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Three new alien freshwater gastropods found in Serbian waters

(Gastropoda, Tateidae and Planorbidae)

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In this article, we report on the first findings and discuss the presence of three alien freshwater gastropods in Serbian waters, namely *Potamopyrgus antipodarum* (J. E. Gray, 1843), *Planorbella* cf. *duryi* (Wetherby, 1879) and *Menetus dilatatus* (A. Gould, 1841). Of these, only *P.* cf. *duryi* was found exclusively in a greenhouse, while the other two were found in the field. In addition, we discuss the morphological and anatomical traits on which we have based the identification of *P.* cf. *duryi*.

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Introduction

The globalization of trade and travel has facilitated and enabled the anthropogenic spread of various species across the globe. Although a majority of these species have failed to establish populations in places outside their native range, some of them have managed to do so successfully. It is not so unusual for these alien species to have a significant impact on the environment, the economy, and human health (Keller et al. 2011). Their spread and the establishment of populations can also be facilitated by recent climate change, and these combined factors, together with a large constellation of negative human impacts, have led to invasive species becoming the main drivers of global biodiversity change (Keller et al. 2011, Xu et al. 2018). Almost all large groups of organisms have invasive species among them. Among molluscs, alien land snails are recognized as the main current and future threat (Hausdorf 2023), but freshwater snails follow them without delay (Preston et al. 2021).

Research on alien freshwater invertebrates in Serbia has increased considerably in the 21st century, resulting in numerous publications reporting new occurrences of alien annelids (Paunović et al. 2005, Jakovčev-Todorović et al. 2006, Zorić et al. 2011), crustaceans (Paunović et al. 2004, Pavlović et al. 2006, Škraba et al. 2013, Živić & Vesović 2019), bivalves (Paunović et al. 2006, 2007, Raković et al. 2013), or cnidarians (Jakovčev-Todorović et al. 2010).

The freshwater gastropods of Serbia are also represented by several alien species such as *Physella acuta* (Draparnaud, 1805), *Melanoides tuberculata* (O. F. Müller, 1774), *Ferrissia californica* (Rowell, 1863) (Zorić et al. 2020, Marković et al. 2021) and *Clathrocaspia knipowitschii* (Makarov, 1938) (Szekeres et al. 2022). Of these, *M. tuberculata* is only known from several thermal springs near the city of Niš (eastern Serbia) and has not been recorded elsewhere (Milenković & Gligorijević 2012, Savić et al. 2021). Other species can usually be found, or already are found in larger rivers, their tributaries and adjactent waters.

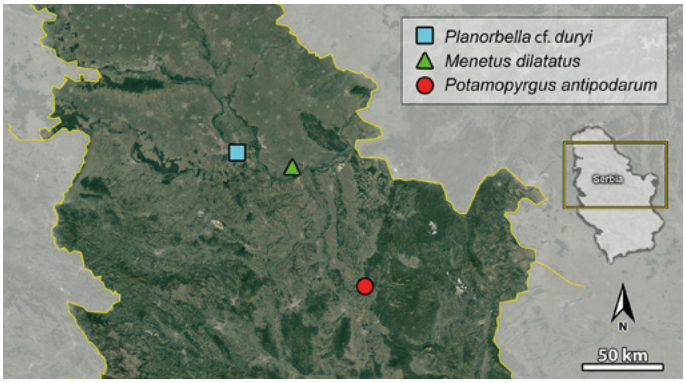

Fig. 1. Distribution map showing the sampling sites of reported species.

The New Zealand Mud snail, *Potamopyrgus antipodarum* (J. E. Gray, 1843), originally native to New Zealand, is one of the most notorious invasive species spread all over the world (Nentwig et al. 2018, Taybi et al. 2021, Geist et al. 2022). The species is highly adaptable and inhabits a wide variety of habitats, including freshwater ecosystems, estuaries and polders (Alonso & Castro-Dıez 2012).

