

SHORT COMMUNICATION

## Absence of the invasive golden mussel in a reservoir near Curitiba, Brazil: A possible case of invasion failure

### Ausência do mexilhão dourado invasor em um reservatório perto de Curitiba, Brasil: um possível caso de invasão malsucedida

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## Abstract

Although most cases of non-native species introductions do not result in the final phases of the invasion process or in negative impacts, there are few reports of failure through their different stages, especially for unintentional introductions. However, unsuccessful invasion cases may help understand which factors are predominant during the invasion process. The golden mussel, *Limnoperna fortunei*, is an invasive species in South America. Since its first record in Río de la Plata watershed, it has spread and caused several ecological and economic impacts in different hydrographic basins. Based on larval sampling through conventional and molecular techniques and visual census by scuba diving, we report the absence of this invasive species after its occurrence recorded in 2003, at the Piraquara I reservoir, Upper Iguazu River basin, Brazil. It is the only potential record of juvenile individuals of this species in a reservoir environment without their population establishment and spreading. Understanding the causes of failures in the invasion process may be crucial to avoid their negative impacts. In this context, the accuracy of non-native species records in new environments is fundamental; recording invasion failure of non-native species may be as important as reporting new occurrences.

**Keywords:** Bivalvia, alien species, ecosystem engineers, invasiveness, naturalization, propagule pressure.

## Resumo

Embora a maioria dos casos de introdução de espécies não-nativas não resulte nas fases finais do processo de invasão ou em impactos negativos, há poucos relatos de insucesso em suas diferentes etapas, especialmente para introduções não intencionais. No entanto, casos de invasão sem sucesso podem ajudar a entender quais fatores são predominantes durante o processo de invasão. O mexilhão dourado, *Limnoperna fortunei*, é uma espécie invasora na América do Sul e, desde seu primeiro registro na bacia do Prata, tem se espalhado e causado impactos ecológicos e econômicos em diferentes bacias hidrográficas. Com base em amostragens de larvas por meio de técnicas convencionais e moleculares e censo visual por mergulho autônomo, relatamos a ausência dessa espécie invasora após seu registro em 2003, no reservatório de Piraquara I, Bacia do Alto Rio Iguaçu, Brasil. Esse é o único potencial registro de indivíduos juvenis dessa espécie em ambiente de reservatório sem seu estabelecimento e propagação. A compreensão das causas de invasões malsucedidas pode ser crucial para prevenir seus impactos negativos. Assim, a precisão dos registros de espécies não nativas em novos ambientes é fundamental, e relatos de invasões malsucedidas de espécies não nativas podem ser tão importantes quanto o informe de novas ocorrências.

**Palavras-chave:** Bivalvia, espécies exóticas, engenheiro ecossistêmico, invasão, naturalização, pressão de propágulos.

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Most introductions of non-native species are not expected to have success in invasion process, and is common the fact that species that are strongly invasive in one area are non-invasive in others (Zenni and Nuñez, 2013). Several mechanisms can operate at each stage of invasion process (Blackburn *et al.*, 2011), thus populations can stagnate in a stage or even recede to earlier stages, until the point of local or regional extinction (Simberloff and Gibbons, 2004). Failures in the invasion process are not easily observed, especially for unintentional introductions, and several studies fail to document or highlight unsuccessful invaders (Ludsin and Wolfe, 2001), simply because such data are often ignored (Skora *et al.*, 2015). However, such unsuccessful invasions after introductions or records of non-native species occurrence can be as important as successful ones to elucidate patterns and processes in biological invasions and might be a key component of several research topics (Zenni and Nuñez, 2013).

The golden mussel, *Limnoperna fortunei* (Mitylidae), is a freshwater bivalve from Southeast Asia (Morton, 1977). The first record of *L. fortunei* in South America occurred in 1991 (Pastorino *et al.*, 1993), at Bagliardi Beach, on the coast of the Río de la Plata (34°55'S; 57°49'W), via ballast water, in consequence of the intense traffic of trans-oceanic ships in the region of Río de la Plata (Darrigran and Pastorino, 1995). Since then, it has spread with an average speed of 240 km/year upstream, established and caused a number of impacts on different hydrographic basins (Darrigran and Drago, 2000; Darrigran and Mansur, 2009; Boltovskoy *et al.*, 2006; Boltovskoy and Correa, 2015). Nowadays, *L. fortunei* occurs in five South American countries: Argentina, Bolivia, Brazil, Paraguay, and Uruguay (Oliveira *et al.*, 2015).

