

Long-term monitoring of the non-native giant river prawn *Macrobrachium rosenbergii* (De Man, 1879) in the Furnas mega reservoir (southeastern Brazil)

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ABSTRACT

In this study, we report six records of the non-native giant river prawn *Macrobrachium rosenbergii* (De Man, 1879) in the Furnas mega reservoir, state of Minas Gerais (Southeast Brazil), during continuous monitoring conducted from 2006 to 2023. All recorded specimens were males of the blue claw (BC) morphotype and possibly entered interior areas of the reservoir via accidental escapes. There was no occurrence of established populations in the region, nor any evidence of disease in the specimens obtained. However, continuous monitoring is recommended to record new escapes and determine the possibility of establishment of giant river prawn populations in the aquatic environment of the Furnas mega reservoir.

KEYWORDS

Bio-invasion, Caridea, escapes, Neotropical region, new records.

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Reservoirs are artificial environments that have unique structural characteristics, such as an upstream lentic portion and a downstream lotic portion. These characteristics promote hydrological and energy flow variations along the reservoir path, allowing humans to use this environment for various purposes (Henry, 1999; Wang et al., 2012). Brazil has the largest number of reservoirs in the world ($N = 393$), which vary in category according to the height of the dam and its storage capacity (FAO, 2016). Therefore, mega reservoirs, structures with heights above 100 meters and storing more than 1 km^3 of water (sensu Gupta et al., 2012), are considered the most important and strategic reservoirs in the country (ONS, 2023).

Among such reservoirs, the Furnas mega reservoir, located in the southeastern region of the country, stands out. Dammed in 1962, it is formed mainly by the Grande and Sapucaí Rivers, which are part of the Upper Paraná River basin, and other small tributaries (Fig. 1). It has a 127 m high dam and a total volume of 22.95 km^3 , its flooded area extends for $1,440 \text{ km}^2$ and its generation capacity is 1,216 MW. Approximately 40 municipalities in the state of Minas Gerais benefit from the Furnas mega reservoir, using it as a water reservoir, for electricity generation, tourism, leisure and direct exploitation of fishery resources (e.g., fishing, aquaculture and related activities). In addition, the mega reservoir directly and indirectly sustains a great diversity of wild life (Rigolin-Sá, 2012).

The Furnas mega reservoir is of great socioeconomic and environmental importance for the entire region where it is located. However, its implementation was responsible for significantly modifying the environmental landscape in its surroundings (Pereira et al., 2012). Added to this are other environmental changes caused by humans, the main type in this region being bio-invasions. Valéry et al. (2008) defined bio-invasion as "... a species acquiring a competitive advantage following the disappearance of natural obstacles to its proliferation, which allows it to spread rapidly and to conquer novel areas within the recipient ecosystem in which it becomes a dominant population."

Bio-invasions are common and constant in the Furnas mega reservoir and are easily observed among

the aquatic fauna of the region, especially in fish (e.g., Nile tilapia *Oreochromis niloticus* (Linnaeus, 1758), peacock bass *Cichla monoculus* Agassiz, 1831 (among other species reported in Azevedo-Santos et al., 2010a; 2011), mollusks (e.g., Asian clam *Corbicula fluminea* (Müller, 1774) analyzed by Paschoal et al., 2015) and crustaceans (e.g., red freshwater crab *Dilocarcinus pagei* Stimpson, 1861 and Amazon River prawn *Macrobrachium amazonicum* (Heller, 1862), analyzed by Azevedo-Santos et al., 2010b and Paschoal et al., 2019, respectively). Therefore, continuous and long-term monitoring of the aquatic fauna of the Furnas mega reservoir is necessary so that new non-native species are cataloged and possible environmental risks and problems are avoided and/or monitored over time, as is the case for the giant river prawn *Macrobrachium rosenbergii* (De Man, 1879) (Fig. 1).

Macrobrachium rosenbergii is a species of Asian origin with an amphidromous life cycle (i.e., its larvae depend on brackish water for development) and is currently the most commonly farmed species in freshwater aquaculture worldwide (New et al., 2010; Oliveira and Santos, 2021). The giant river prawn exhibits sexual dimorphism and social hierarchy, where large males with hypertrophied chelipeds gain adaptive advantages, such as ease in obtaining resources, in conquering and defending territories and in reproductive success. Males of this species have three distinct morphotypes: blue claw (BC) – dominant males with large bodies that have large blue chelipeds covered by spines, which greatly exceed their body length; orange claw (OC) – subdominant males with intermediate body sizes and orange chelipeds without spines that do not exceed their body length; and small male (SM) – submissive males with small bodies and small translucent and delicate chelipeds (Ra'anan and Sagi, 1985). In this context, the present report presents some records of the giant river prawn *M. rosenbergii* in the Furnas mega reservoir over 17 years of continuous monitoring, i.e., without gaps of more than a year. In addition, the possible escape routes and environmental problems caused by this bio-invasion are discussed.

