

First record and range extension of *Corbicula fluminea* (Müller, 1774) (Bivalvia, Cyrenidae) in the Chapada dos Veadeiros region, Goiás, Brazil

Yan Felipe Figueira Soares^{1,2}, Maria Julia Martins-Silva¹

¹ Departamento de Zoologia, Universidade de Brasília, Brasília, DF, Brazil • YFFS: yfellipse@gmail.com  <https://orcid.org/0000-0002-7151-141X> • MJMS: mjsilva@unb.br  <https://orcid.org/0000-0003-2638-7306>

² Programa de Pós-Graduação em Ecologia, Universidade de Brasília, Brasília, DF, Brazil

* Corresponding author

Abstract

Corbicula fluminea (Müller, 1774) is an Asian freshwater clam that is widely distributed throughout the world through multiple introductions. Its invasion can cause environmental and economic damage. In Brazil, *C. fluminea* is recorded in all major hydrographic basins. Here, we report the first record of *C. fluminea* in the Chapada dos Veadeiros region of Goiás, Brazil. This new record extends the known distribution of this species to a conserved area in the Cerrado biome, towards areas of interest for conservation and integral protection units of the biodiversity.

Keywords

Central-Western Region, Cerrado, freshwater mollusk, invasive species

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Introduction

The Golden Clam, *Corbicula fluminea* (Müller, 1774) is a freshwater bivalve mollusk native to South and East Asia (southeastern Russia, Thailand, Philippines, China, Taiwan, Korea, and Japan). It is considered an alien invasive species (AIS) worldwide (Santos et al. 2012). Haag et al. (2020) found that *C. fluminea* can be a major factor in the decline of native populations of freshwater mussels worldwide. This is the most important AIS in the conservation perspective for riverine ecosystems due to its high invasive potential (Leal et al. 2021). The first known record of the introduction of this species was in North America in the 1930s and it has since become the dominant invasive mollusk in that country (Mayfield et al.

2021). Mitigation of the impacts caused by *C. fluminea* have cost 1 billion dollars in the United States of America (Mayfield et al. 2021). Although not known for Brazil, the economic costs have probably been similar.

The first introduction of *C. fluminea* into South America was in the 1960s in the La Plata Basin (Ituarte 1981), possibly via ballast water (Darrigran 2002; Paschoal et al. 2013). This species is currently widespread according to Darrigran et al (2020) and Miyahira et al. (2020). Since the first Brazilian record in the 1970s (Veitheimer-Mendes 1981), *C. fluminea* has been reported in all major river basins. There are records of this species in the Upper Tocantins River in the state of Goiás

(Thiengo et al. 2005) (Tocantins-Araguaia Basin); Tietê River in São Paulo (Suriani et al. 2007), Paranoá Lake in Distrito Federal (Rodrigues et al. 2007), Paranapanema River in São Paulo (Jorcin and Nogueira 2008), Araguari River in Minas Gerais (Maroneze et al. 2011), Toropi River in Rio Grande do Sul (Sá et al. 2013), Ivinhema River in Mato Grosso do Sul (Isaac et al. 2014), Upper Paraná River in Paraná (Ragonha et al. 2014), Jundiá-Mirim River in São Paulo (Beghelli et al. 2014) (Paraná River Basin); São Francisco River in Sergipe (Santana et al. 2013) (São Francisco River Basin); Guandu River in Rio de Janeiro (Miyahira et al. 2017) (Paraíba do Sul River Basin); Cuiabá River in Mato Grosso (Fernandez et al. 2014) (Paraguai River Basin); and Negro River, Amazonas (Pimpão and Martins 2008) (Amazonas River Basin).

This species has been mainly associated with anthropized habitats (Miyahira et al. 2020) promoting environmental and biotic homogenization and facilitating the biological invasion of other taxonomic groups (Agostinho et al. 2008; Petsch 2016; Pigneur et al. 2014; Arantes et al. 2019). In the Tocantins-Araguaia Basin, this species was recorded in the municipalities of Niquelândia and Santa Rita do Novo Destino, Goiás state in an influenced by the Serra da Mesa Reservoir (Thiengo et al. 2005). There are no other records of this species in the region since then. Here, we extend the known occurrence of *C. fluminea* to the Chapada dos Veadeiros region of Goiás, Brazil.

