



Limnoperna fortunei (Dunker, 1857) (Mollusca, Bivalvia, Mytilidae): first record in the São Francisco River basin, Brazil

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Abstract: *Limnoperna fortunei* (Dunker, 1857) is a small mytilid native to Southeast Asia. It was introduced in South America in early 1990 and has dispersed from Argentina to central Brazil, and until 2014 has been restricted mainly to the Paraná and Uruguay river basins. The present note reports the occurrence of *Limnoperna fortunei* for the first time in the São Francisco River basin in northeastern Brazil. The establishment of *L. fortunei* in these regions will require close attention from the government and also by society.

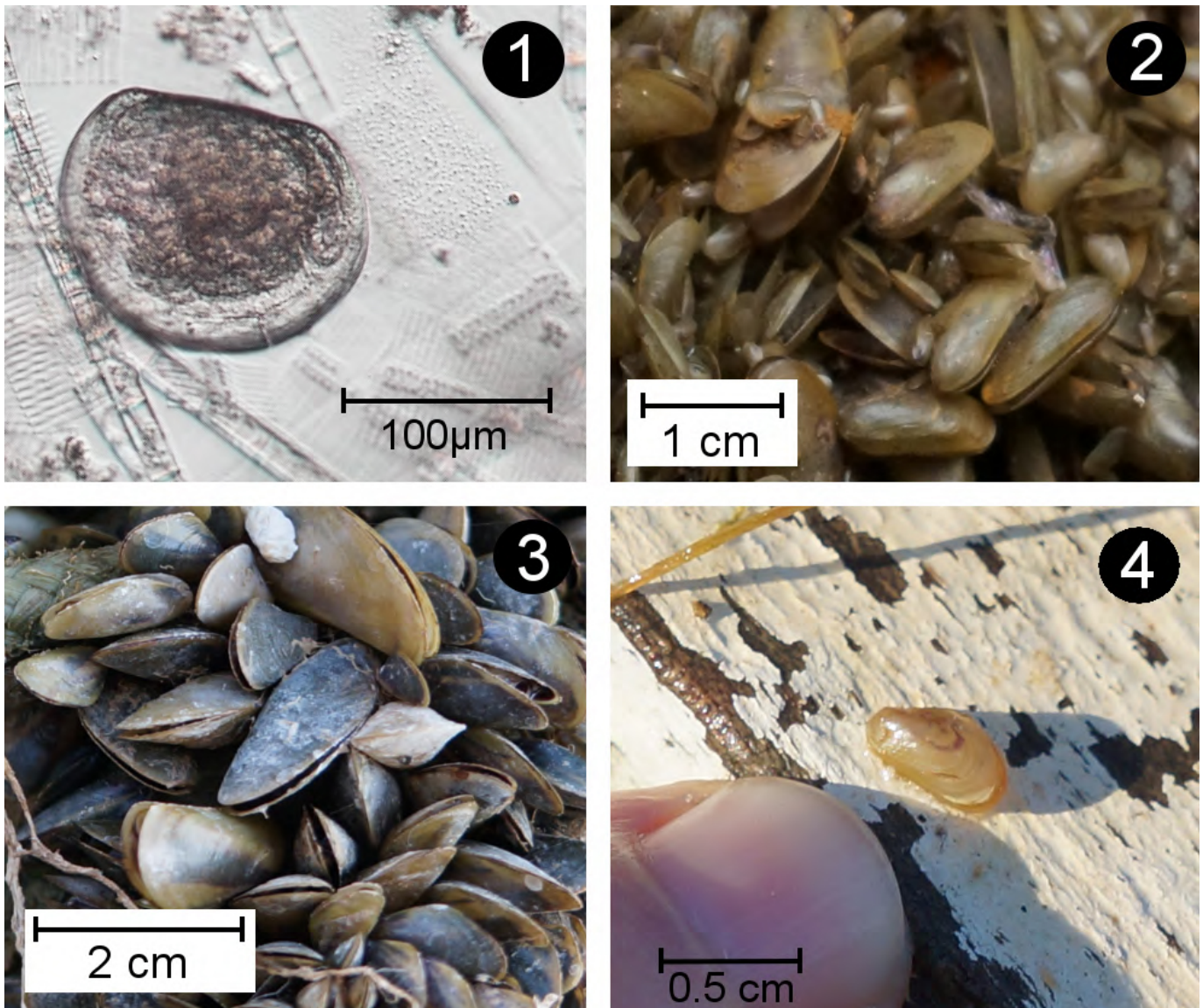
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The Golden Mussel, *Limnoperna fortunei* (Dunker, 1857), is a freshwater, byssate mytilid native to continental Southeast Asia (e.g., Boltovskoy and Cataldo 1999). In the 1960s, this mussel was introduced in other regions of Asia (Morton 1975; Kojima 1982; Tan et al. 1987; Kimura 1994), causing environmental and economic damage, such as the introduction of trematode fish parasites (Urabe et al. 2001) and the biofouling of industrial, raw water, supply and agricultural pipelines (Xu et al. 2013, 2015; Nakano and Strayer 2014).