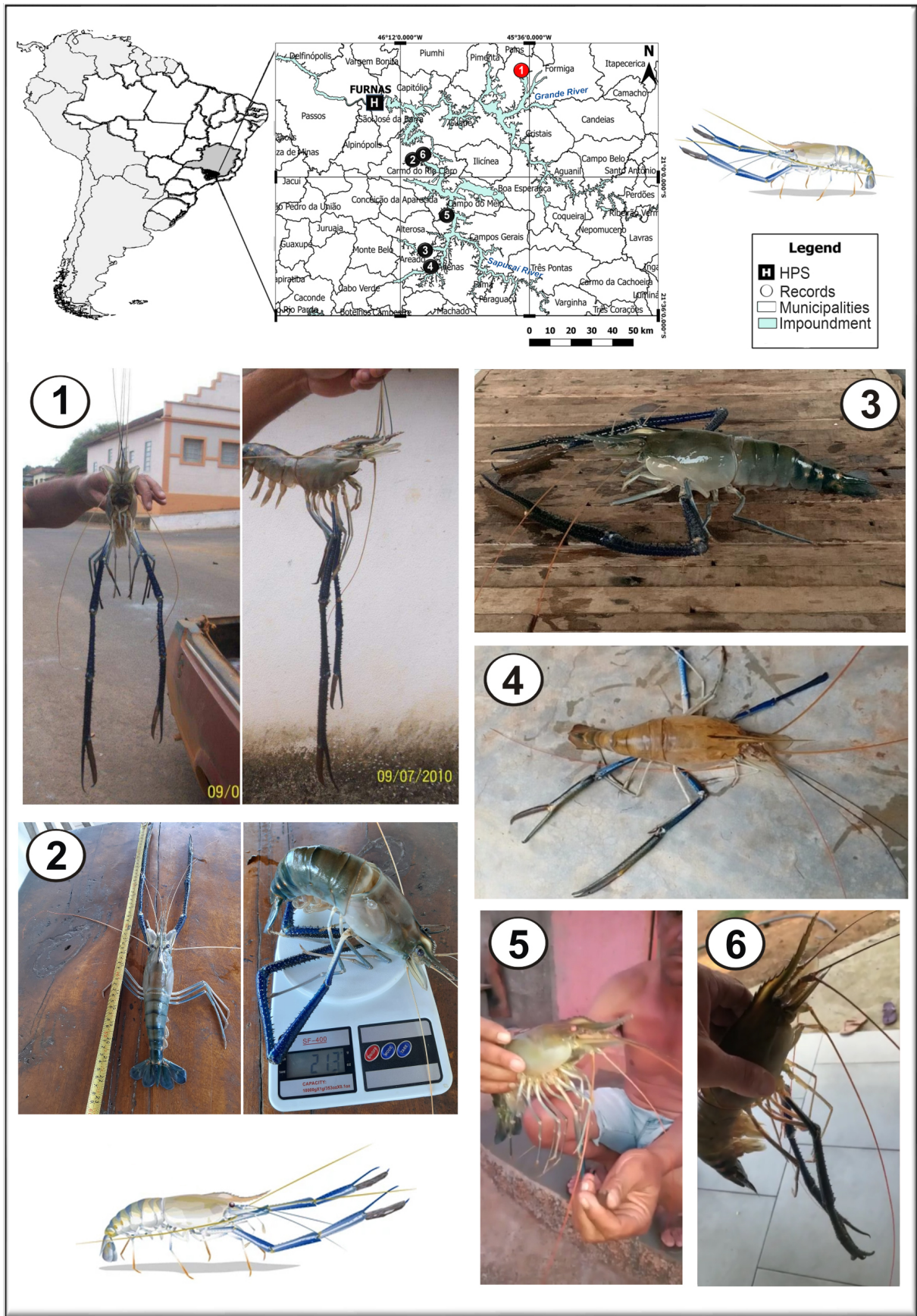


Figure 1. Occurrence of male *Macrobrachium rosenbergii* (De Man, 1879) of the blue claw morphotype recorded in the Furnas mega reservoir according to the time of capture (1 to 6) from 2010 to 2022.

