EARB) in the research on macrozoobenthos regarding the preparation of the Management Plan for the protected area "Ovcharitsa Dam" 2013 (Uzunov, 2013). Within this study we confirmed the presence of the species, collecting materials at approximately the same locality (Site 7). Despite the conditionally drainless nature of the reservoir, it maintains a relatively constant water level due to continuous water supply through a canal from Tundzha River (Uzunov, 2013). We consider the transfer of water through this canal as a potential opportunity for mussel larvae to penetrate from the dam to the Tundzha River, especially given the reverse slope of the derivation (Hanovo village - beginning of the channel system, altitude 104 m), while the reservoir is located higher (altitude 135 m). Supporting this assumption was the finding of the specimens in Tundzha River downstream the Hanovo village (Site 5 & 6).

Regarding the presence of the Asian clam in lower section of Maritsa River (Bulgarian stretch), two scenarios are possible; infestation due to local human activities and passive upstream movement from the lower reaches of the river. Karaouzas *et al.* (2020) reported *C. fluminea* from Luda River (Greek stretch), suggesting that "The most likely entry source of *C. fluminea* in Greece is through active or passive downstream drift through the Bulgarian part of Erythropotamos (Luda) River". We consider this unlikely because this river flows through Bulgarian territory in a rather remote uninhabited border area for only 20.2 km with approximate two thirds as state border. The finding of the Asian clam in a relatively large section of the Bulgarian part of the Maritsa River upstream the Turkish border, is an almost certain prerequisite for the presence of the species downstream, outside Bulgaria.

As the inclusion of *C. fluminea* in the List of alien invasive species on the territory of EARB was relatively late (in 2014), more detailed surveillance is urgently needed in order to assess the degree of *C. fluminea* establishment in the country.

Conclusion

In conclusion, it should be noted that not all surface water bodies have been studied in relation to invasive Asian clam and therefore it is not possible to estimate what percentage of them are affected by it. There are a number of impacts that need to be overcome - damaged infrastructure, facilities, damage to local flora and fauna. Once non-native species are identified, it is then very difficult to eliminate or carry out adequate controls. There is an urgent need to monitor the distribution of *Corbicula fluminea* not only in the Danube catchment area, but also in other river catchments in Bulgaria.