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Shrimps of the Gongogi river, Bahia, Brazil

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Abstract: For the first time, the presence of the species *Macrobrachium carcinus* (Linnaeus, 1758) and *M. jelskii* (Miers, 1877) was recorded in the Gongogi River, tributary of the Contas River less impacted by sewage discharge. The results suggest that the Gongogi Basin may serve as an ecological refuge for crustaceans in this region.

Key words: Caridea; Biodiversity; Conservation; Geographic distribution.

Camarões do Rio Gongogi, Bahia, Brasil. Resumo: Pela primeira vez, foi registrada a presença das espécies *Macrobrachium carcinus* (Linnaeus, 1758) e *M. jelskii* (Miers, 1877) na Bacia do Rio Gongogi, sub-bacia menos impactada por despejos de esgoto. Os resultados indicam que a Bacia do Gongogi pode estar desempenhando o papel de refúgio ecológico para crustáceos Decapoda nessa região.

Palavras-chave: Caridea; Biodiversidade; Conservação; Distribuição geográfica.

Due to the growing global population, the planet has been experiencing continuous environmental impacts resulting from attempts to reconcile meeting human demands with sustainably exploiting natural resources (Amaral *et al.*, 2010). Frequent and sequential changes in climate, land use, and resource exploitation pose significant risks to various species of fauna and flora worldwide (Amaral *et al.*, 2008). In light of these challenges, it is essential to direct ecological research toward aquatic systems, with particular emphasis on keystone species such as the shrimp inhabiting the Gongogi River. A detailed understanding of their distribution, behavior, and feeding habits is crucial for the development of effective management strategies for these riverine ecosystems. Such an approach can help mitigate broader threats—like the introduction of non-native species and dam construction—as well as specific impacts on local aquatic fauna, especially during critical periods such as reproduction (Lima et al., 2014). Understanding the diversity of species occurring in each region is essential for a fundamental comprehension of population or community dynamics (Silva *et al.*, 2024). In inland aquatic environments, shrimp play key roles in maintaining ecosystem balance. Due to their detritivorous habits, they contribute to nutrient cycling, demonstrating significant impacts and relevance to the stability of the ecosystems in which they live (Jacobsen *et al.*, 2008). In such environments, changes in biota composition can substantially affect species abundance and diversity. From this perspective, the introduction of a single non-native species into a river basin can trigger the progressive decline of endemic populations, disrupting their reproductive and foraging behaviors (Lopes et al., 2020). Brazil, the known diversity of freshwater shrimp currently includes three families: Sergestidae Dana, 1852, with the lowest species richness; Atyidae De Haan, 1859, the second most diverse; and Palaemonidae Rafinesque, 1815, the most abundant and diverse, comprising species of greater economic and ecological importance (Pontes, 2009). In Bahia, northeastern Brazil, only the families Atyidae and Palaemonidae have been recorded (Melo, 2003). These families include species adapted to inhabiting both calm water environments, such as lakes, ponds, and swamps (lentic), and more turbulent waters, such as rivers and streams (lotic) (Freire *et al.*, 2012). In the southern region of Bahia, the Contas River Basin is the most important source of water for consumption and irrigation, supplying approximately 15% of state's population (Nogueira *et al.*, 2020). The Gongogi River, a tributary located in southern Bahia within the Northeastern Atlantic Forest hydrographic ecoregion, is the most significant tributary of the Contas River Basin. It is also considered the least impacted by anthropogenic effluents, including urban, industrial, and hospital sewage (Teixeira et al., 2012; Santos et al., 2023; Barros et al., 2021). Despite its ecological relevance, the Gongogi River Basin remains poorly studied with regard to the composition of its local fauna. The basin spans 14 municipalities, with its headwaters in the municipality of Iguaí (Bahia) and its mouth in Ubaitaba (Bahia), where it joins the Contas River. The Contas River subsequently flows into the Atlantic Ocean in the municipality of Itacaré (Bahia) (Teixeira et al., 2012; Santos et al., 2023). Until now the only decapod species recorded in this river is the Atyidae shrimp, *Atya scabra* (Leach, 1815), which holds considerable economic interest due to its large size upon maturation (Barros *et al.*, 2020; Alves *et al.*, 2021). This species is found in relatively shallow waters with fast flow and higher oxygen availability (Barros *et al.*, 2020). Due to its amphidromous reproductive habits and environmental preferences, *A. scabra* has been classified as vulnerable in 10 Brazilian states, including Bahia (Melo & Coelho, 2008; Alves *et al.*, 2021). The present study aims to record two other species of shrimps in the Gongogi River, *viz. Macrobrachium carcinus* (Linnaeus, 1758), which is among the three most economically important species in the genus (Lima *et al.*, 2014), and the small-sized species *M. jelskii* (Miers, 1877), widely used as bait for fish capture (Vera-Silva *et al.*, 2016). Additionally, this investigation aims to provide more information about the crustacean diversity in the region, offering support for future research.

