Vestnik Zoologii, **53**(3): 187–194, 2019
DOI: 10.2478/vzoo-2019-0019

UDC 549.1(1-13:479)

NEW ALIEN SPECIES *MYTILOPSIS LEUCOPHAEATA* AND *CORBICULA FLUMINALIS* (MOLLUSCA, BIVALVIA) RECORDED IN GEORGIA AND NOTES ON OTHER NON-INDIGENOUS MOLLUSCS INVADED THE SOUTH CAUCASUS

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New Alien Species *Mytilopsis leucophaeata* and *Corbicula fluminalis* (Mollusca, Bivalvia) Recorded in Georgia and Notes on Other Non-Indigenous Molluscs Invaded the South Caucasus. Mumladze, L., Bikashvili, A. Japoshvili, B., Anistratenko, V. V. — First records of invasive bivalve freshwater mollusc species *Mytilopsis leucophaeata* (Conrad, 1831) and *Corbicula fluminalis* (O. F. Müller, 1774) in Georgia are reported. No native or alien extant dreissenid species have ever been recorded form this region so far. A finding of *C. fluminalis* in Georgia is also a new record for the country though this species inhabits the rivers of adjacent Azerbaijan. Apart from two mentioned bivalve molluscs three non-indigenous gastropod species are registered from Georgia: freshwater *Ferrisia californica* (Rowell, 1863) and *Physella acuta* (Draparnaud, 1805) and land snail *Eobania vermiculata* (O. F. Müller, 1774).
Key words: alien species, Mollusca, Dreissenidae, Cyrenidae, South Caucasus.

Introduction

Ponto-Caspian region is a major source of macroinvertebrate invasions worldwide (Bij de Vaate et al., 2002). The most important and well-known mollusc invaders of Ponto-Caspian origin are zebra mussel (*Dreissena polymorpha* Pallas, 1771) and quagga mussel (*D. bugensis* Andrusov, 1897) (e. g. Karatayev et al., 2014). However, the region receives an alien mollusc species as well. For instance, dark false mussel *Mytilopsis leucophaeata* (Conrad, 1831) is invasive brackish water dreissenid species native to Gulf of Mexico (Marelli, Gray, 1983) which invaded many areas in North America and Europe including the Ponto-Caspian region (Zhulidov et al., 2018). Similarly, range expansion, though at lesser extent, is also characteristic for freshwater bivalve species *Corbicula fluminalis* (O. F. Müller, 1774) which is native to large parts of western Asia including southern Caspian river systems (Zhadin, 1952). *C. fluminalis* has been recently reported from the Dagestan coast of the Caspian Sea (Nabozhenko, Nabozhenko, 2016). However, strong increase of fresh material found around the Kizlyarsky Gulf (Dagestan) in subsequent years, including whole specimens (see Wesselingh et al., 2019) suggests that species may have established there.

Freshwater molluscs fauna of Georgia (fig. 1), which currently accounts around 90 species (Vinarski, Kantor, 2016) is strongly understudied. Meantime, alien invasive species have been recently registered here with limited information on their distribution, precise time and pathways for introduction. Aiming the conservation of vulnerable aborigine species as well as mitigating the spread of aliens requires a substantial knowledge of regional molluscs distribution and ecology. In the present communication we provide evidences of the occurrence of two alien species of freshwater bivalve molluscs found in Georgia for the first time: *Mytilopsis leucophaeata* (Conrad, 1831) and *Corbicula fluminalis* (O. F. Müller, 1774). Available information on other non-indigenous mollusc species recorded in the region is summarized as well.

