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New data on *Gyraulus* Charpentier, 1837 in Serbia: the occurrence of *G. chinensis* (Dunker, 1848) and dark-tentacle morph of *G. parvus* (Say, 1817) (Gastropoda: Hygrophila: Planorbidae)

Mihailo Vujić & Vukašin Gojšina

Faculty of Biology, University of Belgrade, Studentski Trg 16, 11000 Belgrade, Serbia
Corresponding author: *M. Vujić (mihailovujic01@gmail.com)*

Abstract. Three species of the genus *Gyraulus* (Hygrophila: Planorbidae) are known to date as part of the Serbian fauna—*G. acronicus* (A. Férussac, 1807), *G. albus* (O.F. Müller, 1774), and *G. parvus* (Say, 1817)—with the last species reported exclusively under its junior synonym *G. laevis* (Alder, 1838). None of these species have been recognized as allochthonous in Serbian waters. Herein, we report on the occurrence of *G. chinensis* (Dunker, 1848) in Serbia for the first time, as well as on a morph of *G. parvus* with dark-pigmented tentacles, the allochthonous North American race of this species. We discuss the morphology and identification of these species, as well as the possible pathways of their introduction to Serbia. Both *G. chinensis* and the dark-tentacled morph of *G. parvus* are currently restricted to indoor and human-controlled waters in Serbia.

Key words. Allochthonous, aquarium, aquatic habitat, East Asia, greenhouse, Mollusca, North America

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Introduction

The freshwater gastropod fauna of Serbia currently comprises 70 species (Marković *et al.* 2021; Szekeres *et al.* 2022; Gojšina & Vujić 2024; Gojšina *et al.* 2024, 2025). Among these, eight species are allochthonous: *Potamopyrgus antipodarum* (J.E. Gray, 1843), *Melanoides tuberculata* (O.F. Müller, 1774), *Clathrocaspia knipowitschii* (Makarov, 1938), *Physella acuta* (Draparnaud, 1805), *Pseudosuccinea columella* (Say, 1817), *Menetus dilatatus* (A.A. Gould, 1841), *Planorbella duryi* (Wetherby, 1879), and *Ferrissia californica* (Rowell, 1863). One species, *Gyraulus parvus* (Say, 1817), has been reported several times in Serbia (Marković *et al.* 2021), but only under its junior synonym, *G. laevis* (Alder, 1838) (Lorencová *et al.* 2021). There are both native and allochthonous North American races in Europe. Apart from *G. parvus*, the genus *Gyraulus* Charpentier, 1837 itself includes two more species that have been reported from Serbia: *G. acronicus* (A. Férussac, 1807) and *G. albus* (O.F. Müller, 1774) (Marković *et al.* 2021). *Armiger crista* (Linnaeus, 1758), a closely related planorbid commonly reported as member of the genus *Gyraulus*, is also known from Serbia (Marković *et al.* 2021). The conchologically similar, allochthonous *M. dilatatus* is not closely related, as it belongs to the tribe Helisomatini F.C. Baker, 1928, whereas *Gyraulus* and *Armiger* are members of the tribe Planorbini Rafinesque, 1815 (Gojšina *et al.* 2024).

Lorencová *et al.* (2021) demonstrated that *G. laevis* is actually a unique European race of *G. parvus*, a species that was described from North America. All reports of *G. laevis* in Serbia (Frank *et al.* 1990; Arambašić 1994; Karaman 2001; Paunović *et al.* 2012; Marković *et al.* 2013, 2021) were attributed to the latter, but without clarity on whether Serbian populations belonged to the native or allochthonous North American race. Although conspecific, the native European lineage and the allochthonous North American lineage belong to different haplotypes or so-called races; the allochthonous race is highly invasive and genetically displaces much rarer, native lineage (Lorencová *et al.* 2021; Klobušická *et al.* 2025). While the morphological characters proposed by some authors who

opposed synonymization (e.g. Glöer 2024) are unstable and cannot be used with certainty, the dark pigmentation of the tentacles was shown to be easily observed and enough stable to be used for delimitation of the European and North American lineages (Klobušická *et al.* 2025).