The specimens were collected from the Gongogi River (Figure 1a, 1b). The analyzed material was collected in December 2019 at two sampling points within the same locality (1 - 14°19'14.7"S, 39°27'38.9"W; 2 - 14°19'31.8"S, 39°27'49.5"W; Figures 1c, d) by local fishermen. The specimens were captured using handmade "Matapí" traps (details in Silva *et al.*, 2007). Subsequently, they were anesthetized in a 10% benzocaine solution, transferred to a 10% formalin solution for 24 hours, and finally preserved in 70% ethanol (Barros *et al.*, 2021). Specimens are deposited in the zoological collection of the Laboratory of Zoology and Animal Parasitology at the State University of Southwest Bahia (LZPA-UESB), Juvino Oliveira campus (Vouchers: LZPA∅∅568, LZPA∅∅569, LZPA∅∅570, LZPA∅∅571, LZPA∅∅572, LZPA∅∅573, LZPA∅∅574).

The identification was performed using dichotomous keys and specialized diagnoses as proposed by Melo (2003), Mantelatto & Barbosa (2005), Valencia and Campos (2007), Almeida *et al.* (2008), Pileggi *et al.* (2013), and Vera-Silva *et al.* (2017). Shrimps were sexed based the male appendix presence/absence criterion Subsequently, the specimens' carapace length (CL) was measured using a Mitutoyo digital caliper with 0.001 mm precision. The examined material was deposited in the zoological teaching collection of the LZPA at the Southwest Bahia State University, Juvino Oliveira campus. Species occurrence was assessed based on secondary data following the methodology proposed by Alencar et al. (2023). Two primary sources were consulted: scientific publications, species lists, and biodiversity studies available in the specialized literature; and specimen records deposited in scientific zoological collections, accessed through the online platforms GBIF (2019) and SpeciesLink (2019). Materials from grey literature, such as monographs, theses, and conference abstracts, were not considered. A map of the study area was created using QGIS software version 3.36.1 (QGIS, 2024), employing the WGS84 coordinate system. Shapefiles corresponding