Material and methods

The present article is based on bivalve molluscs samples hand-collected in the five localities (fig. 1, table 1). The specimen from the locality 1 found in June 1989 on the sandy Black Sea beach and is most likely reached from the small river located near the shore in the vicinity of Pichori village (fig. 1, locality 1). Patara Paliastomi Lake (fig. 1, locality 2) is a shallow waterbody (up 1 m depth) with soft, deep silty bottom and dense aquatic vegetation. It is in fact an extension of westward located Paliastomi Lake which characterizes of brackish water with variable salinity level (from 1 to 10 ‰ or more) and relatively high surface temperature — minimal temperature in January rarely approaches here 0 °C. Shaori Reservoir (fig. 1, locality 3) was formed in 1954–1956 and has maximum depth of 14.5 m. Due to high absolute elevation, surface water is always freezing in winter at least partly. Although no salinity data is available for that lake, it is typical freshwater with presumably low salinity (Barach, 1964). The sampling area in Shaori Reservoir is near the dam and is characterized with variation of water level up to 1 m; the bottom there is made of a mix of clay and dense limestone rocks with high amount of eroded plant residues. Tbilisi Reservoir (fig. 1, locality 4) was formed in 1953, situated at 545 m a. s. l. and is a main source of drinking water for the city Tbilisi. The bottom at the sampling area is covered by mix of clay and pebbles and is rather homogenous throughout the reservoir. The samples from the Iori River (fig. 1, locality 5) were collected near outflow of Dali Reservoir with highly disturbed bottom surface. Samples have been collected from the shallow sandy areas on the river beach.

Localities 2 and 3 where sampled initially in 2010 and then repeatedly in 2018 while localities 4 and 5 once, in 2017 (table 1). Samples from 2 and 3 localities collected in 2010 have been stored in the malacological collection of Ilia State University (accession # ISUFM94-95) and were overlooked until 2017. These samples were only recently processed within the ongoing project related to the species inventory of Georgian freshwater molluscs. Old and newly collected specimens were identified using the guides (Zhadin, 1952; Pathy, Mackie, 1993; Welter-Schultes, 2012).

Results

Specimens of *Mytilopsis leucophaeata* collected in Patara Paliastomi account altogether 8 live and 19 dead juveniles (minimum shell length 6.3 mm) and fully grown individuals (maximum shell length — 16 mm) (fig. 2, *1–4*). A single damaged valve (length 17 mm) was only discovered in Shaori Reservoir (fig. 2, *5–6*) during the sampling in 2010. The

Table 1. Examined material from Georgia. The numbers of localities refer to the text and figures

No	Locality	Date	N	E	Species recorded
1	Pichori village, Gali Municipality, 0.2 m a. s. l.	22 June 1989	42°26′54″	41°32′30″	*Corbicula* sp. [subadult whole empty shell]
2	Patara Paliastomi Lake, northeast shore, 2 m a. s. l.	June 2010, May 2018	42° 7′26″	41°46′28″	*Mytilopsis leucophaeata* (Conrad, 1831) *Viviparus viviparus* (Linnaeus, 1758) *Physella acuta* (Draparnaud, 1805) *Theodoxus* sp. *Melanopsis* sp.
3	Shaori Reservoir, south-western shore near the dam, 1150 m a. s. l.	August 2010	42°23′54″	43° 2′24″	*M. leucophaeata* [single damaged valve] *V. viviparus Corbicula fluminalis* (O. F. Müller, 1774) [single specimen]
		May 2018			*V. viviparus* (L., 1758)
4	Tbilisi Reservoir, 545 m a. s. l.	November 2017	41°43′44″	44°52′33″	*C. fluminalis* [empty shells only]
5	Iori River, near outflow of Dali Reservoir, 270 m a. s. l.	July 2017	41°16′23″	45°53′14″	*C. fluminalis* [live subadult specimens]

Fig. 1. Map of the region showing the collection sites. Details for each sampling point are given in table 1.

entire collected false mussels have a mytiliform shell of dark brown valves with bright band on ventral margins of each valve. No regular ornamentation or clear angular ridge on shells — typical characters for *Dreissena* spp. are observed. Collected specimens can easily be distinguished from *Dreissena* by presence of a well visible apophysis near the umbo (fig. 2, *4*). Repeated search of this species in May of 2018 resulted in numerous specimens detected all around the lake Paleastomi, while in Shaori Reservoir no specimens of *M. leucophaeata* were found.

