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NEW RECORDS OF THE EXOTIC ASIAN CLAM *Corbicula fluminea* (BIVALVIA, CYRENIDAE) IN THE STATE OF AMAZONAS, BRAZIL

NOVOS REGISTROS DO BIVALVE ASIÁTICO EXÓTICO *Corbicula fluminea* (BIVALVIA, CYRENIDAE) NO ESTADO DO AMAZONAS, BRASIL

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Resumo

Este estudo registra a ocorrência do molusco invasor *Corbicula fluminea* em três localidades do estado do Amazonas, Brasil: Lago Saracá (Silves), Lago Macurany (Parintins) e rio Amazonas (Itacoatiara). Os espécimes foram coletados em sedimentos expostos e áreas marginais rasas durante a estação seca. A abundância variou entre os locais, com 952 valvas no Lago Macurany, 78 no Lago Saracá e 56 no rio Amazonas. O comprimento das valvas variou de 3,00 a 22,88 mm, indicando diferentes classes de tamanho. Esses registros ampliam a distribuição conhecida de *C. fluminea* na Amazônia e sugerem colonização recente ou mortalidade relacionada à seca, principalmente em ambientes lênticos. A conectividade hidrológica entre lagos e o rio Amazonas durante o pulso sazonal de inundação pode favorecer a dispersão e o estabelecimento da espécie. Como *C. fluminea* altera a estrutura dos sedimentos, reduz a produção primária e compete com bivalves nativos, sua ocorrência em uma região com poucos levantamentos malacológicos representa uma preocupação ecológica. Os registros fornecem informações essenciais para programas de monitoramento e para o planejamento de medidas preventivas visando conter a expansão dessa espécie invasora na bacia Amazônica.

Palavras-chaves: Bivalves invasores; Espécies invasoras; Bivalves de água doce; Planície de inundação amazônica; Distribuição de espécies; Espécies não nativas.

Abstract

This study reports the occurrence of the invasive clam *Corbicula fluminea* at three locations in the state of Amazonas, Brazil: Saracá Lake (Silves), Macurany Lake (Parintins), and the Amazon River (Itacoatiara). Specimens were collected from exposed sediments and shallow marginal areas during the dry season. Abundance varied among sites, with 952 valves recorded in Macurany Lake, 78 in Saracá Lake, and 56 in the Amazon River. Valve lengths ranged from 3.00 to 22.88 mm, indicating different size classes. These records expand the known distribution of *C. fluminea* in the Amazon and suggest recent colonization or drought-related mortality, particularly in lentic environments. Hydrological connectivity between lakes and the Amazon River during the seasonal flood pulse may facilitate dispersal and establishment of the species. Because *C. fluminea* can alter sediment structure, reduce primary production, and compete with native bivalves, its occurrence in a region with limited malacological surveys raises ecological concerns. These records provide essential baseline information for monitoring programs and support preventive management actions to limit the spread of this invasive species throughout the Amazon basin.

Keywords: Invasive bivalves; Invasive species; Freshwater bivalves; Amazon floodplain; Species distribution; Non-native species.