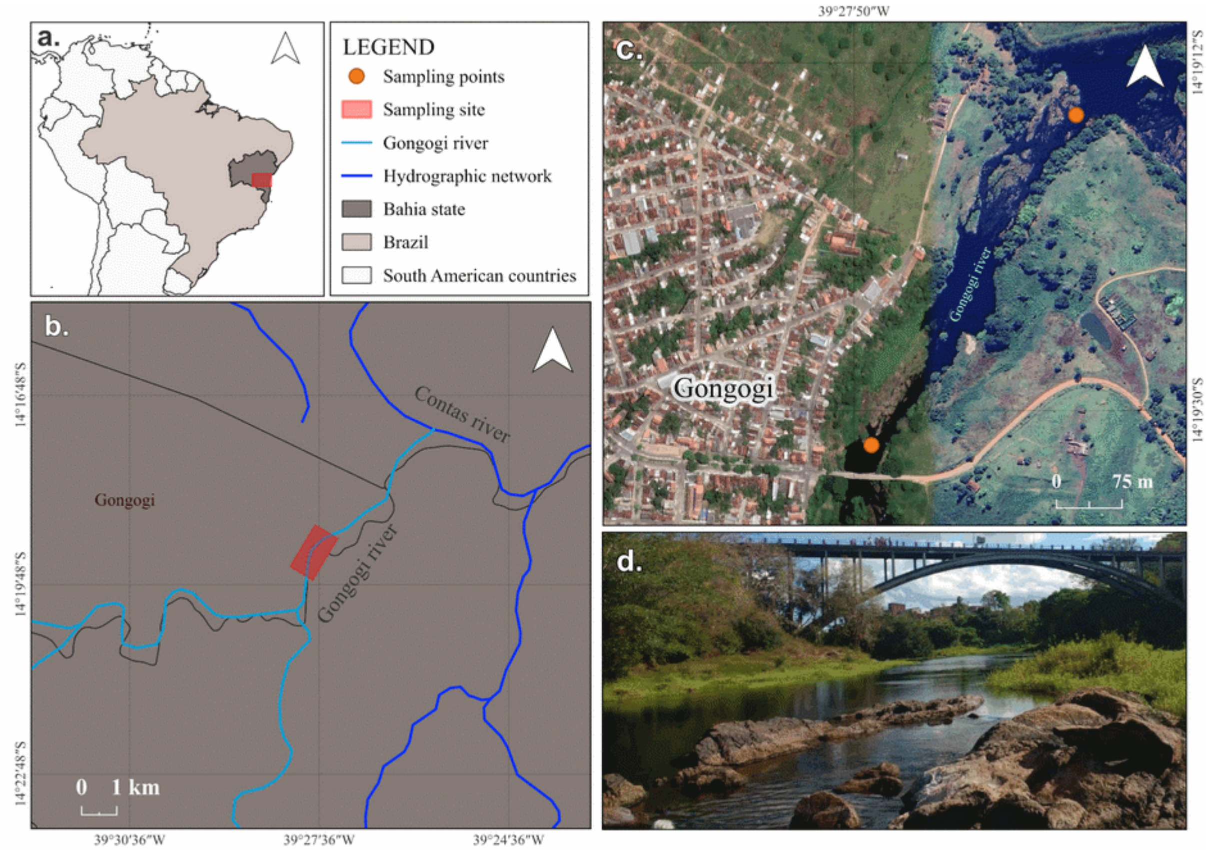

Figure 1. Gongogi River, Bahia, Brazil. a – Map of Brazil highlighting the study area. b – Hydrography of the Gongogi River Basin emphasizing the study locality. c – Sampling points. d – Study area in the Gongogi River.

to national boundaries were obtained from the Natural Earth platform (2022), while state and municipal boundaries for Brazil were sourced from the Brazilian Institute of Geography and Statistics (IBGE, 2022). Hydrographic divisions were acquired from the National Water Resources Council (CNRH) and the National Water Agency (ANA, 2016).

Family Atyidae De Haan, 1849
***Atya scabra* (Leach, 1815)**
(Fig. 2 A–B)

Examined Material: Brazil, Bahia, Gongogi, Gongogi River (14°19'14.7"S, 39°27'38.9"W - 14°19'31.8"S, 39°27'49.5"W). A total of 22 individuals were sampled: 20 males and 2 females. The carapace length of males ranged from 20.99 to 33.69 mm, while that of females ranged from 16.15 to 16.22 mm. Vouchers: LZPA∅∅572, LZPA∅∅573, LZPA∅∅574. Collector: Barros, A. G, december 2019.

Distribution: The species has a broad amphi-Atlantic distribution (Hobbs and Hart, 1982), occurring from southern Mexico to Brazil (Ceará to Santa Catarina), as well as in most Caribbean islands (Panama, Costa Rica, Trindad and Tobago, Puerto Rico). In Africa, it is found from Liberia southward to Angola, including the Cape Verde Islands and islands in the Gulf of Guinea (São Tomé and Principe, Cameroon, Guinea Ecuatorial) (Grave *et al.*, 2013; Oliveira *et al.*, 2019).

Diagnosis: Short rostrum without teeth on its margins, with lateral projections forming an obtuse angle with the rostrum. Evident lateral and pterygostomial spines. Telson with two rows of 5 to 7 dorsal spines. First and second pereiopods with fingers ending in long brushes of setae. Third pereiopod extending beyond the last segment of the antennular peduncle. Merus ventrally rounded and longer than wide, with irregular rows of corneous tubercles on the lateral surface. Carpus is half the length of the merus. Propodus is 1.4 times longer than the carpus, featuring rows of sclerotized tubercles. Dactylus with a single longitudinal row of 6 to 7 tubercles on its flexor surface (Oliveira, 1945).