Together with *M. leucophaeata*, in Patara Paliastomi and Paliastomi lakes in 2010 and 2018 other freshwater species were collected: *Viviparus viviparus* (Linnaeus, 1758), *Physella acuta* (Draparnaud, 1805), *Theodoxus* sp. and *Melanopsis* sp. In Shaori Reservoir *V. viviparus* and a single specimen of *Corbicula fluminalis* (O. F. Müller, 1774) were collected. In both these localities *V. viviparus* was outnumbered all other species. It should be stated however, that the molluscs listed above were collected from the shorelines zone only while deeper areas have not been examined. The same patterns were observed during the field work in 2018 except the absence of *M. leucophaeata* and *C. fluminalis* in Shaori Reservoir.

Sampling in 2017 both in Tbilisi Reservoir and lower reach of the Iori River resulted in hundreds of *C. fluminalis* specimens. However, only empty shells in Tbilisi Reservoir were collected while live specimens (juveniles) in the Iori River have been found. Studied specimens of *Corbicula* found in all localities (except the shell collected in 1989 from the sea beach near Pichori village, fig. 1, locality 1) demonstrate close resemblance to each other (fig. 3, *9–14*), match well to *Corbicula* from Azerbaijan (fig. 3, *1–4*) and all considered as conspecific, belonging to *Corbicula fluminalis* (O. F. Müller, 1774). The shell of *Corbicula* collected in Pichori has certain specificity in shape, characters of growth sculpture and lock arrangement (fig. 3, *5–8*) that differentiate it from *C. fluminalis* and makes it look like the 'olden clam' *Corbicula javanica* (Mousson, 1849) from Indonesia. Since in our material, only a single shell of "*C. javanica*"-like form is available from the locality 1, we are unable to unambiguously assign it to any *Corbicula* species. This specimen is marked here as *Corbicula* sp.

Discussion

Species of the bivalve family Dreissenidae are naturally occurring only in northern part of Ponto-Caspian region including northern Black Sea, the Sea of Azov and Caspian

Sea basins situated northward of Great Caucasus Chain. From southern Caucasus and in particular southeast Black Sea region (such as Colchis lowland in western Georgia) no extant dreissenid species have been recorded so far.

Dreissenid species *Mytilopsis leucophaeata* was reported from Europe as early as 1835 (Nyst, 1835; Verween et al., 2005) and now is widely spread in west European countries (Heiler et al., 2010; Dziubińska, 2011). *M. leucophaeata* became significant pest in some parts of invaded areas while in native habitats it is usually uncommon (see Kennedy, 2011). East European regions and in particular Ponto-Caspian basin were occupied relatively recently by this species. It was firstly discovered in 1996 in the northern Caspian Sea (as