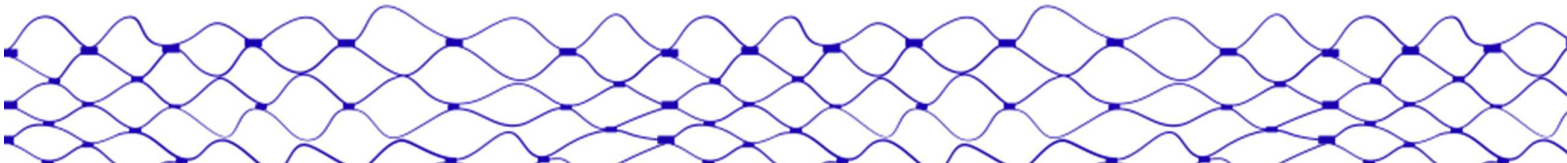
Introduction

Corbicula fluminea (Müller, 1774) is an exotic, edible and highly invasive species, widely recognized for its remarkable ability to adapt to different environments and rapid geographical expansion (Gama et al. 2016; Santos et al. 2018). It is a functional and self-fecundating hermaphrodite organism, capable of self-fertilization and early maturation within 3 to 6 months (Cao et al. 2017; Ludwig et al. 2024). The combination of internal incubation of semi-floating planktonic larvae and these reproductive traits facilitates its rapid dispersal and colonization of new habitats. This species occupies preferentially shallow environments with sandy sediments and low organic matter and is present in both lotic and lentic systems (Way et al. 1990; Cenzano and Würdig 2006; Silveira et al. 2016). Its efficiency in filtering phytoplankton and removing organic matter directly affects water quality and local ecological processes (Rollwagen-Bollens et al. 2021).

In addition, their bioturbation activity alters the biogeochemistry of sediments and compromises the survival of native bivalves such as unionids (Vaughn and Hakenkamp 2001; Majdi et al. 2014; Nicholaus et al. 2024). Studies show that *C. fluminea* can reduce phytoplankton biomass by up to 70 % and decrease annual primary production by up to 61 % in environments where it is present (Pigneur et al. 2014; Ilarri et al. 2014; Crespo et al. 2015). This species also interferes with the reproduction of native bivalves by filtering sperm from the water column and ingesting gloquids, as well as promoting abiotic changes, such as the release of toxic ammonia, which can result in mass mortality (Pigneur et al. 2013; Modesto et al. 2019; Labaut et al. 2021; Carranza et al. 2023).

The spread of *C. fluminea* causes blockages in intake and cooling systems of hydroelectric plants, water treatment stations, and industries, resulting in high maintenance costs and economic losses. The invasion and establishment of this species represent a growing challenge for public management and the conservation of aquatic ecosystems (Henderson 2010; Patrick et al. 2017; Haubrock et al. 2022). Considering the numerous factors involved, as well as the high invasive potential and broad environmental tolerance of *C. fluminea*, it is imperative to conduct systematic studies focused on mapping invaded areas, identifying dispersal routes, and improving early detection strategies to contain its spread, especially in sensitive ecosystems. Furthermore, it is crucial to promote research that addresses the occurrence and ecological impacts associated with invasive exotic species, such as *C. fluminea* (Henderson 2010; Patrick et al. 2017). This invasion process is worrying, especially in regions with low species diversity studies. In Brazil, the first record of *C. fluminea* occurred in 1981, in the Jacuí and Guaíba river basins, in the state of Rio Grande do Sul (Veitenheimer-Mendes 1981).

Since then, several studies have documented its expansion into the southern region, including occurrences in the Taim Ecological Station and adjacent areas (Mansur and Garces 1988), in Uruguaiana (Castillo et al. 2007), in the Toropi (Sá et al. 2013) and Alto Paraná rivers (Ragonha et al. 2014), the Patos-Mirim lagoon system (Cardoso et al. 2025).



In the Southeast, the first record was reported by Avelar (1999), followed by reports in the Barra Bonita, Bariri and Ibitinga reservoirs, on the middle Tietê River (Suriani et al. 2007). The species has also been recorded in the Paranapanema River (Jorcin and Nogueira 2008), the Sapucaí (Vianna and Avelar 2010), the Araguari river basin (Maroneze et al. 2011), the Jundiaí-Mirim River micro-basin (Beghelli et al. 2014), the Manhuaçu (Lima 2017), the Guandu (Miyahira et al. 2017) and the Itupararanga reservoir (Vendramini and Arruda 2022), Mourão River near its confluence with the Ivaí River (Delta S Engenharia 2025). In the Midwest, *C. fluminea* has been identified in the Cuiabá (Callil and Mansur 2002), Ivinhema (Isaac et al. 2014), Manso (Fernandez et al. 2014), Teles Pires (Poleze and Callil 2015) and Tocantinzinho (Soares et al. 2021) rivers, as well as Lake Paranoá, in the Federal District (Rodrigues et al. 2007).