Gyraulus chinensis is native to East and South Asia and has been introduced around the globe (Welter-Schultes 2012). It is now known to have been introduced into Africa (Guinea Bissau, Brown *et al.* 1998; South Africa, Appleton & Miranda 2015), Western Asia (Israel, Mienis *et al.* 2015; Vaisman & Mienis 2020), the Lesser Antilles (Pointier 2008), and Australia (Ponder *et al.* 2024). The native status of populations from Kyrgyzstan recorded by Glöer *et al.* (2014) is doubtful. In Europe, the species appears to be widespread, occurring outdoors in the southern part of the continent, probably as a result of more favourable winter temperatures, and in indoor or heated waters in areas with a pronounced continental climate (Saito *et al.* 2023). Saito *et al.* (2023: fig. 1) provided a map of localities where the species occurs in Europe, clearly separating data from indoor and outdoor waters. *Gyraulus chinensis* was probably introduced several times into Europe, based on molecular evidence (Saito *et al.* 2023). Saito *et al.* (2023) emphasized that the aquarium industry and keeping is an important in the spread of *G. chinensis* across Europe. This claim is supported by observations of other authors, who recorded the species in aquaria and the aquarium-plant trade (Appleton & Miranda 2015; Vaisman & Mienis 2020).

The aim of this article is to report the presence of *G. chinensis* indoors in Serbia, and to present first record of the North American race of *G. parvus*, from a pool in greenhouse in the Jevremovac Botanical Garden, Belgrade.

Material and Methods

Specimens of *Gyraulus parvus* and *G. chinensis* were collected by hand. Specimens of *G. parvus* were fixed immediately in 70% ethanol. Specimens of *G. chinensis* were first kept in aquarium water to allow observation and photography of their mantle colouration, and then transferred to plastic tubes filled with 70% ethanol as a fixative. Shells and living specimens were photographed using a Nikon SMZ800N stereomicroscope equipped with a Nikon DS-Fi2 camera. Scale bars were set using a Nikon DS-L3 control unit. Specimens were identified using two identification guides (Welter-Schultes 2012; Glöer 2019). Collected specimens are deposited as vouchers in collection of Institute of Zoology, Faculty of Biology, Belgrade (IZOO).

Results

***Gyraulus chinensis* (Dunker, 1848)**
Figures 1A–C, 2A–C

Material examined. SERBIA, Belgrade, New Belgrade, Milutina Milankovića Street, 44.8052°N, 020.4226°E, 19 January 2026, leg. V. Gojšina & M. Vujić, 13 specimens (IZOO-MG-047).

Remarks. We observed a persistent population, with abundant individuals, in tanks with various ornamental fish and plants in the aquarium section of a pet centre. Numerous living specimens, as well as empty shells, were recorded between 2023 and 2026. Specimens were found in the sand and gravel substrate, on the glass of the tanks, and in submersed plant pots, mainly among plant roots. They are virtually omnipresent in tanks, except in those with fish that typically prey on snails, such as *Botia* spp. and *Chromobotia macracanthus* (Bleeker, 1852). *Gyraulus chinensis* occurs among various aquatic plant species, including *Echinodorus* spp., *Eleocharis acicularis* (L.) Roem. & Schult, *Anubias barteri* Schott, *Rotala rotundifolia* (Buch.-Ham. ex Roxb.) Koehne, and *Hydrocotyle tripartita* R.Br. ex A.Rich., among others. Besides a few intentionally kept gastropod species for sale—*Neritina pulligera* (Linnaeus, 1767), *Vittina natalensis* (L.A. Reeve, 1845), *Anentome helena* (von dem Busch, 1847), and *Pomacea bridgesii* (Reeve, 1856)—three additional, "stowaway" snails co-occur with *G. chinensis*: *M. tuberculata*, *P. duryi*, and *P. acuta*.

***Gyraulus parvus* (Say, 1817)**
Figures 1D–F, 2D

Material examined. SERBIA, Belgrade, Palilula Municipality, Jevremovac Botanical Garden, 44.8159°N, 020.4731°E, 10 September 2025, leg. V. Gojšina, 9 specimens (IZOO-MG-048).