In South America, dense populations of Golden Mussels can reach up to 200,000 individuals per m² (Boltovskoy et al. 2006), and they can attach to native mollusks (e.g., *Diplodon koseritzi* and *Leila blainvilliana*) and crustaceans (e.g., *Aegla platensis*) (Darrigran 2002; Mansur et al. 2003; Lopes et al. 2009). Due to the high density of settled populations and their efficiency in water filtration, clusters of Golden Mussels can also interfere with the water physico-chemical equilibrium,

removing large amounts of particulate matter, changing the photic zone and planktonic populations directly dependent on this (Boltovskoy and Correa 2015). The result is a potential change in the food chain, along with enhancing cyanobacterial blooms through selective grazing (Gazulha et al. 2012). In South America, this species can also be a problematic source of biofouling in water-related activities, such as hydroelectric power plants and urban water supply, causing important social and economic losses (e.g., Perepelizin and Boltovskoy 2011). After the establishment of *L. fortunei*, the invasion is further enhanced by human activities such as fishing and transportation, which actively transport veligers and/or encrusting colonies (Belz et al. 2012). In addition, at least 50 South American fish species have included the Golden Mussel in their diets (Cataldo 2015), further facilitating the spread of this invader (Belz et al. 2012).

The first record of the Golden Mussel in the South American continent was reported in 1993 at the mouth of the Río de la Plata, Argentina (Pastorino et al. 1993). The main hypothesis on the mussel entry pathway is that *L. fortunei* arrived via ballast water from vessels coming from Asia (Darrigran and Pastorino 2004). Since 1993, this species has spread swiftly upstream in the Paraná-Paraguay waterway at a rate of up to ca. 250 km year⁻¹ (e.g., Boltovskoy and Correa 2015). The first record of *L. fortunei* in Brazil was reported in 1998 in the states of Rio Grande do Sul and Mato Grosso do Sul (Mansur et al. 1999; Mansur et al. 2003). Until now, it was believed that the extent of the invasion covered an area that extended from the Brazilian Pantanal and the northern tributaries of the Paraná River, to the Río de la Plata estuary (Oliveira et al. 2015).



Figures 1–4. Specimens of *Limnoperna fortunei* found in the São Francisco River basin. **1:** Larvae identified at the proximities of fish cages in the Sobradinho reservoir. **2:** Individuals collected in condenser tubes of the hydroelectric plant of Sobradinho. **3:** Individuals collected in fish cages in the Sobradinho reservoir. **4:** An individual collected at the initial section of the São Francisco River transposition channel. Photos by N.P.U. Barbosa.