Family Palaemonidae Rafinesque, 1815
***Macrobrachium carcinus* (Linnaeus, 1758)**
(Fig. 2 C–D)

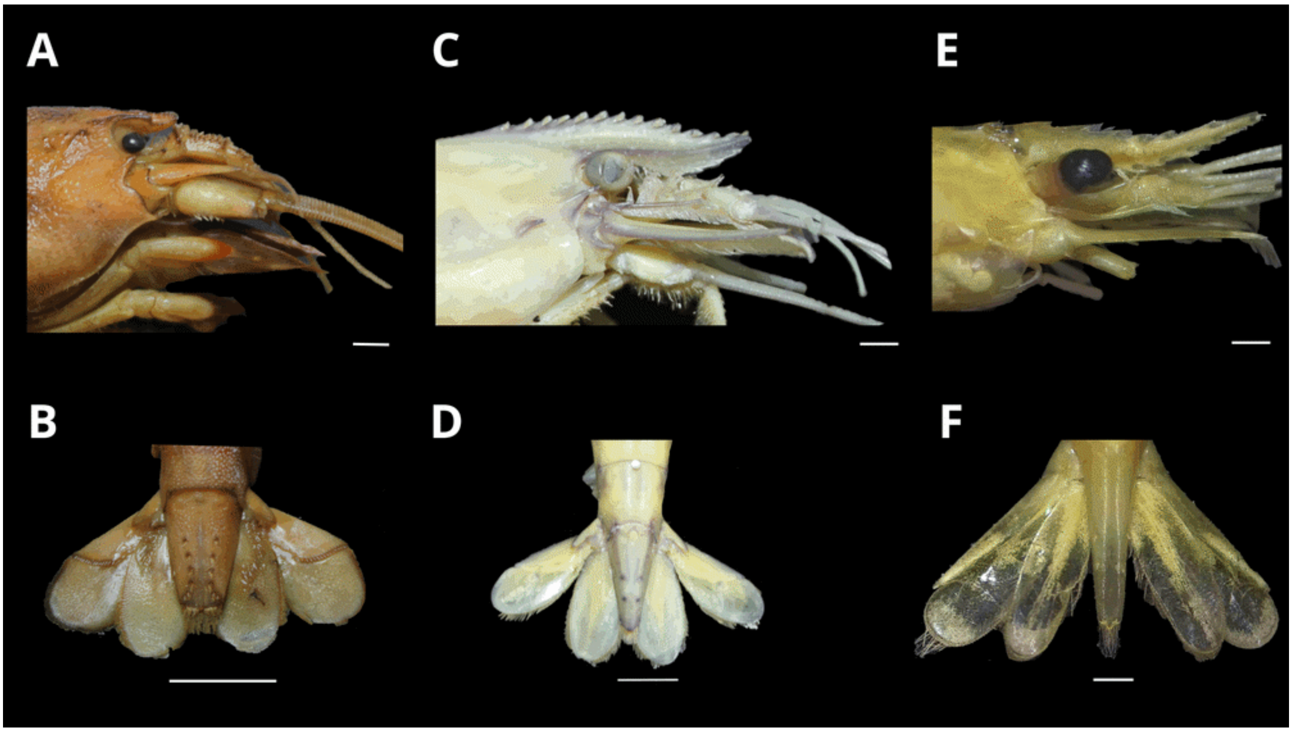

Figure 2. Rostrum and telson of Palaemonidae shrimps collected in the Gongogi River. A–B: *Atya scabra* (Leach, 1815), C–D: *Macrobrachium carcinus* (Linnaeus, 1758), E–F: *Macrobrachium jelskii* (Miers, 1877).

Examined Material: Brazil, Bahia, Gongogi, Gongogi River (14°19'14.7"S, 39°27'38.9"W - 14°19'31.8"S, 39°27'49.5"W).Two females were sampled. Carapace lengths were 33.92 mm and 44.86 mm. Voucher: LZPA∅∅568. Collector: Barros, A. G, december 2019.