Methods

The new record presented here was made during a study of the benthic fauna in which 14 sites were sampled in the Tocantinzinho, Couros, and São Bartolomeu rivers. All sampling sites are within the region known as Chapada dos Veadeiros, which is characterized by a plateau

at elevations above 1,200 m. The Chapada dos Veadeiros region, in Goiás state, is within the Cerrado biome, near the center of the biome. All sampling sites in this study were in the Pouso Alto Environmental Protection Area (Pouso Alto EPA), which allows for sustainable use.

We sampled using a D-net for benthos in a 5 m × 2 m area with three replicates (totaling 10 m²) each for 30 min. Physical features and chemistry of the water were measured, such as river depth and width, dissolved oxygen, turbidity, conductivity, and pH.

Results

We found 16 specimens of *Corbicula fluminea* (Fig. 1) at only one sampling site, in the Tocantinzinho River, Upper Tocantins River Basin (Fig. 2). The stretch of river in this sample area 50 m wide and had a depth of 1.5 m near the banks but the main river channel was deeper. The water was slightly acidic (pH 6.03). Dissolved oxygen was 11 mg/L, and the electrical conductivity was 46.4 mS. The margins in this site are natural and intact, as the riverbank is composed mainly of embedded rocks which make it difficult for people to access.

New record. BRAZIL – **Goiás**; Pouso Alto EPA, Chapada dos Veadeiros, Colinas do Sul municipality, -14.2580, -047.9838; 495 m a.s.l, Maria Julia Martins-Silva leg.; 7.VIII.2019; 16 individuals (14 living individuals and 2 shells), CMUnB 1359.

Identification. Our specimens conform to the descriptions by Mansur and Pereira (2006) for *C. fluminea*. The specimens had subtriangular shells with curved dorsal margin. The external shell surface has narrow, large and widely spaced concentric ribs over the entire surface. The periostracum varies from yellow (usually in young) to dark brown. The umbones are elevated and inflated. The internal shell color was light yellow.

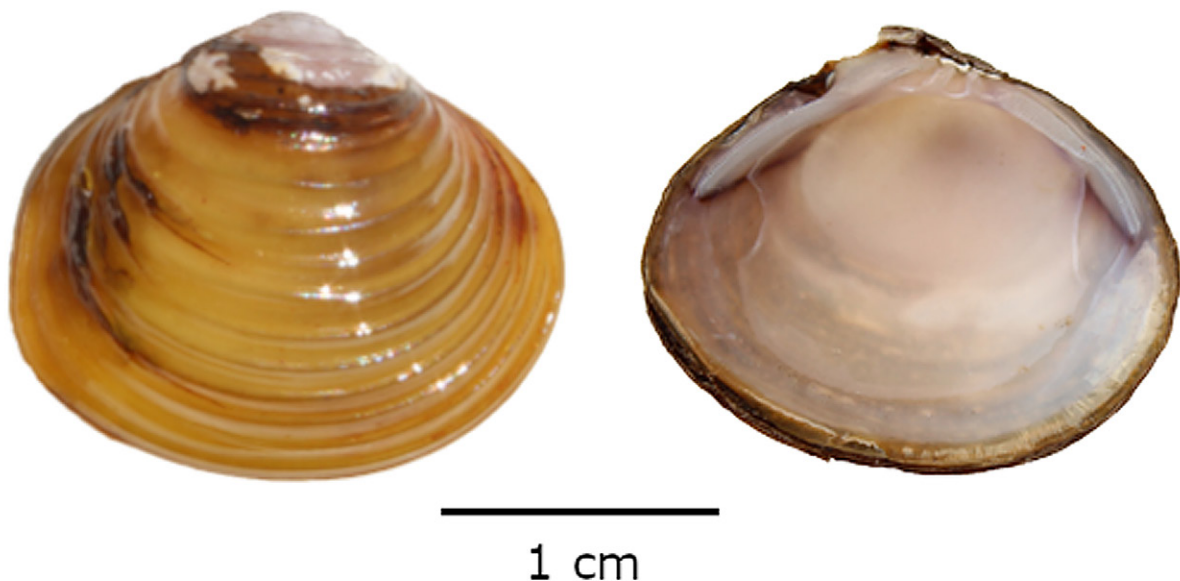


Figure 1. *Corbicula fluminea* collected at Chapada dos Veadeiros (CMUnB 1359), external and internal view.