The present work reports the occurrence of *L. fortunei* (Figures 1–4) at three sites of the São Francisco River watershed, in Northeastern Brazil (Figure 5). The records corresponds to larvae and adults collected near a network of fish cages in the Sobradinho reservoir (09.40932° S, 040.81770° W), in condenser tubes of the Sobradinho hydroelectric power plant (09.433427° S, 040.828606° W), and at the mouth of the north axis of the São Francisco River transposition system (08.545940° S, 039.456330° W). Records occurred between 20 and 23 October 2015. Permission for collections was granted by ICMBio/SISBIO with registry number 32491-1.

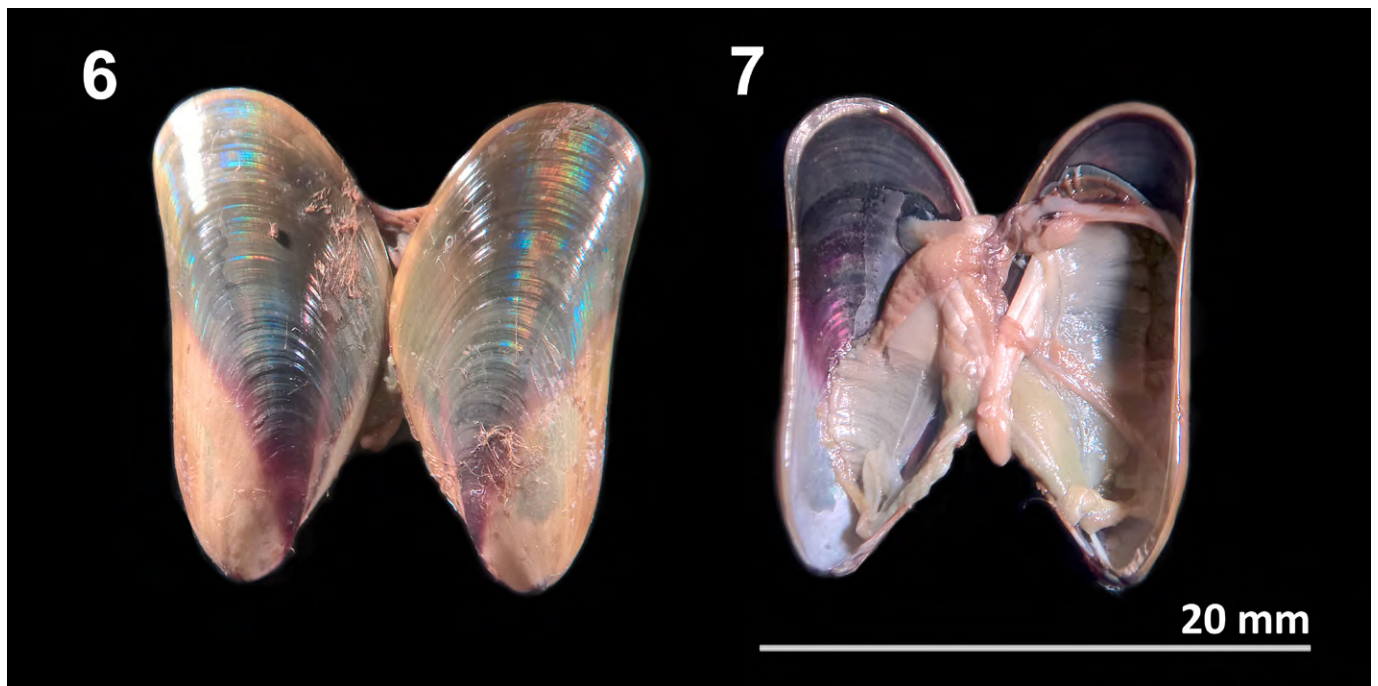
The adult specimens were collected by hand and were identified with the aid of a specialized bibliography, based on Simone (2006) and Pereira et al. (2012). The shells of the collected specimens (five individuals in each locality) are formed by two equal valves showing a triangular outline with an elongated base; the length

ranged from 1.5–3 cm. The specimens have subterminal umbones, smooth and glossy periostracum and a simple hinge ligament, corroborating the description of *L. fortunei* proposed by Mansur (2012) (Figures 6 and 7). The specimens were fixed in 70% alcohol and stored in the zoology collection of the Federal University of Mato Grosso (CIAMT-Biv), under the registration numbers CIAMT- Biv 947, CIAMT- Biv 948 and CIAMT- Biv 949.