Distribution: The species has a wide distribution across the Americas, from southern United States (Florida, Mississippi, Texas) and Mexico to Central America, including Guatemala, Nicaragua, Costa Rica, Panama, Cuba, Puerto Rico, Jamaica and Barbados, and in South America in Colombia, Venezuela, Guyana, Suriname, and Brazil. In Brazil, it is found in the states of Pará, Piauí, Ceará, Pernambuco, Alagoas, Sergipe, Bahia, Espírito Santo, Rio de Janeiro, São Paulo, Santa Catarina, and Rio Grande do Sul (Ramos-Porto & Coelho, 1998; Melo, 2003; Almeida *et al.*, 2008).

Diagnosis: Lanceolate rostrum with the apex curved upward; dorsal margin with 11 to 14 regularly spaced teeth. Smooth carapace and abdomen. Terminal margin of the telson forms a semicircle, with one pair of internal spines and a reduced external spine that does not extend beyond the telson's terminal margin. The first pair of pereiopods extends beyond the scaphocerite. The second pair of pereiopods is elongated and prominent, symmetrical in shape and size, extending beyond the scaphocerite. A prominent tooth is present on the medial edge of the movable finger and another on the proximal edge of the fixed finger, usually followed by 3 to 4 denticles at the base of each finger (Valencia & Campos, 2007).

Macrobrachium jelskii (Miers, 1877)
(Fig. 2 E–F)

Examined Material: Brazil, Bahia, Gongogi, Gongogi River (14°19'14.7"S, 39°27'38.9"W - 14°19'31.8"S, 39°27'49.5"W). A total of 190 individuals were sampled: 104 males and 76 females. Carapace length for males ranged from 7.63 mm to 3.27 mm, while for females, it ranged from 10.88 mm to 3.74 mm. Vouchers: LZPA∅∅569, LZPA∅∅570, LZPA∅∅571. Collector: Barros, A. G, december 2019.

Distribution: The distribution records are limited to South American countries, extending geologically from the islands of Trinidad and Tobago and including Suriname, Guyana, Venezuela, Peru, Bolivia, Argentina, and Brazil. In Brazil, it has been recorded in the states of Amapá, Amazonas, Pará, Maranhão, Ceará, Rio Grande do Norte, Paraíba, Pernambuco, Alagoas, Sergipe, Bahia, Acre, Mato Grosso, Espírito Santo, Rio de Janeiro, Minas Gerais, São Paulo and Paraná (Pileggi *et al.*, 2013; Vera-Silva *et al.*, 2017).

Diagnosis: Slender rostrum, slightly curved upward, extending slightly beyond the scaphocerite; 5–9 dorsal teeth, 1–2 subapical teeth, and 1–2 postorbital teeth; 4–7 ventral teeth. Second right and left pereiopods are similar in shape and size; slender; glabrous; carpus with a protuberance at the distal end; carpus length 1.3 to 2.1 times the chela; chela length 0.4 to 0.5 times the carapace length. Telson with the posterior margin ending in a median apex, 2 pairs of plumose setae, and 2 pairs of spines; the internal pair of posterior spines distinctly surpasses the posterior median apex (Vera-Silva *et al.*, 2017).