From 2006 to April 2023, bio-invasions have been observed and monitored throughout the flooded area of the Furnas mega reservoir, either through seasonal field collections (monthly, bimonthly or semiannually, i.e., locations were sampled at least twice a year) and/or consensual interviews (at least one interview after encountering the non-native specimen) and reliable photographic documentation (i.e., without evidence of image alteration or manipulation) from professional fisher-people in the region. Animals were verified by active sampling (one collector with a sieve or D-net, which was employed several times along the marginal vegetation and macrophyte banks) and passive collection (traps baited with beef liver or gillnets were placed near the margin, and removed after 24 hr). The first record of *M. rosenbergii* was documented in 2010 in a stretch of the Grande River portion of the mega reservoir. There was a subsequent gap in records until 2022, when five new occurrences were recorded in the Sapucaí River portion and added to the initial record. All six records of *M. rosenbergii* in the mega reservoir were of large dominant (BC) males (Fig. 1 and Appendix). These specimens exhibited the key characteristics for the identification of the species (Holthuis and Ng, 2010): a long, upward-curving rostrum with a distinct basal crest, chelipeds large and deep bluish in color covered by spines along their length, and a distinct velvety pubescence on the movable finger (Fig. 1). There were no clinical signs of disease caused by viruses or microsporidia in these specimens, as was previously reported in this mega reservoir for other species of the genus (Paschoal et al., 2021). These animals were captured using gillnets (40 mm), photographed and subsequently were sold or used as bait or consumed by collectors. Due to this, only the BC male observed during the second record of the species in the mega reservoir was deposited in a scientific collection. This prawn was deposited in the Coleção de Crustáceos do Departamento de Biologia (CCDB), da Faculdade de Filosofia, Ciências e Letras de Ribeirão Preto, Universidade de São Paulo, under the catalog number CCDB 7551.

After these occurrence records were obtained, new collections were performed in the same areas to detect the possible establishment of the species.

However, no other giant river prawn individuals were found, and only individuals of *M. amazonicum* were captured at the site, allowing the conclusion that the records described here are accidental escapes. In the Sapucaí River portion, net cage farming is a very frequent activity, and escapes of aquatic organisms in this area are very common (Azevedo-Santos et al., 2011). In addition, there have been failed and often illegal attempts at combined farming of *O. niloticus* tilapia and giant river prawn in the Furnas mega reservoir (L.R.P. Paschoal, pers. comm.). It is possible that during pond maintenance and/or harvesting, some individuals of *M. rosenbergii* escaped to areas far from the original farming area. In addition, the fact that we recorded only BC males in the region reinforces the hypothesis of an escape from an already established, artificial population. As described by New et al. (2000), BC males are considered the reproducers of the herd and are the most profitable animals for the breeder due to their large bodies when compared to the other morphotypes, which would explain the occurrence of only this morphotype in the mega reservoir.

As suggested by Oliveira and Santos (2021), monitoring the aquatic environment allows us to understand the status of *M. rosenbergii* bio-invasions in Brazil. It can be concluded that in the Furnas mega reservoir, the giant river prawn did not present established populations and that accidental escapes of this species occurred without compromising the biota. However, recently, some populations of *M. amazonicum* was able to colonize several areas of this mega reservoir and the Marechal Mascarenhas de Moraes reservoir below it (Paschoal et al., 2019). Thus, we suggest the continuous monitoring of *M. rosenbergii* in this region, as well as in other areas of recorded occurrence in Brazil. Such action could avoid direct impacts on the aquatic biota, such as the reduction of native populations, local extinctions and transmission of diseases.

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ADDITIONAL INFORMATION AND DECLARATIONS

Author Contributions

Conceptualization and Design: FJZ, LRPP; Performed research: AJPC, LRPP; Acquisition of data: LRPP; Analysis and interpretation of data: AJPC, FJZ, LRPP; Preparation of figures/tables/maps: LRPP; Writing – original draft: AJPC, LRPP; Writing – critical review & editing: AJPC, FJZ, LRPP.

Consent for publication

All authors declare that they have reviewed the content of the manuscript and gave their consent to submit the document.

Competing interests

The authors have no conflicts of interest to declare.

Data availability

All data generated and analyzed during this study are presented in this article.

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Study association

No particular study defined.

Study permits

Field collection and transportation of specimens were made under the SISBIO permit number 87496-1 issued to L.R.P. Paschoal

Appendix. Additional information on the occurrence records of *Macrobrachium rosenbergii* (De Man, 1879) from Furnas mega reservoir between 2010 and 2022.

Occurrence	Date of capture	Section of the reservoir where the specimen was obtained	Municipality (district)	Coordinates	Collector	Total length (mm)*	Morphotype
1	09.vii.2010	Grande River	Formiga (Pontevila district)	20°33'14.4"S 45°37'36.1"W	Raimundo Luiz	nm	BC
2	10.iii.2022	Sapucai River	Carmo do Rio Claro	20°55'52.0"S 46°08'00.6"W	Divino Silva	215.6	BC
3	14.v.2022	Sapucai River	Areado	21°18'57.6"S 46°05'00.6"W	Carlos Donizeti	nm	BC
4	10.vi.2022	Sapucai River	Alfenas	21°23'19.0"S 46°02'30.5"W	Nelson Augusto	nm	BC
5	29.x.2022	Sapucai River	Alfenas (Barranco Alto district)	21°09'27.0"S 45°58'45.5"W	Rafael Silva	nm	BC
6	24.xi.2022	Sapucai River	Carmo do Rio Claro	20°55'06.6"S 46°07'04.1"W	Bruno Ribeiro	213.7	BC

* : distance between the posterior margin of the ocular orbit to tip of telson

BC: blue claw

nm: not measured