Additionally, we collected plankton samples with the intention of identifying larvae of *L. fortunei* through the use of a 35µm plankton net, pulled horizontally for 3 min. The samples were fixed with 70% ethanol and were examined in an inverted fluorescence microscope, NIKON Eclipse Ti-E/B. Larvae were observed in valved stages phase “D” and straight hinge ligament. Larvae had a length ranging 120–160 µm, showing characteristics that confirm them as *Limnoperna fortunei*, as described by Santos et al. (2005).



Figure 5. New infestation area for *Limnoperna fortunei* in Northeastern Brazil, indicating the dam of Sobradinho and the São Francisco River transposition channel.



Figures 6 and 7. *Limnoperna fortunei*. **6:** External view. **7:** Internal view. Photo by Vinícius de Abreu e Carvalho.

The occurrence of *L. fortunei* is reported for the first time in the São Francisco River basin. This new report extends by ca. 1,500 km the geographical distribution of this species in South America (Figure 8). The presence

of this organism in the São Francisco River is a matter of concern for all society because until recently it was believed that this basin was free of *L. fortunei* infestations. It is not yet clear what will be the impact

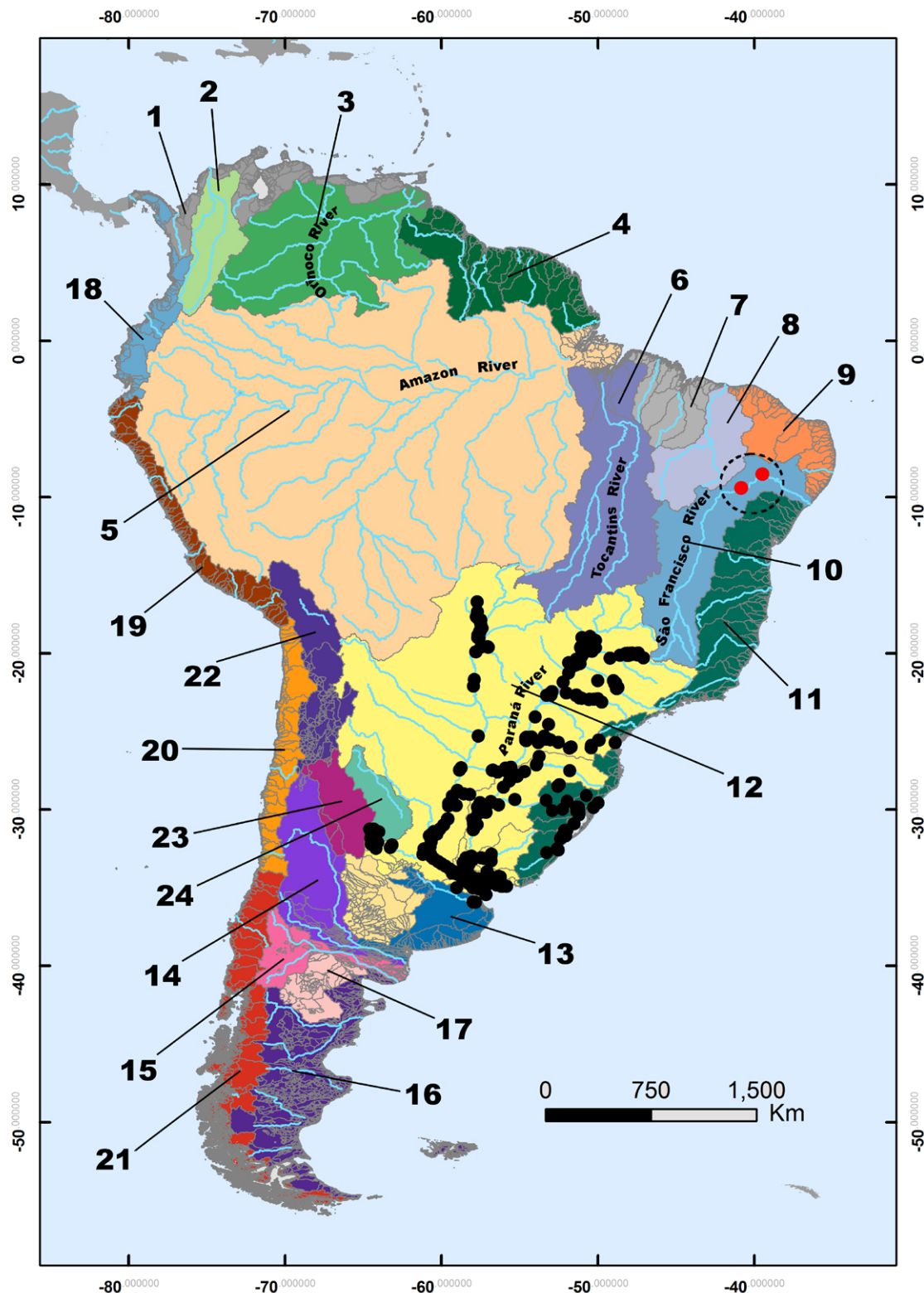


Figure 8. Actual distribution of *Limnoperna fortunei* in South America, including the old sitings (black dots) and new sitings related in this paper (red dots inside the dashed circle) (CBEIH 2015, Oliveira et al. 2015). The basins are indicated on the map by the numbers: 1) Caribbean Coast, 2) Magdalena Basin, 3) Orinoco Basin, 4) Atlantic North Coast, 5) Amazon Basin, 6) Tocantins Basin, 7) Atlantic Western Northeast, 8) Paraíba Basin, 9) Atlantic Eastern Northeast Coast, 10) São Francisco Basin, 11) Atlantic East Coast, 12) La Plata Basin (Paraná Basin), 13) Atlantic Southeast Coast, 14) Colorado Basin, 15) Negro Basin, 16) Atlantic South Coast, 17) Central Patagonia Highlands, 18) Pacific Coast - Colombia/Ecuador, 19) Pacific Coast - Peru, 20) Pacific Coast - North Chile, 21) Pacific Coast - South Chile, 22) La Puna Region, 23) Salinas Grandes Basin, 24) Mar Chiquita Basin, and 25) Pampas Region.