Expanding knowledge on the distribution of species is fundamental for an adequate understanding of the diversity, abundance, and richness that compose specific ecosystems. Jacobsen *et al.* (2008), in characterizing the diversity of aquatic invertebrates, highlight the importance and relevance of studies like this, which characterize aquatic biota and pave the way for future research. The Gongogi River region holds high biodiversity potential due to its vegetation similarities with better-studied rivers, such as the Contas River and other major continental basins (Teixeira et al., 2012). However, the only study focused on describing the fauna of crustaceans this environment is restricted to the species *A. scabra* (Barros *et al.*, 2021), which suggests that the overall biodiversity of this basin is being underestimated or evaluated only in comparison to the diversity of other, better-studied basins. The species listed in this study represent the first effort to understand the diversity of decapod crustaceans in the region. Almeida et al. (2008) conducted a study based on collections carried out between 1997 and 2005, documenting the occurrence of *A. scabra*, *M. jelskii*, *M. carcinus*, *M. acanthurus*, and *M. amazonicum* in the Contas River Basin, specifically within its main tributary. Fourteen years later, using a similar methodology (handmade traps) in the Gongogi River, a tributary of the Contas River, only *M. acanthurus* and *M. amazonicum* were not collected. The absence of these two species may be linked to specific local environmental factors, such as changes in water quality, availability of suitable microhabitats, or seasonal variation. This finding underscores the importance of continuous studies with broader spatial and temporal coverage to better understand crustacean distribution in the region, thereby informing strategies to mitigate the impacts of anthropogenic activities on their abundance and distribution. Teixeira *et al.* (2012), Barros *et al.* (2021), and Santos *et al.* (2023) have noted that, in recent years, of the Contas River Basin has been receiving increasing amounts of effluents, primarily from domestic and industrial sewage. This has rendered the basin progressively less suitable for organisms sensitive to environmental changes, such as *Atya scabra* (Melo & Coelho, 2008). Santos *et al.* (2023) also emphasized the importance of the Gongogi tributary to the Contas River Basin, as it holds the status of the primary water contributor and is classified as having the lowest pollution levels among the tributaries of the Contas River Basin. *Atya scabra* and *M. carcinus* exhibit an amphidromous lifestyle (Lara & Wehrtmann, 2009; Alves *et al.*, 2021). They inhabit freshwater environments but require migration to estuarine regions for successful reproduction (Herrera-Correal *et al.*, 2013). Therefore, any changes in water flow can critically influence their reproductive and behavioral dynamics (Lara & Wehrtmann, 2009). Understanding the distribution and reproductive biology of these species is crucial, as they hold significant commercial value. On the other hand, *M. jelskii*, a potential invasive species, in tributary, with high adaptive capacity, poses a risk of disrupting the local community (Moraes *et al.*, 2017). Any changes in the abundance of a species, whether prey, predator, or any trophic guild member, have the potential to impact the local ecosystem (Herrera-Correal *et al.*, 2013). Such impacts could disrupt nutrient cycling and alter the structure of the food web (Alves et al., 2021). Consequently, the environmental changes experienced by the Contas River Basin in recent decades, primarily due to sewage discharge (Teixeira et al., 2012; Barros et al., 2021; Santos et al., 2023), may have prompted the migration of these species to other areas or caused declines in local populations, potentially leading to local extinctions. We believe this could represent a near-future scenario, based on recent discussions of similar cases in the Gongogi River tributary and comparisons with other nearby basins (Teixeira *et al.*, 2012; Santos *et al.*, 2023). Studying the conditions of the two basins, Teixeira *et al.* (2012) and Santos *et al.* (2023) highlight their opposing realities, with the Contas River Basin receiving a much higher pollutant load compared to the Gongogi River tributary. This distinction allows us to infer that species more sensitive to pollution tend to seek less affected environments and find in the Gongogi River tributary a less altered and more suitable habitat for survival. Kamp *et al.* (2007) define such regions, with fewer environmental alterations, as ecological refuges for species with greater habitat selectivity.

Habitats supporting economically important species, such as *M. carcinus* and *A. scabra*, must undergo constant evaluation and investigation to monitor shrimp assemblage composition and their population dynamics in their regions of occurrence. Furthermore, the potential risk posed by the presence of *Macrobrachium jelskii*, a non-native (allochthonous) species in the region, highlights the need to evaluate whether its presence and fluctuations in abundance may affect other species (Pileggi & Mantelatto, 2010; Moraes et al., 2020). This concern becomes even more pressing considering that the Gongogi River tributary, according to specialized literature, exhibits a lower degree of landscape alteration compared to adjacent tributaries (Santos et al., 2023). Initial biodiversity surveys of decapod crustaceans in this basin over at least one annual cycle could provide crucial baseline data on the structural and population composition of these species. Such studies could also confirm whether this basin functions as an ecological refuge. The characterization of the Gongogi River Basin as an ecological refuge, coupled with literature reports on the environmental conditions of the basins discussed, suggests that the Gongogi River tributary may serve as a refuge for Decapoda species already reported in the Contas River Basin. Quantifying the degree of landscape alteration and anthropogenic pollution levels could enable testing of some of our hypotheses.

Ethical statement

The present investigation did not involve regulated animals and did not require approval by an Ethical Committee. The authors declare no conflict of interest.

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