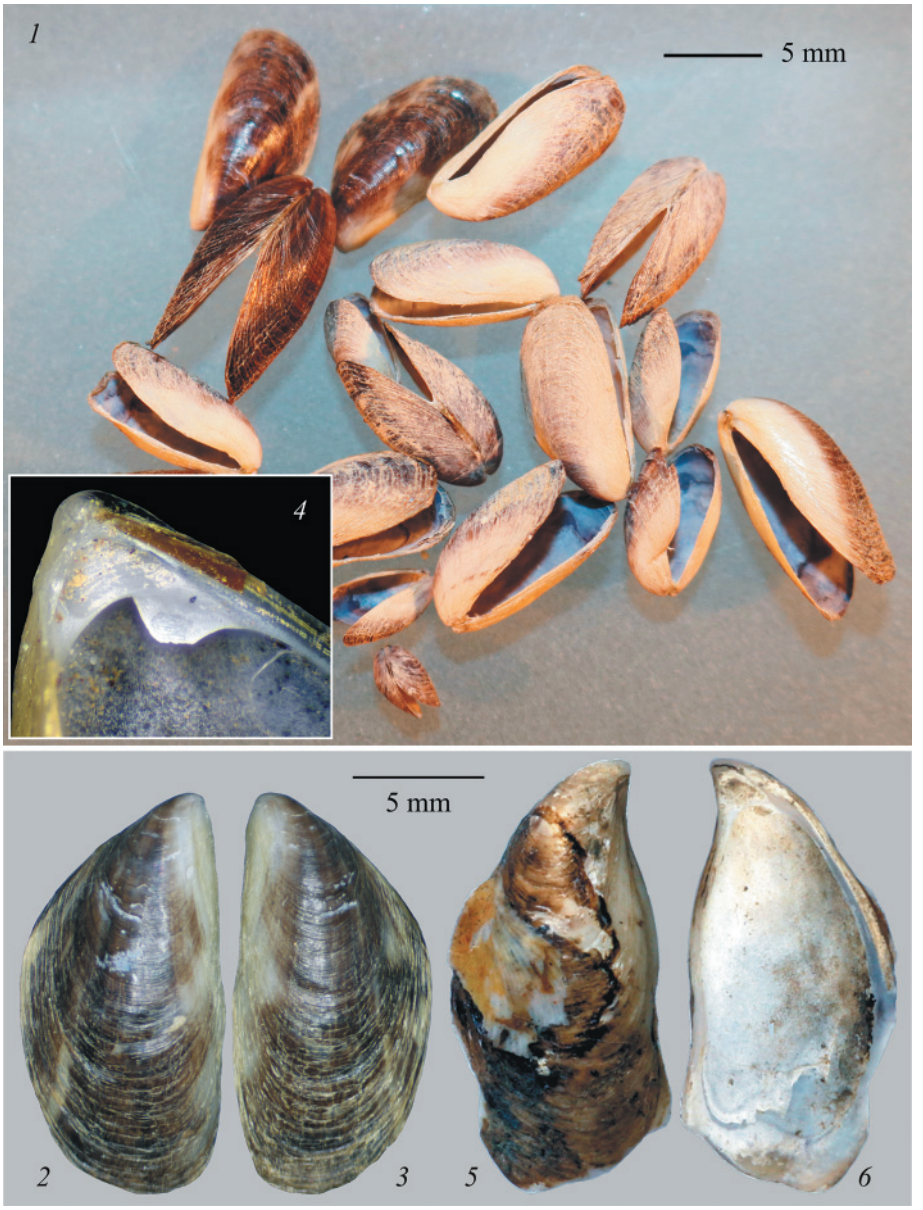

Fig. 2. *Mytilopsis leucophaeata*: *1* — shells from Patara Paliastomi Lake (locality 2); *2–4* — whole specimen from the same locality (*2* — right valve, *3* — left valve, *4* — enlarged inner view of position *2* showing the apophysis); *5–6* — a single right valve of shell from Shaori Reservoir (locality 3) from outside (*5*) and inside (*6*) views correspondingly.

cited in Zhulidov et al., 2018), followed by its discovery in Ukrainian Black Sea coast (Dnister Liman) in 2001 (Therriault et al., 2004) and again in 2009 from Ukraine (Southern Bug, near Mykolayiv) and the southern Caspian Sea (Heiler et al., 2010). Recently more populations of this species from Ukraine and Russian Azov-Black seas region and from the Caspian Sea were recorded (Zhulidov et al., 2018). However, until now, no records of dreissenid species neither Ponto-Caspian natives or invasive have been known from southwest Caucasian inland waters.