on the freshwater organisms of this basin; however, it is expected that in the short term major environmental, economic and social problems will occur. Several upstream protected areas could be affected by this new invasion, such as the Verde Grande State Park, Lagoa do Cajueiro State Park, and the Cavernas do Peruaçu National Park (all in the state of Minas Gerais). The presence of *L. fortunei* on fish farm cages in the Sobradinho reservoir is also worrying as pointed out by Oliveira et al. (2014). In the medium and long terms, the Golden Mussel could reach the metropolitan region of Belo Horizonte (across the Velhas River, which is one of the most important tributaries of the São Francisco River), where they can affect the water supply for more than 5 million people.

The presence of *L. fortunei* at the mouth of the north axis of the São Francisco River transposition channel is also extremely worrying, because this channel will connect the São Francisco basin to the Atlantic Eastern Northeast coastal basin (Figure 8). The infestation of these basins is a matter of time, and many reservoirs are at risk (Figure 2). Several small villages, which are already suffering water supply problems, depend on these waters. The establishment of *L. fortunei* in these regions will require close attention from the government and also by the society. Updated plans for environmental education and control strategies of this invader needs to be part of the political and environmental agenda of Northeastern Brazil, and an urgent organization of a task force against the Golden Mussel is welcome and necessary from now on.

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