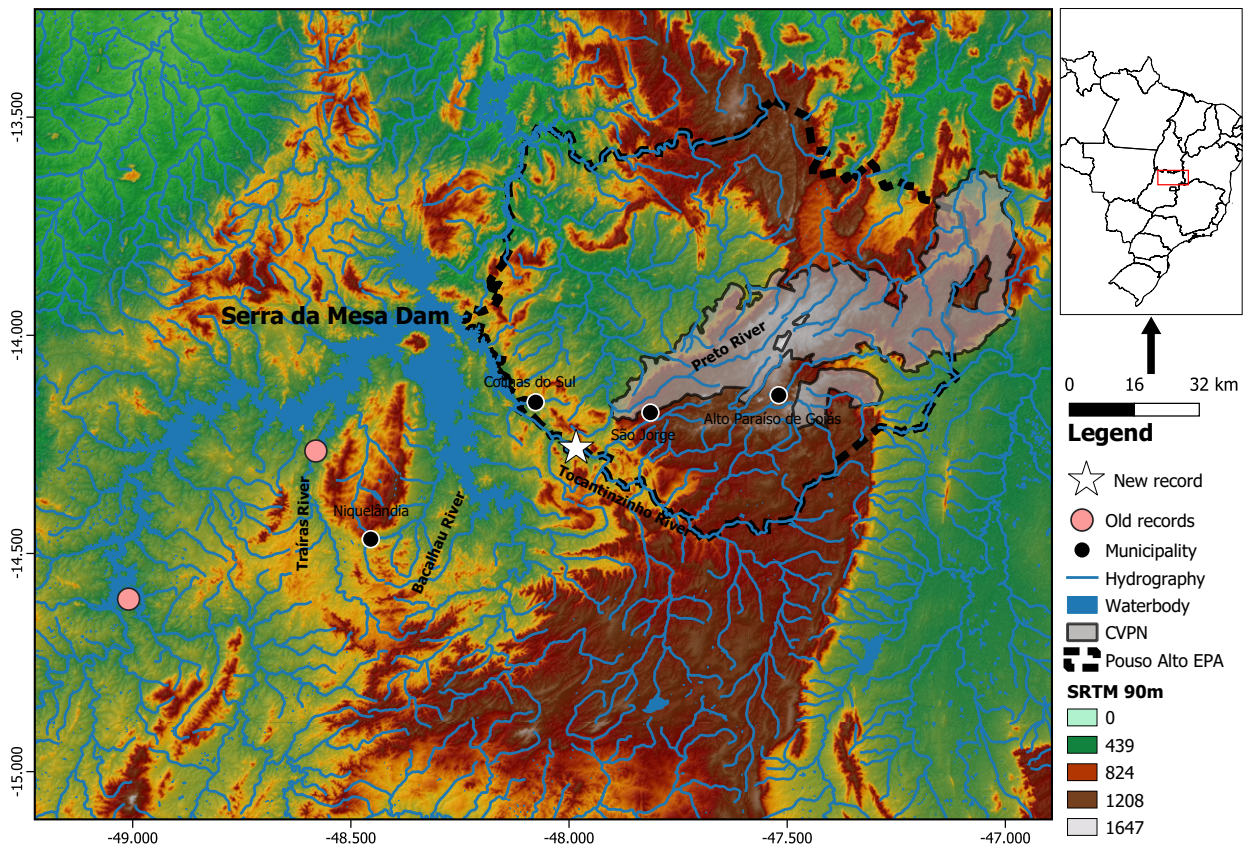


Figure 2. New record *Corbicula fluminea* (white star), previous records (pink circle) and municipality (black circle). Boundaries of the Chapada dos Veadeiros National Park (solid black line) and boundary of the Pouso Alto Environmental Protection Area (dashed black line).