Ecologically highly-tolerant *Mytilopsis leucophaeata* commonly lives in brackish waters though it can cope with wide range of salinity from 0.1 to 26.4 ‰ (Verween et al., 2010). The Paliastomi Lake is a brackish waterbody that is directly connected with the Black Sea

Fig. 3. *Corbicula fluminalis*: *1–4* whole specimen from native range, Vilesh River near Masally, Azerbaijan (*1*, *2* — right valve, *3*, *4* — left valve); *5–8* — whole specimen from Pichori village (locality 1) (*5*, *6* — right valve, *7*, *8* — left valve); *9–10* — a single left valve from Tbilisi Reservoir (locality 4) from outside (*9*) and inside (*10*); *11–12* — a single left valve from Shaori Reservoir (locality 3) from outside (*11*) and inside (*12*); *13–14* — a single left valve from Iori River (locality 5) from outside (*13*) and inside (*14*).

by Maltakva canal and regularly feeds from seawater. On the other hand, Patara Paliastomi might be less saline (not appropriate data is available) though supposedly still within the optimal salinity range of *M. leucophaeata*. Re-examination of the Patara Paliastomi lake and Paliastomi lake after 8 years after first visit in 2010 provided new evidence of the occurrence of *M. leucophaeata* in both lakes. In particular, shells were found all along the lake shoreline indicating the existence of viable population. Since the Paliastomi Lake is an offshore lake with lack of hard substrate, the species seems rather limited in its fine scale distribution (Zhulidov et al., 2018) but at coarser scale, it might be more widespread along the entire Caucasian Black Sea coast and is also expected in Turkish Black Sea offshore. In contrast to Paliastomi Lake, Shaori Reservoir is purely freshwater with Ca^{+} as a primary source of mineralization and is supposedly less suitable for *M. leucophaeata*. Moreover, *M. leucophaeata* is known to prefer warm waters for successful reproduction and low temperature (near 0 °C) can cause a complete extinction of the population (Kennedy, 2011) although the species seems to be tolerable to habitats subject to winter freezing (Zhulidov et al., 2018). Thus, existence of viable population of *M. leucophaeata* in the Shaori Reservoir is questionable. Indeed, a repeated examination of the collection site in May of 2018 did not confirm the presence of the species there, leaving the finding of its shell in 2010 misterious.

Discharge of ballast water is considered as usual means of long distance, inter-basin dispersal for the larvae of *M. leucophaeata*. The benthic stage of this mussel may be dispersed while attached to ship hulls (Van der Gaag et al., 2016). Accordingly, once approached to new areas, the larvae or adults can subsequently spread along the canal system actively or with the help of human activity (Heiler et al., 2010; Zhulidov et al., 2018). Again, Patara Paliastomi as well as Palaiastomi Lake is highly accessible for species spreading with the help of ballast water. In contrast, Shaori Reservoir is inaccessible for species migrating upstream due to dam systems at the Shaori and Tkibuli Reservoirs — a second large reservoir situated 12 km downstream from Shaori. Therefore, it is quite difficult to trace the relevant pathway of introduction of *M. leucophaeata* in Shaori Reservoir. Sergeyeva (1968) reported that the *D. polymorpha* was introduced in Tkibuli Reservoir in early sixteenth to "support the development of freshwater macroinvertebrate community". However, after subsequent checking few years later, it was concluded that *D. polymorpha* did not form any self-sustaining population there. If the introduction of *M. leucophaeata* is related to that event, then the invasion of the species in Ponto-Caspian region could be much older than currently supposed (Heiler et al., 2010; Zhulidov et al., 2018). Nevertheless, existing records of *M. leucophaeata* in Ponto-Caspian basin (Zhulidov et al., 2018) indicates that the species has been widely represented in the region after 1995 though the exact pathways and the mechanisms of its distribution still remains highly speculative.

The other bivalve species belonging to the genus *Corbicula* Megerle von Mühlfeld, 1811 collected in four out of five studied localities (fig. 1, 1, 3–5, table 1) seems to be a second alien species at least in western Georgia. According to Zhadin (1952) *Corbicula fluminalis* (O. F. Müller, 1774) occurs only in some inland waters around the Caspian Sea and is native species eastern South Caucasus, at least for lower part of the Kura River. Even more, fossil representatives of Cyrenidae, e. g. *Corbicula fluminalis* var. *apscheronica* Andrusov, 1923 are known in Azerbaijan since Apsheronian, Eopleistocene (e. g. Kolesnikov, 1950). Recent populations of *C. fluminalis* were currently registered in Azerbaijan in lower reach of the Kura River and Vilesh River (V. Anistratenko, pers. observation, May 2017).

