

NEW RECORDS OF LARVAE AND ADULTS OF THE INVASIVE GOLDEN MUSSEL (*LIMNOPERNA FORTUNEI* DUNKER, 1857) IN THE IVAÍ RIVER (PARANÁ, BRAZIL)

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Abstract: Golden mussel is a freshwater bivalve native from South Asia, but introduced in South America. It is very aggressive, causing ecological and economic problems in invaded environments. Here, we presented new records of larvae and adults of golden mussel in the Ivaí River (Paraná, Brazil). We believe this finding is important mainly because (i) the Ivaí River basin is the second largest basin in the state of Paraná, (ii) Ivaí River is of great relevance to maintain regional freshwater biodiversity, and (iii) Ivaí River is one of the few tributaries free of dams of the Upper Paraná River. Consequently, due to its high conservation importance, records of the invasive golden mussel in Ivaí are worrisome. We recommend future studies about golden mussel distribution in Ivaí River to monitor and, if possible, minimize their spread.

Keywords: biological invasion, invasive exotic species, species range.

NOVOS REGISTROS DE LARVAS E ADULTOS DO MEXILHÃO-DOURADO (*LIMNOPERNA FORTUNEI* DUNKER, 1857) INVASOR NO RIO IVAÍ (PARANÁ, BRASIL)

Resumo: O mexilhão-dourado é um bivalve de água doce nativo do Sul da Ásia, mas introduzido na América do Sul. É muito agressivo, causando problemas ecológicos e econômicos nos locais invadidos. Aqui, apresentamos novos registros de larvas e adultos do mexilhão-dourado no rio Ivaí (Paraná, Brasil). Acreditamos que esta descoberta é importante principalmente porque (i) a bacia do rio Ivaí é a segunda maior bacia do estado do Paraná, (ii) o rio Ivaí é de grande relevância para manter a biodiversidade de água doce regional, e (iii) o rio Ivaí é um dos poucos afluentes livres de barragens do Alto Rio Paraná. Consequentemente, devido à sua importância para conservação, os registros desse bivalve invasor no rio Ivaí são preocupantes. Recomendamos estudos futuros sobre a distribuição do mexilhão-dourado no rio Ivaí para monitorar e, se possível, minimizar sua disseminação.

Palavras-chave: invasão biológica, espécies exóticas invasoras, distribuição geográfica.

Limnoperna fortunei (Dunker, 1857), popularly known as “golden mussel”, is a native mollusk from Southeast Asia which was accidentally introduced around 1990 in South America (Pastorino et al., 1993). After its

establishment in Rio de La Plata basin (Argentina), the golden mussel quickly dispersed to other regions in South America (Darrigran & Pastorino, 1995). In Brazil, its occurrence has been recorded mainly in the South, Southeast and Midwest (Mansur et al., 2003; Takeda et al.,

2003; Avelar et al., 2004; Oliveira et al., 2006; Petsch et al., 2021; Amo et al., 2021). However, the golden mussel has recently been registered in the Brazilian Northeast (Barbosa et al., 2016).

Golden mussels ecological amplitudes are wide-ranging concerning water temperature, dissolved oxygen, pH, ammonium ion concentration and light intensity (Liu et al., 2020). Also, golden mussels can occupy the substrate forming dense aggregations (i.e., macrofouling), causing economic and ecological impacts. Economic impacts of golden mussel are associated with macrofouling problems in water-intake structures and filters of water-supply systems, industrial plants, and hydroelectric power plants (Mansur et al., 2003; Ricciardi, 2003; Darrigran et al., 2007). The ecological damages are related to its large populations, which could reach hundreds of thousands of individuals per square meter, and the volume-filtered water could severely change the freshwater environments (Sylvester et al., 2005; Boltovskoy et al., 2006; Cataldo et al., 2012). Also, dense populations of golden mussel have a major impact on the structure of associated macroinvertebrate communities (Darrigran et al., 1999; Sardiña et al., 2011; Pinha et al., 2013; Duchini et al., 2018; Silva et al., 2021).