Species of the genera *Helisoma* and *Planorbella* originate from North America and are found in Europe as alien species, mainly in greenhouses, but also in the field (Leiss & Reischütz 1996, Glöer 2019). The two most frequently mentioned species are *H. anceps* (Menke, 1830) and *P. duryi* (Wetherby, 1879). Another member of the tribe Helisomatini, which originates from North America and is not considered native to Europe, is *Menetus dilatatus* (A. Gould, 1841). This species is known from several European countries, including the Czech Republic (Beran 2003, 2005), Poland (Berger & Dzięczkowski 1979, Kołodziejczyk & Lewandowski 2015), Great Britain, France, Germany (Strzelec 2011) and Ukraine (Stadnychenko 2014).

In this article, we report on the first findings of *P. antipodarum* and *M. dilatatus* in Serbian waters and briefly discuss their occurrence. We also report on the occurence of *Planorbella* cf. *duryi* in the greenhouse of the Jevremovac Botanical Garden in Belgrade, for which we further discuss the species identity.

Material and methods

The specimens examined were collected by hand and fixed directly in 70 % ethanol. Shells and genitalia were photographed using a Nikon SMZ800N stereomicroscope with a Nikon DS-Fi2 camera or a Zeiss SteReo Discovery.v12 stereomicroscope with a Leica Flexacam C3 camera. Distribution maps were made using Google Earth Pro. The nomenclature of the male genitalia of *P. duryi* follows Baker (1945) and Hubendick (1955) (the latter one as alternative in brackets). All specimens are stored at the Institute of Zoology, Faculty of Biology, Belgrade, Serbia. Abbreviations: IZOO-MG = Institute of Zoology, Faculty of Biology, University of Belgrade, Serbia.

Results

Subclass Caenogastropoda L. R. Cox, 1960
Family Tateidae Thiele, 1925

Potamopyrgus antipodarum (J. E. Gray, 1843)

Material examined: Two specimens, town of Despotovac, small brook near the old watermill, 44°05'46.20"N 21°26'11.38"E, 191 m a.s.l., 23.VI.2022, leg. M. Vujić (IZOO-MG-001); 45 specimens, same locality data as previous, 25.II.2023, leg. M. Vujić & V. Gojšina (IZOO-MG-005).

Description of characters observed in Serbian specimens

All the collected specimens were covered in black debris giving the shell a completely black appearance, but it is in fact brownish-yellowish. Sutures are deep and whorls are therefore convex. The peristome is complete, thinner on the palatal and thicker on the parietal side. The operculum is blackish (due to the incrustation) (Fig. 2).

Remarks. All the specimens examined were found at the same site (Fig. 1), a small brook in the centre of the town of Despotovac. The brook is very shallow (up to about 10 cm in the places where snail samples were taken) and has a muddy bottom. The flow rate of the brook is slow and it is heavily overgrown with aquatic vegetation, both riparian and submerged. The edges of the brook bed are walled. The water

was assessed in situ as highly organically polluted, mainly due to the presence of an inflow of untreated sewage not far from where the snails were collected. Together with *P. antipodarum*, there are also a few other aquatic snails, *Radix* sp., *Gyraulus* sp. and also allochthonous *Physella acuta*. The associated plant species is mainly fool's watercress (*Helosciadium nodiflorum*).

The population of *P. antipodarum* was very dense and we were able to collect numerous specimens in a short time. We stirred up the mud at the bottom of the brook by hand and numerous specimens appeared floating on the surface of the water.

Subclass Heterobranchia Burmeister, 1837
Family Planorbidae Rafinesque, 1815

***Planorbella* cf. *duryi* (Wetherby, 1879)**

Material examined: 21 specimens, city of Belgrade, Jevremovac Botanical Garden, greenhouse, 44°48'57.27'' N 20°28'23.33'' E, 92 m a.s.l., 14.I.2022, leg. V. Gojšina (IZOO-MG-004); eight specimens, same locality data as previous, 21.IV.2022, leg. V. Gojšina (IZOO-MG-003); three specimens, same locality data as previous, 28. IV.2022, leg. V. Gojšina (IZOO-MG-002).