In Brazil, the first records of this species were: in the Guaíba Lake, state of Rio Grande do Sul in 1998 (Mansur *et al.*, 1999) and, in the same year, in a lagoon connected to the Paraguay River, near to Corumbá city, state of Mato Grosso do Sul (Oliveira and Barros, 2003). In 2001 *L. fortunei* was recorded in the Itaipu Dam, on the Paraná River, state of Paraná (Zanella and Marenza, 2002). Its occurrence in the Guaíba Lake is considered to be the outcome of a separate invasion event, probably resulting from commerce between Argentina and Brazil (Darrigran, 2002).

Curiously, Takeda *et al.* (2003) reported the occurrence of *L. fortunei* in two reservoirs around Curitiba (Piraquara I and Guaricana), and suggested that this was an independent introduction of unknown cause. However, we report here the absence of *L. fortunei* in the Piraquara I reservoir and in all basin of this river by means of many empirical evidences. Similarly, in the Guaricana reservoir, Belz *et al.* (2005) carried out an extensive survey for larvae and adults of *L. fortunei*, intensifying sampling in the bottom substrate, but did not find evidences of the presence of this species.

The reservoir of Piraquara I or “Caiguava” is located in the Piraquara River, in the Upper Iguaçú River basin, state of Paraná, Brazil (25°30'19.8"S, 49°01'42.8"W). Most of the substrate of this reservoir is composed by mud and sand (personal observation). This reservoir is one of the main water supply of Curitiba and managed by Companhia Paranaense de Saneamento (SANEPAR). In 2012, this reservoir was sampled for a genetic study of *L. fortunei* by collecting plankton using horizontal trawling, filtering approximately 4.000 l of water. The analysis included both the conventional screening technique using a stereoscopic microscope and the application of molecular markers, with no evidence of the presence of the golden mussel (Borges *et al.*, 2017). The method using molecular markers is very sensitive and accurate. Pie *et al.* (2006) developed specific markers for *L. fortunei*, and the method can detect 1 to 5 larvae in 2.000 m<sup>3</sup> of water (Boeger *et al.*, 2007). In addition, bimonthly samplings through scuba diving were carried out in 16 sites of Piraquara I reservoir, at an average depth of 3m, were undertaken encompassing different types of structures (natural and artificial; *e.g.* tree branches, rocks, ceramic pipes and soft substrate) between July/2015 and December/2016, totalizing 720 minutes of underwater sampling. During this period neither individuals of *L. fortunei* (juvenile or adult) were detected, nor vestiges of the species (*e.g.* shells of dead individuals) (F. Frehse, unpublished data).

In the record made by Takeda *et al.* (2003) only five small individuals of *L. fortunei* (between 0.9 - 2.4 mm in length) were collected in the Piraquara I reservoir, through bottom substrate samples, using a Petersen grab. Interestingly, *L. fortunei* does not usually live buried in soft substrates, instead specimens settle to hard structures (Darrigran and Damborenea, 2009). Unfortunately, Takeda *et al.* (2003) did not provide information about the deposited material in a museum, in order to check identification.

The possible failure in the establishment of *L. fortunei* in the Piraquara I reservoir may be related to the low propagule pressure in this environment (Lockwood *et al.*, 2005), since no recreational activities, namely sport-fishing, sailing and boats, are allowed. Such activities are common vectors of species introduction (see Frehse *et al.*, 2016). Another possible reason could be the low water temperature recorded during the winter season (~14 °C). Although individuals of *L. fortunei* can survive at low temperatures, even the juveniles at about 10.7 °C (*e.g.* Spaccesi, 2013), temperatures below 16-17 °C may limit the golden mussel's reproduction (Darrigran *et al.*, 1999; Cataldo and Boltovskoy, 2000; Boltovskoy *et al.*, 2009). Additionally, larvae development rates are low at 20 °C (see Cataldo *et al.*, 2005). However, further studies analyzing biotic and abiotic characteristics of this reservoir should be performed to infer about the real causes of invasion failure.

Therefore, the occurrence of *L. fortunei* in the Piraquara I reservoir is the only potential record of juvenile individuals of this species in a reservoir environment without its population establishment and spreading. Examples of invasion failure are scarce due to the lack of constant long-term monitoring and early detection programs. In this sense, this reservoir in the south of Brazil may provide more information and a better knowledge about the mechanisms driving successful invasions of *L. fortunei*.

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