Remarks. We discovered a small population of several specimens in a concrete pool within the tropical dome of the greenhouse at Jevremovac Botanical Garden, Belgrade. From the same pools, Gojšina *et al.* (2024) reported a population of *P. duryi*, another North American, allochthonous planorbid. When the specimens of *G. parvus* were collected, the pools were used for the cultivation of various tropical aquatic plants, such as *Cryptocoryne* spp., *Anubias* spp., *Cyperus alternifolius* Rottb., *C. papyrus* L., and, on the water surface, *Lemna minor* L. The bottom of the pool consists of mud and decaying leaves from the plants cultivated above pool, and there are dense stands of macroalgae on the rocks and edges. The gastropod fauna comprises both allochthonous and native aquatic snails, namely *Bithynia tentaculata*

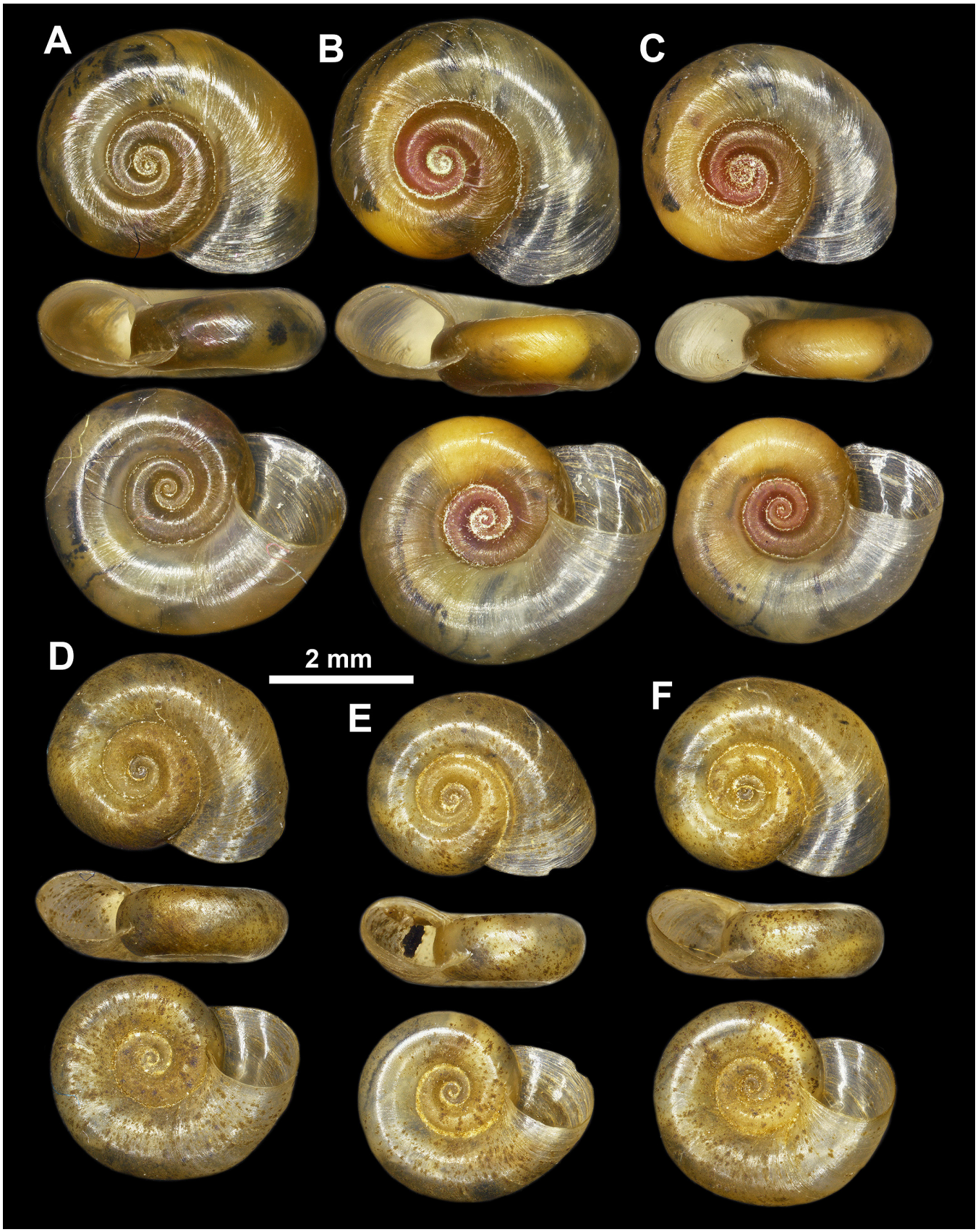

Figure 1. Shells of *Gyraulus chinensis* (**A**–**C**) and *G. parvus* (**D**–**F**) from Belgrade, Serbia.