Description of characters observed in Serbian specimens

The shells were relatively small to medium sized, planispiral, greenish-brownish in colour. The peristome is sharp and relatively thin. The aperture is large, ear-like shaped. The umbilicus is open and there is a blunt keel present along the shell surface (Fig. 3C). The mantle is characteristically patched with medium sized black blotches. The penis consists of two parts, the praeputium and the vergic sac (or penial sheath as in Hubendick (1955)). The appearance of these parts can vary so that the penis may be bipartite (Fig. 3A) rather than simple (Fig. 3B) (for further examples, see Baker, 1945: pg. 303, pl. 33). Inside the vergic sac, a simple verge could be observed. Inside the praeputium, there is a cup shaped penial gland (or praeputial organ as in Hubendick (1955)). The gland has its own duct which is thick and externally visible around the part where the gland itself is located. The radula of analysed specimens is the same as described by Baker (1945). The central tooth is bicuspid, lateral ones are tricuspid and pointed, while marginal ones are multicuspid and claw like. One of the cusps of the marginal teeth is particularly strong. There are also some intermediate forms of lateral teeth close to the marginals which show additional smaller cusps between the mesocone and endocone/exocone.

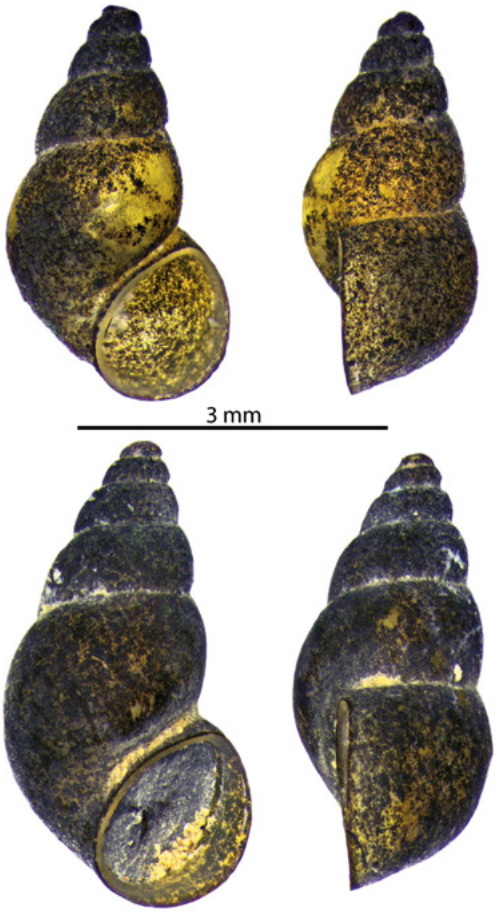

Fig. 2. *Potamopyrgus antipodarum* (J. E. Gray, 1843) from the town of Despotovac.

Remarks. Specimens of *Planorbella* were found exclusively in the greenhouse of the Jevremovac Botanical Garden in Belgrade (Fig. 1). They were found in large numbers in several small pools. Due to the high variability of the shells and the lack of comparative specimens, we could not identify them to species level with absolute certainty. Two possible options are *H. anceps* and *P. duryi*, and some of our specimens showed mixed characteristics, especially in shell morphology. Therefore, shell appearance was not considered in species identification. We consider it unlikely that both species are present. This issue is discussed further below. In the same pools, we found a single, empty shell, of *Pomacea* sp. However, as *Pomacea* has not established the population, this record is not considered. Another allochthonous snail, *Physella acuta*, also occurs in the same pools and it is the first indoors occurrence in