In the Northeast, records are distributed along the São Francisco River, at different points in the state of Sergipe (Santana et al. 2013; Melo et al. 2024); in the Poxim-Açu (Rosa and Dantas 2020; Rosa et al. 2025), Itaim, in Piauí (Leal et al. 2021), and Jacarecica rivers, also in Sergipe (Rosa and Freitas-Filho 2023). In the northern region, Pará presented the first records, with occurrences in the Surubiú River, in Alenquer, and on an island in the Tocantins River, in Cametá (Beasley et al. 2003). More recently, it was observed in the Gelado stream, in Carajás (Oliveira et al. 2023), at the Estaleiro da Paz, in Pará (Barros, Sampaio and Batista 2025).

In the state of Amazonas, there are only two previous confirmations: one in Tupé Lake and Calatão, both on the Negro River (Pimpão et al. 2008), and another on Concha Beach, on Tefé Lake (Souza et al. 2017). The Amazon basin, with its complex river system and flood pulse dynamics, is a system vulnerable to the introduction of non-native species. The main channel of the Amazon River acts as a hydrological corridor for the dispersal of organisms during seasonal floods (Hurd et al. 2016).

The flood pulse concept (Junk et al. 1989) posits that this temporary connection between the river and adjacent environments, such as floodplain lakes, facilitates the passive transport of species. These lakes offer lentic habitats with favorable substrates rich in organic matter (Sobrinho et al. 2016), which can be colonized by invasive bivalves. Considering the high biodiversity and endemism of bivalves in the region (Albert et al. 2011), the potential establishment of exotic species, such as *C. fluminea*, represents an ecological threat through competition with native fauna (Modesto et al. 2019).

To date, there are no records of the presence of *C. fluminea* in the municipalities of Itacoatiara, Silves, and Parintins. Therefore, the objective of this study is to report the occurrence of this species in the Amazon River and in Lakes Saracá and Macurany, both located in the state of Amazonas, thereby contributing to expanding the knowledge of its geographical distribution.

Material and Methods

Study area

Sampling was conducted in November 2024 during the dry season in the state of Amazonas, Brazil, under SISBIO permit no. 0951140120240923. Three environments were surveyed:

1. Amazon River, Itacoatiara, Right bank of the main channel (3°11′16.94″S, 58°24′7.751″W).
2. Saracá Lake, Silves, Floodplain Lake hydrologically connected to the Amazon River (2°50′42.529″S, 58°12′32.22″W).
3. Macurany Lake, Parintins, Large floodplain lake located on the margin of the Amazon River (2°39′3.816″S, 56°43′28.512″W).

All sites are characterized by shallow marginal zones with exposed sediments during the dry season, promoting accessibility for bivalve sampling.