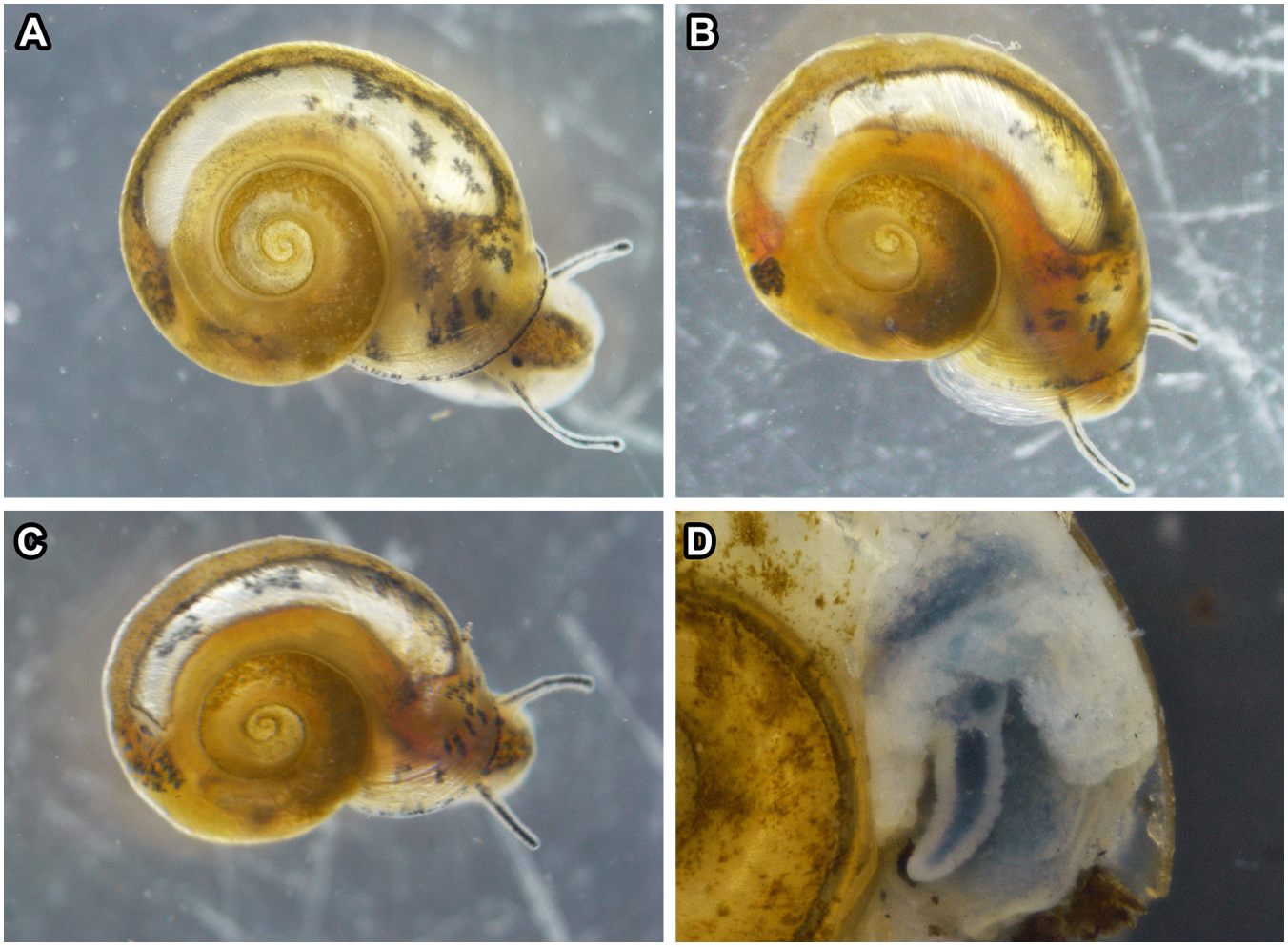

Figure 2. Living specimens of *G. chinensis* (**A**–**C**) and tentacle pigmentation in preserved specimen of *G. parvus* (**D**) from Belgrade, Serbia. Not to scale.

(Linnaeus, 1758), *Anisus vortex* (Linnaeus, 1758), *Hippeutis complanatus* (Linnaeus, 1758), *Lymnaea stagnalis* (Linnaeus, 1758), and *P. acuta*, in addition to the already mentioned *P. duryi*.