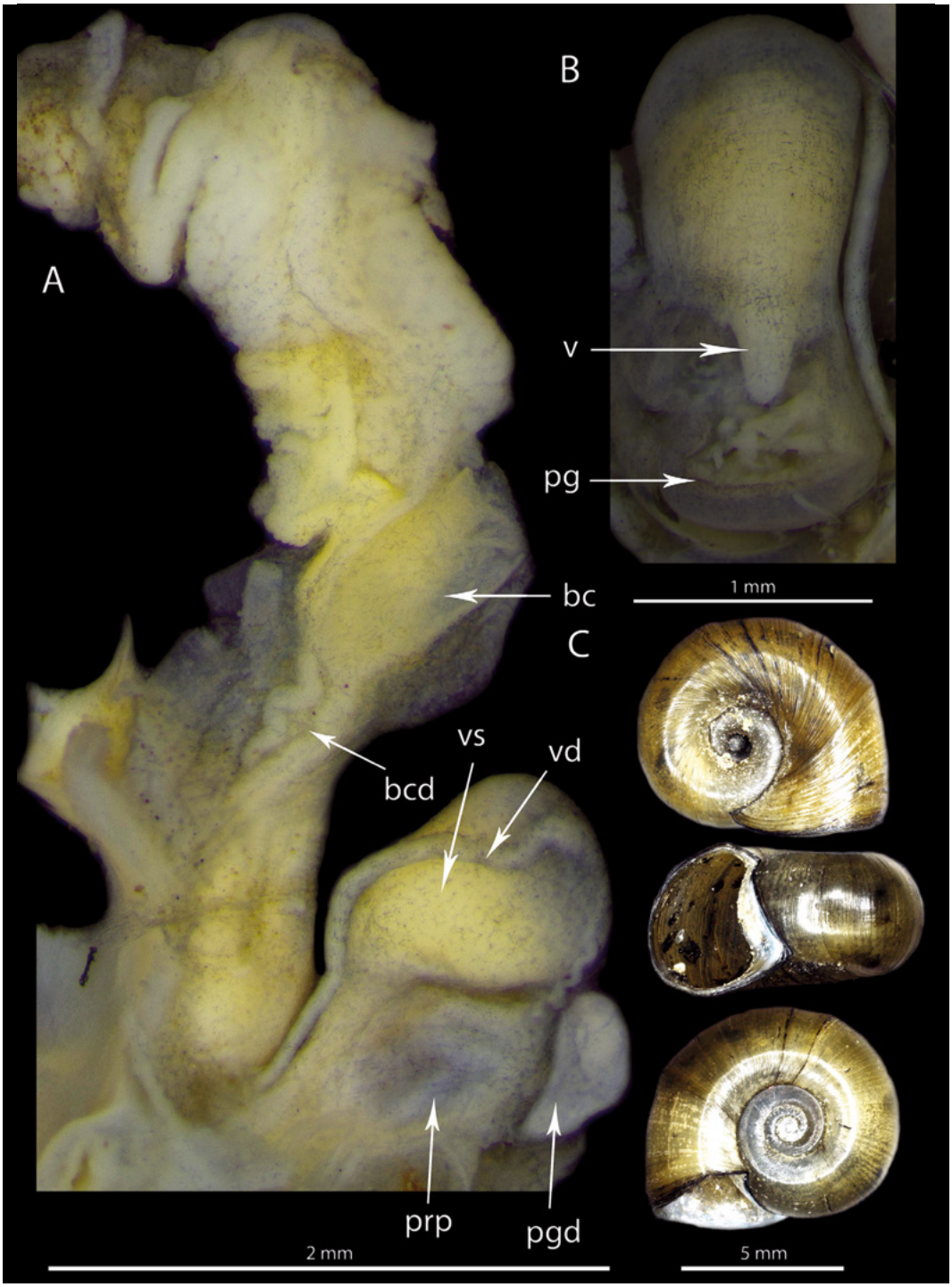

Fig. 3. *Planorbella* cf. *duryi* (Wetherby, 1879) from greenhouse in Belgrade. **A.** Whole genitalia; **B.** inside of the penial complex; **C**. shell of examined specimen. bc, bursa copulatrix; bcd, duct of the bursa copulatrix; pg, penial gland; pgd, duct of the penial gland; prp, praeputium; v, verge; vd, vas deferens; vs, vergic sac.