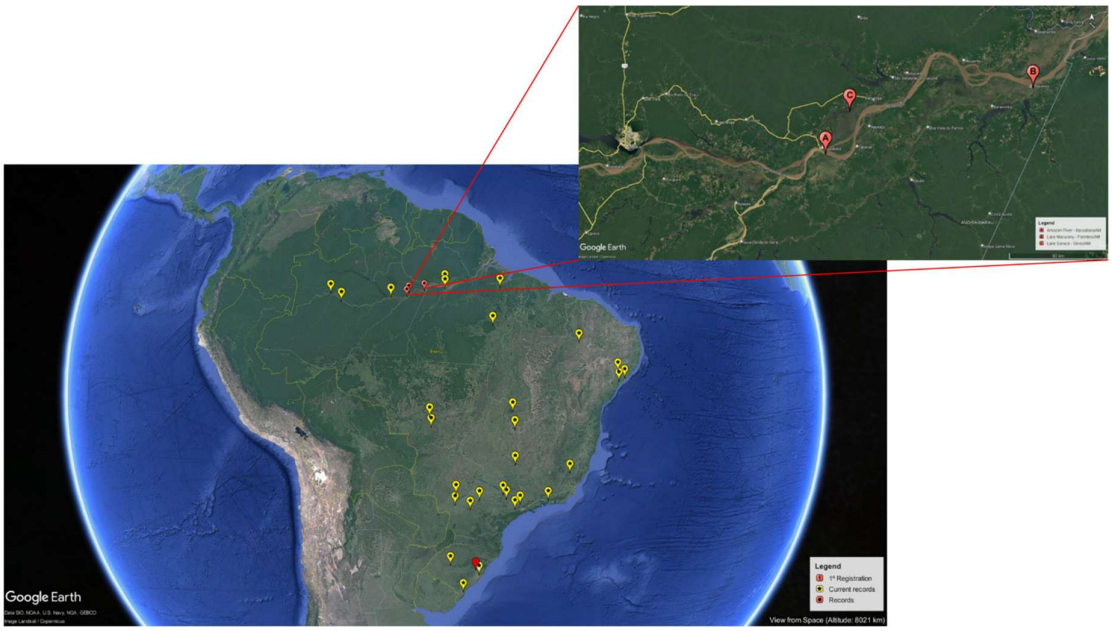


Figure 1. Location of the study area in the state of Amazonas, Brazil, showing the sampling sites in the Amazon River (Itacoatiara), Saracá Lake (Silves), and Macurany Lake (Parintins). The map also summarizes the previously reported occurrences of *Corbicula fluminea* in Brazil and highlights the new records documented in the present study.

Sampling procedures

Sampling was standardized, adopting a collection effort of one person per hour at each sampling point. Prospecting was conducted through active visual search for specimens along a continuous marginal strip, covering sections of exposed sediment and shallow submerged areas (< 6 cm deep). Empty articulated valves were collected manually in the dry and wet zones of the margins, while live individuals were recorded in the shallow portions of the substrate.

Specimen processing and identification

To standardize the morphometric analyses and enable comparisons among the sampling sites, 40 individuals were measured per collection point, totaling 120 measurements. The length, width, and height of the articulated valves were used in descriptive analyses (mean ± standard deviation). After collecting, the empty articulated valves were labeled and stored in plastic bags for transport. The live molluscs were wrapped in damp cotton, secured with latex rubber bands and packed in plastic bags.

The specimens were then transported to the laboratory at the Federal University of Santa Catarina - SC. At the laboratory, the live specimens were fixed in 70 % alcohol and packed in plastic bottles. Both the live organisms and the empty articulated valves were quantified and submitted to morphometric analysis of the valves, as well as species identification. Morphometric analyses included the measurement of articulated valves length, height, and width using a caliper with 0.05 mm precision (Simone 2006). Identification was carried out using taxonomic keys and specialized literature (Mansur et al. 2012).

Data analysis

For each site, descriptive statistics (mean ± standard deviation) were calculated for all morphometric variables. Normality of data was assessed using the Shapiro–Wilk test, and homogeneity of variances using Levene's test.

Comparisons among sites were conducted using one-way ANOVA with a 95% confidence level. All analyses were performed in JASP version 0.95 (Leuven, Belgium).

Results

New registrations and identification

This study documents the first confirmed occurrence of *Corbicula fluminea* (Müller, 1774) (Bivalvia: Cyrenidae) in the municipalities of Itacoatiara (Amazon River), Silves (Saracá Lake), and Parintins (Macurany Lake), state of Amazonas, Brazil. Abundance varied among the sites, with the highest number of individuals recorded in Macurany Lake (n = 952), followed by Saracá Lake (n = 78) and the Amazon River (n = 56). Shells of different size classes were collected at all locations (Fig. 2).