Gyraulus chinensis can be separated from congeners in Serbia by its characteristic mantle-colour pattern of numerous, irregular black spots. Its shell is also smaller and glossier than *G. acronicus. Gyraulus chinensis* lacks the strongly pronounced reticulated shell surface microsculpture of *G. albus.* It is larger, at least specimens from Serbia, and flatter than *G. parvus*. *Gyraulus parvus* can be separated most easily from *G. albus* by the lack of the reticulated microsculpture, and from *G. acronicus*, by the smaller size, glossier shell surface, and sometimes also absence of the peripheral fringe (Welter-Schultes 2012; Glöer 2019). The North American lineage of *G. parvus* morphologically differs from European lineage of *G. parvus* by presence of darkly pigmented tentacles (Klobušická *et al.* 2025), which we observed in specimens from the Jevremovac Botanical Garden (Fig. 2D). Tentacle pigmentation has not been reported for any Serbian populations.

Discussion

To date, three *Gyraulus* species have been reported as occurring in Serbian waters: *G. acronicus*, *G. albus*, and *G. parvus*; the last species has been reported multiple times under its recently recognized junior synonym, *G. laevis* (Alder, 1838) (Marković *et al.* 2021). Lorencová *et al.* (2021) found that the European native *G. laevis* actually belongs to the same clade as the North American *G. parvus*, which has been introduced into Europe and has spread across the continent. Despite molecular evidence provided by Lorencová *et al.* (2021), some authors such as Glöer (2024) opposed

to synonymization. Glöer (2024) cited the existence of certain characters that separate *G. laevis* and *G. parvus*. We identified several significant weaknesses in the information presented by Glöer (2024), which leads us to question the reliability of the work.

Glöer (2024) specifically mentioned differences in the vas deferens, elevation of the penultimate whorl, and ecology but did not provide sufficient evidence for these distinctions to support his viewpoint of there being two separate species. The attenuation of vas deferens is not discussed in detail, and a comparison of the vas deferens of *G. laevis* and *G. parvus* is not shown, but only the latter is illustrated. Conchological differences, such as the elevation of the penultimate whorl, cannot be used as definitive characters due to potential variability and character overlap, which were not discussed by Glöer (2024) but have been addressed by Lorencová *et al.* (2021). It is unclear how many specimens or populations Gloër analyzed. There is no clear evidence of ecological separation between the two species, no sample is provided to support the existence of ecological differences, and the reported differences can most likely be explained by chance.

In accordance with the above, we agree with Lorencová *et al.* (2021) in retaining *G. laevis* and *G. parvus* as conspecific, and that there are both native and allochthonous races in Europe: one native and the other allochthonous, native to North America. Taking into account that the allochthonous race has been present in Europe since at least 1970 (Meier-Brook 1983), it is possible to assume that specimens reported under the name *G. laevis* before that date could belong to the native race. Jaeckel *et al.* (1958) first mentioned *G. laevis* in Serbia, which corresponds to a time when probably only the native race was present there. All other accounts of *G. laevis* in Serbia (Frank *et al.* 1990; Arambašić 1994; Karaman 2001; Paunović *et al.* 2012; Marković *et al.* 2013, 2021) are from after 1970 and therefore could refer to either race. As no molecular characterization of Serbian populations has been done, there is no information about the presence of particular races in the country. The final verdict on the current distribution of these races in Serbia is possible exclusively by examining haplogroups according to Lorencová *et al.*'s (2021) methodology. However, Klobušická *et al.* (2025) found that there is a sufficiently stable and easily observed character available to distinguish the two races: the presence or absence of dark pigmentation in the tentacles (Fig. 2D). Klobušická *et al.* (2025) showed that tentacle pigmentation corresponds well to the two haplotypes. Specimens we found in the Jevremovac Botanical Garden greenhouse possess dark-pigmented tentacles, so it is almost certain that these snails belong to the North American race. Although the ecological differences between these two races need to be examined in more detail to draw conclusions about their possible taxonomic significance, the individuals we found correspond to what has been reported in previous publications (Lorencová *et al.* 2021; Glöer 2024; Klobušická *et al.* 2025).