As the most invasive species, the invasion success of golden mussel is related to its short life cycle and high reproductive rates. Also, it is related to dispersal characteristics of its life cycle, which includes two stages: the planktonic larval stage (when individuals are easily carried by water flow to new environments) and the adult encrusting stage (when individuals tend to disperse due to traffic of vessels between connected water bodies) (Lodge et al., 1998; Ezcurra de Drago et al., 2006; Ernandes-Silva et al., 2016).

The Ivaí River basin is the second largest basin in Paraná state (South of Brazil), with a drainage area of 35,845 km² and 685 km in length (Velho, 2016). This area has socio-economic importance for the region, and is the main source of water supply (Santos, 2013). The Ivaí River basin supports about 12% of the total population of the Paraná state and has extensive areas for the sugarcane culture and cattle raising (Santos, 2013), which may contribute to siltation and destruction of riparian vegetation (Frota et al., 2016). Despite the agricultural activities that affect the Ivaí River, it is still a river of great importance to maintain regional freshwater biodiversity. For example, considering only the main channel of this river, 118 species of fish were recorded, including many endemic species (Frota et al., 2016). Also, Ivaí

River is one of the few tributaries free of dams of the Upper Paraná River (Affonso et al., 2015).

In addition to land-use impacts, in 2007, larvae and adults of the invasive bivalve golden mussel were detected in the Ivaí River (Takeda et al., 2012). Despite the importance of this record, the access to this source is restricted because it is only available in Portuguese and published in print. Thus, we wrote this note to ensure the information that occurrences of golden mussels were recorded in the Ivaí River, both in larval stages and adults. Also, our records are in different locations from those obtained by Takeda et al. (2012). Consequently, we hope to increase the knowledge of golden mussel spatial distribution and decrease the Wallacean gap for this important invasive species.

We found larvae of golden mussel in the Ivaí River near its confluence with the Paraná River (Fig. 1; 53°40'57.36" S and 23°17'38.2" W) through quarterly sampling from November 2013 to April 2015. Larvae sampling was carried out in the central region of the Ivaí River channel through a motor pump with a 63 µm plankton net mesh. We filtered 100 L of water from the subsurface and fixed the sample in 80% alcohol. In the laboratory, the larvae were identified and classified in their valve stages (Santos et al., 2005): larva D (90-130 µm), straight-hinged (140-180 µm), umbonated (190-220 µm), pediveliger (230-270 µm) and plantigrade (280-490 µm). We recorded six larval individuals throughout the sampled period: one individual straight-hinged (April 2015), three individuals umbonated (two individuals in May and one individual in November 2014), one individual pediveliger (May 2014) and one plantigrade (February 2014) (Tab. 1).

We found adults of golden mussel in Ivaí River between Engenheiro Beltrão and Floresta municipalities (Paraná, Brazil), in a place locally known as "Salto das Bananeiras" (Fig. 1; 23°40'15.6" S and 52°09'39.6" W). We searched for golden mussel adults for approximately 10 min (one person) in a rocky substrate in April 2020. We found three adults individuals of golden mussels (deposited at Laboratório de Lagos Rasos e Invasões/Nupélia in the Universidade Estadual de Maringá) (Tab. 1). However, because of the low sample effort, the occurrence of golden mussel adults in the area is probably underestimated.

Our record of adults of golden mussel is approximately 60 km upstream to the first record in the Ivaí River (Takeda et al., 2012) and about 250 km upstream of Paraná River, where golden mussel has been found since 2000 (Za-