Discussion

Here, we report a new record of *Corbicula fluminea* in the Tocantinzinho River. This new record represents the first of this invasive species from the Chapada dos Veadeiros region, in Colinas do Sul municipality, Goiás state. This region is within the Pouso Alto Environmental Protection Area near Chapada dos Veadeiros National Park. This new record expands the distribution of *C. fluminea* by at least 200 km southeast of the first records of this species in the Basin of the Tocantinzinho River, which were mainly associated with the Serra da Mesa Reservoir (Thiengo et al. 2005). Previous records of this species are from the reservoir of the Serra da Mesa dam, which is formed by the confluence of the Maranhão, Almas, and Tocantinzinho rivers. However, none of these records include upstream portions of the Tocantinzinho River—stretches of the free river outside the area influenced by the Serra da Mesa dam. Our record is important because it shows that *C. fluminea* has expanded its occurrence into conserved areas of the Cerrado biome. Our new record of *C. fluminea* was made 15 years after the first sighting of this invasive species by Thiengo et al. (2005), which demonstrates that this species is established in the region.

Predictive models for the occurrence of *C. fluminea* have shown its a preference for shallow water and sandy substrates with little organic matter (Silveira et al. 2016). In the Tocantinzinho River, this species was found on

shallow waters in the river. Linares et al. (2020) and Darrigran et al. (2020), demonstrated that the occurrence of this species is correlated with anthropogenic modifications. For example, the construction of dams is associated with multiple biological invasion processes that favor the occurrence of these molluscs, mainly by modifying the water body. However, our sampling site was quite preserved, and the specimens probably came from anthropized localities in downstream stretches within the same Basin. Invasive species, such as *C. fluminea* and *Melanooides tuberculata* (Müller, 1774), have repeatedly been associated with the construction of dams in Brazil (Franca et al. 2007; Miyahira et al. 2017; Linares et al. 2018, 2019, 2020; Branco et al. 2019). Recent studies have indicated that these species use reservoir as ecological steppingstones to spread to new sites (Johnson et al. 2008; Linares et al. 2018). In the Chapada dos Veadeiros region, the Serra da Mesa Reservoir act as source population for the dispersal of *C. fluminea* to other areas of the Basin, such as the Tocantinzinho River. However, knowledge the dispersion capacity of *C. fluminea* is incipient, and more sampling is needed between the reservoir and at our site to be able to better explain the expansion of this species. Genetic studies would also be helpful in determining the linkage between the two sites.

Even so, two hypotheses are possible to explain the expansion of *C. fluminea* upstream of the Serra da Mesa reservoir. The first hypothesis is that the removal and transport of sand from rivers for construction may

be responsible for the dispersal of this species and may explain the gaps in its occurrence along the rivers (Belz et al. 2012; Sonia et al. 2012). The second is that this *C. fluminea* may pass through the digestive system of fish alive and be carried to new stretches of the river by fish movements; several species of invasive mollusks have been found in the last portion of the digestive tract of fish still alive, indicating a potential mechanism of dispersion for these organisms (Cantanhede et al. 2008; Isaac et al. 2014; Avila-Simas et al. 2019; Rosa et al. 2019; Darrigran et al. 2020; Gonzalez-Bergonzoni et al. 2020).

Our new record has relevant to conservation in Chapada dos Veadeiros region, the most preserved area in northeastern Goiás. We recommend that monitoring be carried out to better understand the demographics and the pattern of dispersal of *C. fluminea* upstream in the rivers as the São Miguel, Couros e Vãozinho, for example. These rivers have numerous stretches within areas of environmental protection.

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Authors' Contributions

Conceptualization: MJMS, YFFS. Data curation: MJMS. Formal Analysis: MJMS, YFFS. Funding acquisition: MJMS. Investigation: MJMS, YFFS. Methodology: MJMS. Project administration: MJMS. Resources: MJMS. Supervision: MJMS. Validation: MJMS. Visualization: MJMS, YFFS. Writing – original draft: MJMS, YFFS. Writing – review and editing: MJMS, YFFS.

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