Our new record of *G. parvus* comes from Jevremovac Botanical Garden in Belgrade where another allochthonous planorbid, *P. duryi*, has already been reported (Gojšina *et al.* 2024). The introduction pathway of *P. duryi* into this greenhouse was probably linked to the importation of plants from Florida, USA (Gojšina *et al.* 2024). Given that *G. parvus* occurs in Florida (Dillon *et al.* 2026), it is possible that its introduction followed the same pathway as *P. duryi*. However, final conclusions about the origin of the populations in the greenhouse can only be drawn after molecular characterization. The European origin of the *G. parvus* population in the greenhouse cannot be excluded, given that we recorded several gastropod species common in outdoor Serbian waters also in the outdoor waters of the same botanical garden. The other recorded species, besides *P. duryi*, are *Bithynia tentaculata*, *Anisus vortex*, *Hippeutis complanatus*, *Lymnaea stagnalis*, and *Physella acuta*. Although definitive conclusions about the origin of Serbian populations remain unresolved, *G. parvus* can be considered partly allochthonous. If hybridization of native and allochthonous races occurs, it could lead to the loss of the genetic uniqueness of the local race, which can be described as a special type of threat, and to the best of our knowledge, is unique among Serbian molluscs. This phenomenon, however, is known and has already been discussed as a real threat, which can even lead to extinction (Levin *et al.* 1996; Rhymer & Simberloff 1996; Ayres *et al.* 2004; Todesco *et al.* 2016; Zemanova *et al.* 2017; Klobušická *et al.* 2025). One of the topics for future research on *G. parvus* in Europe should be the potential hybridization of the native and allochthonous races, as well as assessing the threats to the native race through genetic homogenization.

The first observation of *G. chinensis* in Serbia is reported herein. According to our observations, *G. chinensis* is currently restricted to, or certainly only known from, one pet centre in Belgrade. However, it is almost certain that *G. chinensis* has a much wider distribution in the country, at least in aquaria, given that this pet centre is one of the main sources of aquaria, fish, invertebrates, plants, substrates, equipment, and decorations for aquarists. It is certain that gastropod stowaways are transported to private aquaria throughout Belgrade and Serbia almost every working day.

Gyraulus chinensis is currently the smallest stowaway gastropod occurring in aquaria in Serbia (maximum diameter *c.* 5 mm; Welter-Schultes 2012), and it is consequently most likely overlooked as part of the unintentionally introduced aquarium fauna. Based on our observations, a persistent population of *G. chinensis* exists at this particular pet centre, as we observed an abundant population from 2023 to 2026. The pathway of its introduction is clearly the stocking of aquaria, and, more precisely, we assume it is linked to the trade of ornamental aquatic plants. Vaisman & Mienis (2020) reported this species from *Echinodorus* plant merchandise in Israel. The Belgrade pet centre has a rich supply of various aquatic plants, kept both in fish tanks and in separate tanks without fish. The plants originate from a nursery in the town of Sombor, in northern Serbia. If our assumptions about the origin of the population of the Belgrade pet centre popultion of *G. chinensis* are correct, this infers the existence of at least two locations where the species occurs, and quite certainly in larger number of locations. *Gyraulus chinensis* seems to be restricted to indoor and/or heated waters in Europe where the climate is continental (von Proschwitz 2005, 2025; Beran & Glöer 2006; Saito *et al.* 2023). The species successfully survives outdoors in southern Europe, probably due to warmer water temperatures (Muñoz-Antoli *et al.* 2010; Saito *et al.* 2023). Although there are currently no data indicating that the species could survive long-term in cool, non-artificially heated environments, especially during the winter months, there are a many thermal springs and streams in Serbia (Dokmanović *et al.* 2012) that could provide adequate habitat for colonization if the species were introduced. Examples of species that have escaped from aquaria and now occur in thermal waters of Serbia are already known, such as at the spa of Niška Banja and the spa of Vidrište near Niš; a guppy, *Poecilia reticulata* W. Peters, 1859 (Milenković *et al.* 2014; Vujić & Gojšina in press), the gastropods *Melanoides tuberculata* (Milenković & Gligorijević 2012; Savić *et al.* 2021) and *P. duryi* (Vujić & Gojšina in press), and some tropical aquatic plants common in aquaria (Milenković *et al.* 2014; Vujić & Gojšina in press) occur there. During our sampling of the fauna of thermal waters in 2023–2024, we did not find *G. chinensis*. Saito *et al.* (2023) found that the aquarium industry and keeping aquaria are an important pathway for the introduction of *G. chinensis* into Europe, based on molecular evidence, and that introductions probably happened several times from different origins, based on the genetic diversity and close relationships between *G. chinensis* haplotypes from Europe and its native range, namely Hong Kong, Taiwan, and the Ryukyu Islands (Saito *et al.* 2023). Future studies of haplotype(s) present in Serbian populations may connect Serbian populations to their origin populations in Asia.

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