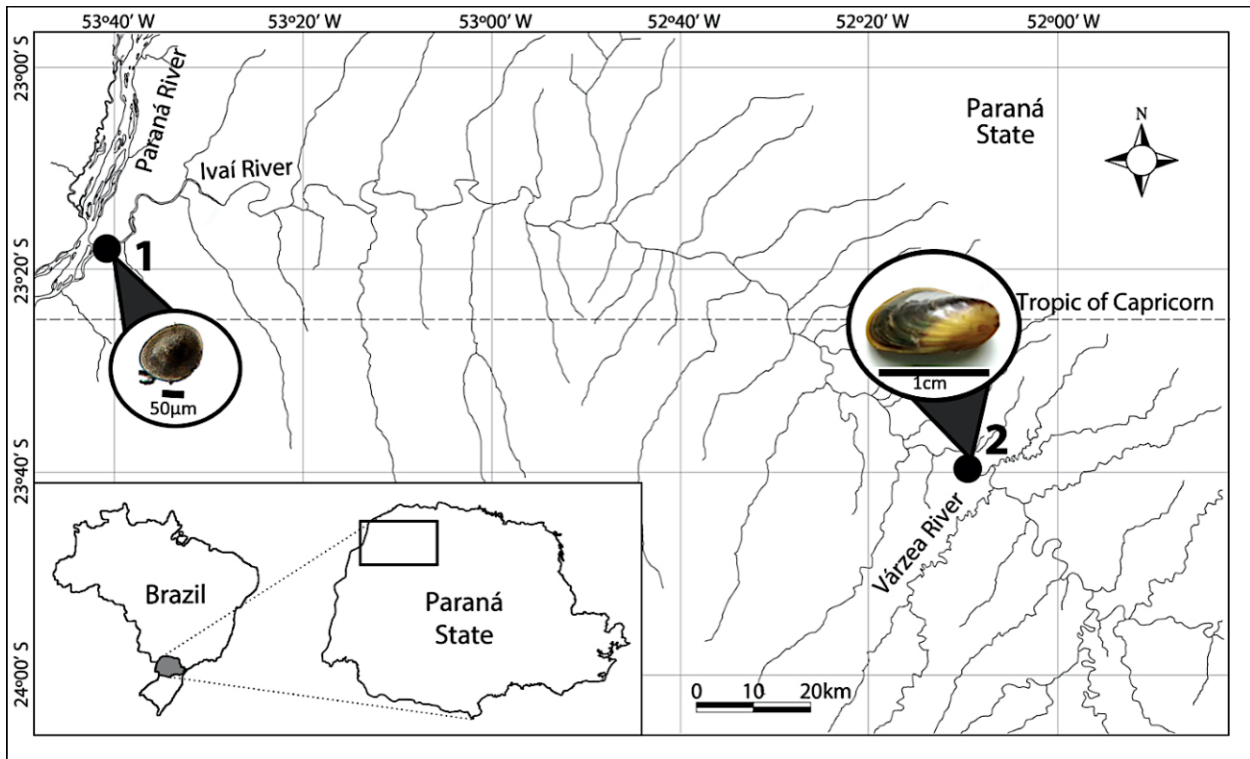


Fig. 1. Occurrence sites of larvae (1) and adults (2) of golden mussel (*Limnoperna fortunei* Dunker, 1857) in Ivaí River (Paraná, Brazil). Larva figure is only illustrative (from Ernandes-Silva et al., 2016), while the adult image corresponds to one of the individuals found in our study.

Tab. 1. Occurrence of larvae and adults of *Limnoperna fortunei* recorded in Ivaí River (Paraná, Brazil). N. individuals = Number of individuals found.

Golden mussel	N. individuals	Data
Larval stages		
Straight-hinge	1	April 2015
Umbonated	3	May and November 2014
Pediveliger	1	May 2014
Plantigrade	1	February 2014
Adults	3	April 2020

nella & Marendá, 2002; Rückert et al., 2004) and is the probable source of dispersal to the Ivaí River. Although Ivaí River is not suitable for commercial navigation and is free of dams (two major vectors of freshwater invasive species dispersal; Oliveira et al., 2015), golden mussel could spread from Paraná to Ivaí River through small boats (Oliveira et al., 2015).

Controlling the invasion and spread of golden mussel is a worldwide challenge (Darrigran et al., 2012; Sanson et al., 2020; Gonzá-

lez-Bergonzoni et al., 2020). The spread of larvae and adults of golden mussel in the Ivaí River is worrisome because this mussel is an aggressive invasive species (Ricciardi, 2003; Oliveira et al., 2010). Also, because the Ivaí River is one of the last tributaries of Paraná River free of dams and holds many endemic species, its conservation is crucial to maintain freshwater biodiversity in the region. We hope that the control agency will look for mitigation measures, given that the golden mussel invasion pro-

cess seems to be in initial phases in the Ivaí River, with few larvae and adults recorded in only a few sites so far. Because the identification of adults of golden mussel is relatively easy, we encourage the use of “citizen science”, in which local residents could help in the golden mussel monitoring. In this way, we recommend more studies about golden mussels in the Ivaí River to monitor, and if possible, avoid their spread.

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