Although its occurrence in Georgian part of Kura River basin was highly expected, no any published record of *Corbicula* species from Georgia appeared so far. This particularly concerns to the western part of the country — our findings close to the mouth of the Enguri River (fig. 1, locality 1) and in Shaori Reservoir (fig. 1, locality 3) are so far the only known records of this species in the Black Sea coastal part of Georgia. From a geographical point of view, it is worth underlining that two sites of *Corbicula* records are located in the basins of rivers flowing into the Black Sea (fig. 1, locality 1 and 3) while two others findings (in

Tbilisi Reservoir and Iori River) are located (fig. 1, locality 4 and 5) within the Kura River basin which flows into the Caspian Sea.

It is difficult to say exactly how the *Corbicula* got into the water-bodies of rivers flowing into the Black Sea, but it probably entered through the Kura River watercourses in its upper part. Introduction and expansion of this species outwards native area has recently been recorded in Shura-Ozen´ River in Caspian Dagestan coast (Nabozhenko, Nabozhenko, 2016). Apparently the initial area of the *Corbicula* restricted mainly to the Kura River basin, gradually expands and may soon include also other water-bodies in the western part of South Caucasus. Available material and data on this species is unfortunately relatively scarce to outline the distribution pattern of *Corbicula* in the region and additional investigation required to establish the relevant pathway of its introduction. Nevertheless, the here reported data on *Corbicula* from Georgia can be considered as a new record for *C. fluminalis* for the country.

Apart the above discussed species there are three additional non-indigenous mollusc species invaded to Georgia. One is recently registered freshwater planorbid gastropod *Ferrissia californica* (Rowell, 1863) [formerly widely known as *Ferrisia fragilis* (Tryon, 1863)] that was recorded from Tskaltsitela Cave. This is the first record of a sustained population of an invasive freshwater pulmonate in an underground environment (Vinarski, Palatov, 2018). These authors suggest that *F. californica* might be invaded the Tskaltsitela cave some 10 to 20 years ago. However, since the freshwater mollusc fauna of Georgia is yet purely studied, occurrence of this species in other part of the region is also highly expected.

Other freshwater mollusc turned out to be alien pulmonate, *Physella acuta* (Draparnaud, 1805), which is one of the most common species in Georgian inland waters (Javelidze, 1973, our unpublished data) and was until recently considered as a native species for Europe. However, it has been shown that this species is actually invasive, originated from North America and spread in Palearctic region during the last several hundreds of years (Vinarski, 2017).

The third non-indigenous gastropod species is a terrestrial helicoid snail *Eobania vermiculata* (O. F. Müller, 1774) reported from the Black Sea coastline (Mumladze & Paposhvili, 2016). This species is most probably a very recent invader of the region and a single invasive terrestrial mollusc known so far from Georgia.

To summarize, currently five non-marine mollusc species can be considered as an alien/invasive for Georgia. All these except *E. vermiculata* seem to be introduced much earlier before they would have been recorded. Accordingly, additional research, especially in fresh and brackish waters is needed to evaluate diversity of alien mollusc species, invading trends, and treats/ecological consequences on the native fauna.

The authors thank two anonymous reviewers for constructive remarks on an earlier version of this paper. Levan Ninua (Ilia State University) kindly provided additional data on *Corbicula* from Tbilisi Reservoir. Olga Anistratenko (Institute of zoology NAS of Ukraine) assisted in preparing the plates. Mikhail Son kindly helped to collect missing references. This study was supported by Shota Rustaveli National Science Foundation under the research grant "Biodiversity of Freshwater Molluscs of Georgia (#217086).

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Received 13 November 2018
Accepted 5 March 2019