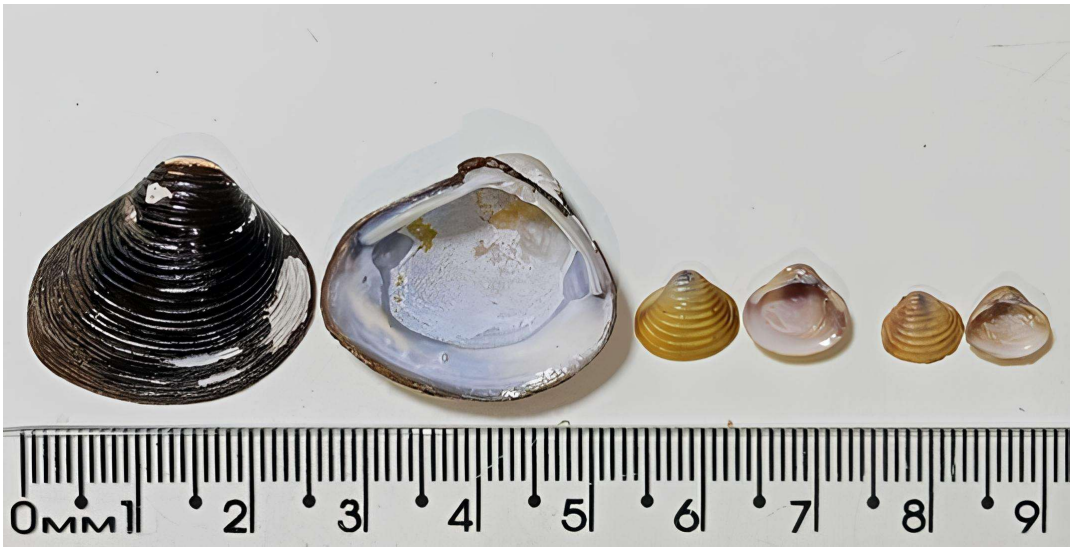


Figure 2. External and internal views of the *Corbicula fluminea* valves and the different lengths found at three collection sites in the Amazon 2024.

Amazon river (Itacoatiara)

A total of 56 empty and articulated valves were collected. Some shells still contained soft tissue in advanced decomposition. Mean shell mass was 0.85 ± 0.83 g, and mean morphometric values were:

- length: 13.44 ± 5.55 mm
- width: 14.77 ± 5.79 mm
- height:9.49 ± 3.26 mm

Saracá lake (Silves)

Three live specimens and 78 empty articulated valves were recorded. Mean shell mass was 1.01 ± 0.94 g, and mean dimensions were:

- length: 13.37 ± 4.14 mm
- width: 14.49 ± 4.71 mm
- height: 9.58 ± 2.71 mm

Shells were recovered primarily from muddy substrates, whereas live individuals were found in shallow submerged areas.

Macurany lake (Parintins)

A total of 952 empty and articulated valves of *C. fluminea* were collected. Although the species appears to be distributed along the full length of the lake (~10 km), sampling was conducted at a single standardized point. Mean shell mass and dimensions were:

- mass: 0.76 ± 0.36 g
- length: 12.34 ± 3.00 mm
- width: 13.03 ± 2.98 mm
- height: 9.04 ± 2.00 mm

Numerous articulated and disarticulated valves were observed on the exposed sediment along the lake margin (Fig. 3).

Figure 3. *Corbicula fluminea* articulated valves on the exposed sediment at the margin of Lake Macurany, Parintins (AM), indicating mortality associated with the drought 2024.

Mean valve length was similar among the three sampling sites (Fig. 4), with values ranging from 12.34 ± 3.00 mm in Macurany Lake to 13.44 ± 5.55 mm in the Amazon River. No significant differences were detected among sites (ANOVA, $P > 0.05$).