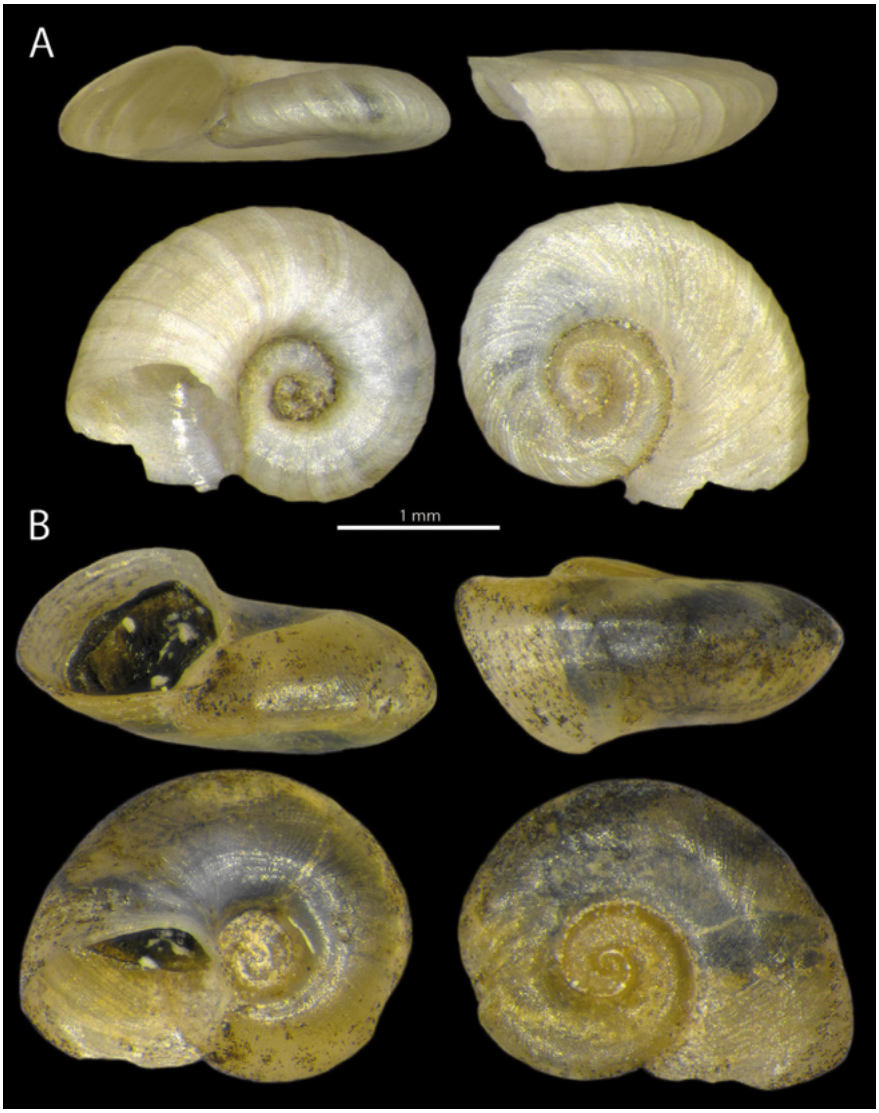

Fig. 4. A. *Gyraulus crista* (Linnaeus, 1758); **B.** *Menetus dilatatus* (A. Gould, 1841) from the village of Malo Bavanište.

Serbia of this generally very widespread alien snail. These pools are made of concrete and are intended for growing tropical aquatic plants in a greenhouse. On the water surface, *Lemna* sp. dominates heavily, with several *Pistia stratiotes* plants. *Colocasia gigantea*, *Cyperus alternifolius*, *Cyperus papyrus*, and some submerged unidentified plants are also planted in the pools. The interior of pools are extensively overgrown by green algae, in which the snails were collected inter alia.

Menetus dilatatus (A. Gould, 1841)

Material examined: two specimens, village of Malo Bavanište, Raj beach at Danube, 44°44'40.76'' N 21°06'50.62'' E, 67 m a.s.l., 26.IX.2019, leg. V. Gojšina (IZOO-MG-006).

Description of characters observed in Serbian specimens

The shell is light brownish, minute and planispiral. The surface is radially striated and occasionally spirally. The last whorl is strongly enlarged. The

peristome is thin and fragile, the aperture is also enlarged. The lower side is almost completely flat. The umbilicus is moderately wide (Fig. 4).

Remarks. Two living specimens were found at Raj beach in the village of Malo Bavanište (Fig. 1) among plants on the silent shore on the Danube river. This species is somehow similar to *Gyraulus crista* (Linnaeus, 1758) but several characters show clear differences between them. The shell of *G. crista* is generally more flat, surface sculpture can be in form of strong ribs with fringes in some forms of *G. crista* and the aperture is more evenly rounded in *M. dilatatus* (Rowson et al. 2021). Also, spiral striation is frequently mentioned for *M. dilatatus* and is observed in Serbian specimens.