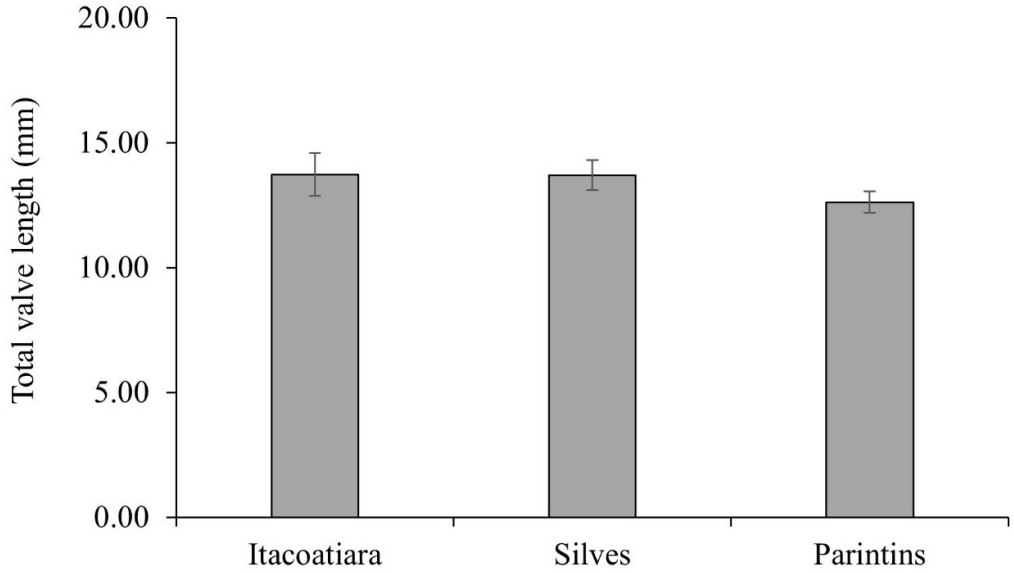


Figure 4. Mean total length (mm) of *Corbicula fluminea* valves collected in Amazon River (Itacoatiara, AM), Lake Saracá (Silves, AM), and Lake Macurany (Parintins, AM) 2024. The bars represent the means, and the lines represent the standard error of the mean.

Discussion

Confirmation of new records and population structure

The occurrences documented in Itacoatiara, Silves, and Parintins represent new distribution records of *Corbicula fluminea* in the state of Amazonas. Previous confirmations in the region were limited to Tupé Lake and Catalão, on the Negro River (Pimpão & Martins 2008), and to Tefé Lake (Souza & Gomes 2017). The predominance of juveniles (< 15 mm), consistent with observations in other invaded environments (Rosa & Dantas 2025), suggests either recent colonization events or the recovery of populations following environmental stress. Conversely, the substantial number of empty articulated valves in Macurany Lake indicates that this location previously supported a well-established population. These new records are ecologically significant because the three sites (Itacoatiara, Saracá, and Macurany) are hydrologically connected to the main channel of the Amazon River, which acts as a natural corridor for species dispersal during seasonal floods (Hurd et al. 2016).

Hydrological connectivity and dispersal mechanisms

The dispersal of C. fluminea in the Amazon may be influenced by the region's hydrological dynamics. The Amazon River functions as a major corridor for aquatic organisms, particularly during the flood season (Hurd et al. 2016). According to the flood pulse concept (Junk et al. 1989), temporary connectivity between the main channel and floodplain lakes can increase the passive transport of larvae and juveniles. These lakes provide lentic habitats with substrates rich in organic matter (Sobrinho et al. 2016), which favor the establishment of invasive bivalves. The combination of hydrological connectivity and suitable habitat conditions can facilitate the expansion of *C. fluminea* into the sites examined in this study.

Implications for native bivalve communities

The presence of live *C. fluminea* specimens in Saracá Lake is ecologically significant because the lake integrates a drainage network that includes the Anebá, Itapani, Uatumã, Sanabani, and Urubu rivers (Abreu & Vieira 2020). During the dry season, these systems form a mosaic of shallow lacustrine habitats that serve as nurseries for aquatic organisms (PROECOTUR/AM 2001). *C. fluminea* is known to negatively affect native bivalves through competition, filtration of gametes, and ingestion of glochidia (Modesto et al. 2019), as well as through sediment bioturbation that alters habitat conditions (Vaughn & Hakenkamp 2001; Majdi et al. 2014). In Silves, where only a single record of *Castalia ambigua* shells exists (Pimpão 2010), the establishment of *C. fluminea* raises concerns about the vulnerability of poorly documented native species.

Influence of extreme climate events

The exceptionally severe droughts recorded in the Amazon in 2023–2024 likely contributed to the extensive shell mortality observed during sampling. Low water levels expose benthic substrates, leading to desiccation of clams and mass die-offs, as reported for other extreme climatic events in the region (Siqueira-Souza et al. 2024; Braz-Mota & Val 2024). Nevertheless, such episodes do not necessarily indicate invasion failure. *C. fluminea* exhibits high physiological tolerance and rapid recolonization capacity, supported by self-fertilization and larval dispersal (Cao et al. 2017; Ludwig et al. 2024). After hydrological recovery, upstream populations or remnant individuals can reestablish new colonies, consistent with patterns observed in other studies (Werner & Rothhaupt 2008). The presence of numerous empty and articulated valves observed at the collection sites therefore suggests that the species had previously reached a stage of stable establishment and that its disappearance reflects a temporary unsuitability of the habitat, not necessarily an ecological limitation or population unviability under Amazonian conditions (Werner and Rothhaupt 2008; Siqueira-Souza et al. 2024; Braz-Mota and Val 2024).