Discussion

Potamopyrgus antipodarum is known from some neighbouring countries such as Bulgaria (Irikov & Georgiev 2008), Romania (Sîrbu 2004), Hungary (Héra 2005), Croatia (Žganec et al. 2020) and Bosnia & Herzegovina (Savić et al. 2020), but surprisingly has not yet been reported from the territory of Serbia. We suspect that this is mainly due to the fact that many regions of Serbia have not been sufficiently researched in terms of mollusc. This species has a high survival rate, even when ingested (Vinson & Baker 2008), and reproduces exclusively parthenogenetically outside its native range which is an important factor in its rapid spread and survival (Geist et al. 2022). We assume that this species is much more widespread in Serbia and it is quite possible that it is already present in larger lowland rivers such as the Danube, Sava, Tisza, and Velika Morava. Possible ways in which the species arrived at the site near the town of Despotovac include dispersal by birds or from aquaria, although the latter is less likely. Further records and monitoring of its distribution are needed to gain a real insight into the status of the species in the country, as well as its actual distribution and potential negative impact on local ecosystems.

When analysing the *Planorbella* specimens from the greenhouse in Belgrade, we noticed some intraspecific variability in shell morphology, which led us to disregard this feature in the identification. We analysed other anatomical features and characteristics of the radula to identify our specimens, relying mainly on important works such as those of Baker (1945) and Pilsbry (1934) and the more recent work of Sitnikova et al. (2010). Regarding the morphology of the radula, Baker (1945) mentioned that the typical *Helisoma* (to which *H. anceps* belongs) has a rounded mesocone on the lateral teeth, in contrast to the subgenus *Seminolina* Pilsbry, 1934 (to which *P. duryi* belongs), which has a pointed mesocone. The lateral teeth of our specimens had a pointed mesocone, but we decided not to rely solely on this feature as we are not sure of its taxonomic significance. We also analysed the penis complex (Fig. 3A, B), which should be informative. Baker (1945) mentions that the penis gland is more cup-shaped in *Helisoma* than in *Seminolina* and that the glandular duct is longer in *Seminolina*. In our specimens, the appearance of the glandular duct agrees with the illustrations in Baker (1945) and Sitnikova et al. (2010) for *P. duryi*. We could not make a decision based on the shape of the penis gland because we did not have the necessary reliably identified comparative material. All specimens were found in small ponds in the greenhouse, and we found some plants that had been brought from Florida. It is almost certain that these snails were brought with the plants as usual, and since *P. duryi* is native to Florida, we consider it more likely that our specimens represent *P. duryi*. This is also supported by the appearance of the penis gland duct, which bears more resemblance to *P. duryi* than to *H. anceps*. However, it is clear that some of the morphological and anatomical features require further clarification, and DNA analysis is also recommended. This species has not yet been recorded in the wild in Serbia, not even in the outdoor water bodies of the same botanical garden, where the only planorbid present is *Planorbarius corneus* (Linnaeus, 1758).

M. dilatatus has been recorded in the Danube and nowhere else. We cannot predict its actual distribution in Serbia. Due to its small size and similarity to some *Gyraulus* species, it is possible that some records of this species are overlooked. The detection of *M. dilatatus* in Serbia represents a very significant extension of its colonised range towards southern Europe. As the species has not yet been found in the Balkans, the record from Malo Bavanište may indicate that due to the geographical proximity there is a real possibility that this species has already colonised some parts of the Balkans. Further surveys are necessary to gain insight into the current distribution of *M. dilatatus* in Serbia and the wider area of southeastern Europe, given that there are real chances that it is already present somewhere in that region.

These new records increase the number of alien freshwater gastropods in Serbia from four to seven. Of these, *P. acuta* is the most widespread and is found in almost all types of water bodies in Serbia. *Ferrissia californica* is known from several localities but is probably much more common than reported in Marković et al. (2021). This is due to its small size and unique shape which makes it easier to be overlooked during regular samplings. *Melanoides*

tuberculata is restricted to several thermal springs and has not been recorded elsewhere (Milenković & Gligorijević 2012, Savić et al. 2021). Considering its limited dispersion potential and the fact that these snails require higher water temperatures, which are present only in a small number of thermal springs in Serbia, only a few new findings of this species in the region could be expected.

Clathrocaspia knipowitschii was recently reported from the Danube (Szekeres et al. 2022) and its dispersal remains yet to be monitored. Finally, we assume that *P. antipodarum* will continue to be reported from several localities and from different regions of Serbia. In this context, the importance of tracking this species and monitoring invasive species in general should be emphasised once again.

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