Potential anthropogenic vectors

In addition to natural hydrological processes, human activities likely influence the spread of *C. fluminea* across the study region. The intense movement of vessels in Itacoatiara and Parintins creates wave action that accelerates shoreline erosion (Freitas Júnior et al. 2024), potentially transporting shells and displacing individuals. Previous work suggested that the species may have been introduced into the lower Amazon via ships frequenting major ports such as Manaus and Belém (Beasley et al. 2003).

Fishing activities may also facilitate dispersal, as occurrences often coincide with areas of intensive fisheries (Minchin 2014). Flood-driven connectivity among lakes further amplifies opportunities for passive transport (Pereira et al. 2018). This intense traffic results in the formation of marshes along the riverbanks (Freitas Júnior

et al. 2024). Schmidlin and Baur (2007) state that *C. fluminea* does not adapt well to rivers with running water, such as the Amazon River, which explains the lower number of articulated valves found in the Amazon River region in Itacoatiara. Also according to these authors, the species is widely found in fine-grained substrates, such as sand, associated with shallow, slow-flowing waters. This pattern justifies the greater number of articulated valves in Macurany Lake and Saracá Lake, as well as the presence of three live specimens recorded in Saracá, which are calm-water lakes with sandy substrates.

The mechanism of propagation and dissemination of *C. fluminea* in the three cities analyzed remains unknown. However, it is known that the flow of boats is high in the three regions where this species is collected, especially in Itacoatiara and Parintins. These cities, located on the banks of the Amazon River, have an intense traffic of small, medium and large vessels, including cargo ships, ocean liners and fishing boats, coming from different origins. Beasley et al. (2003) suggest that the introduction of *C. fluminea* into the lower Amazon possibly occurred via ships that frequent the ports of Manaus and Belém. Fig. 1 shows the localities of *C. fluminea* occurrence in Brazil according to those reported in the cities. According to Minchin (2014), it is possible that fishermen are contributing to the dispersal of *C. fluminea* species, since most of the places where the presence of the species is recorded are associated with fishing activity. Another hypothesis raised, according to Pereira et al. (2018), is the flooding period, which increases connectivity between floodplain environments and can thus facilitate the dispersal of the species between environments.

Management considerations and monitoring needs

The presence of *C. fluminea* in hydrologically connected lakes increases the risk of expansion into other tributaries and artificial systems, including hydroelectric reservoirs, which are known to function as secondary dispersal corridors (Haubrock et al. 2022). Effective management therefore requires continuous monitoring, sediment sampling, and early detection programs, especially in port areas and navigation routes. Implementing such measures within basin-level management programs can reduce the spread of invasive species and support conservation strategies in the Amazon (Ferreira-Rodríguez et al. 2019).

Conservation Implications

The first confirmed records of *C. fluminea* in the municipalities of Itacoatiara, Silves, and Parintins expand the known distribution of this invasive bivalve in central Amazonia and indicate that established populations are already present in these environments. Early detection of newly established populations is essential to strengthen monitoring programs and support management actions aimed at limiting the further spread of the species. Considering the species' high reproductive and dispersal capacity, together with the hydrological connectivity of the Amazon basin and the ecological importance of its ecosystems, continuous monitoring of invaded

areas should be prioritized to support strategies for the conservation of native freshwater biodiversity.

Conclusion

This study reports the first confirmed records of *C. fluminea* in the municipalities of Itacoatiara, Silves, and Parintins, expanding the known distribution of the species in central Amazonia. The occurrence of multiple size classes, together with the high abundance of articulated valves, indicates that the species is established in these floodplain environments.

The presence of *C. fluminea* in previously unrecorded areas reinforces the importance of continuous monitoring, particularly in regions with intense vessel traffic and seasonal flood dynamics that may facilitate its dispersal. The implementation of systematic surveys, early detection protocols, and targeted management actions will be important to reduce the potential ecological impacts of this invasive bivalve on native species and freshwater ecosystems throughout the Amazon basin.

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