



MULTIPLE OBSERVATIONS OF MORPHOLOGICAL ANOMALIES IN *Macrobrachium amazonicum* (HELLER, 1862) (DECAPODA: PALAEMONIDAE) FROM AN AMAZONIAN URBANIZED AREA

Rafael Lima de Barros¹; Déborah Elena Galvão Martins^{1,2*}; Girlene Fábila Segundo Viana³; Israel Hidenburgo Aniceto Cintra¹; Flavio de Almeida Alves-Júnior^{1,2}

Abstract

Herein, we describe multiple occurrences of morphological abnormalities in *Macrobrachium amazonicum* (Heller, 1862) collected in a hypertrophic urban river that flows through the city of Belém, Pará State, Eastern Amazonia, Brazil. The samples were performed between 2022 and 2025, using traditional local traps called “matapi” placed in shallow areas of the Guamá River (01°27'54.2"S; 048°26'02.6"W). After sampling, all individuals were transported to the *Laboratório de Crustáceos* (LabCrus/UFRA) where they were identified, sexed, measured, and only the anomalous specimens were photographed. A total of 4,830 individuals of *M. amazonicum* were collected, of which 54 (8 males and 46 females), corresponding to 1.12% of the total, showed abnormalities. The deformities were observed in the rostrum (68.5%) and in the telson (31.5%). The highest incidence of abnormal females was observed in May and June 2022, with other peaks in March and August 2023; while for males, the highest presence of abnormalities was in August 2025. The Guamá River receives heavy inflows of urban and industrial effluents, which may be one of the causes of the anomalies observed in *M. amazonicum*. However, other conditions may be associated with these anomalies, such as nutritional or genetic factors. This study increases the knowledge on morphological abnormalities in shrimps, especially in *M. amazonicum*, and highlights the need for biological and environmental monitoring along the main urban river (Guamá River) in the city of Belém, Pará.

Keywords: Rostral anomalies. Telson abnormal. State of Pará. Prawn anomalies. Guamá River.

¹*Laboratório de Crustáceos* (LabCrus), Socio-Environmental and Water Resources Institute (ISARH), Federal Rural University of Amazonia (UFRA), Avenida Presidente Tancredo Neves, nº 2501, Terra Firme, 66077-830 Belém, Pará, Brasil

²*Núcleo de Ecologia Aquática e Pesca da Amazônia* (NEAP), Post-Graduate Programme in Aquatic Ecology and Fisheries (PPGEAP), Federal University of Pará (UFPA), Avenida Perimetral, 2651, Terra Firme, 66077-530 Belém, Pará, Brasil

³Bentos Laboratory (LABENTOS), Serra Talhada Academic Unit (UAST), Federal Rural University of Pernambuco (UFRPE), Avenida Gregório Ferraz Nogueira, s/n, 56909-535 Serra Talhada, Pernambuco, Brasil

*Corresponding author: deborah.martins@ufra.edu.br

Submitted on: 27 Nov. 2025

Accepted on: 08 Jan. 2026

Published on: 06 Feb. 2026

© Copyright 2026



1 Introduction

The Amazon river prawn *Macrobrachium amazonicum* (Heller, 1862) is one of the most representative species within the family Palaemonidae Rafinesque, 1815, which has a wide geographical distribution in hydrographic basins and estuarine areas of South America, especially associated with tropical and subtropical regions (HOLTHUIS, 1952; MAGALHÃES, 2000; RODRIGUES et al., 2025). In the Amazon region, *M. amazonicum* is characterized as a fishery resource of great economic and social importance, where it is exploited both for the subsistence of riverside communities and for local trade (MACIEL; VALENTI, 2009; ALCÂNTARA; KATO, 2016; SILVA et al., 2017). Additionally, this species may be assigned as an environmental biomonitor (CARDENAS-CAMACHO; GONZÁLEZ-REINA; VELASCO-SANTAMARÍA, 2024); however, few studies have been conducted in northern Brazil.

In this scenario, morphological abnormalities may be seen as indicators of stress in the animal, since structural deformities are often associated with chemical contamination and ecological imbalances (MANTELATTO et al., 1999; LOPES et al., 2008; MARQUES; AMÉRICO-PINHEIRO, 2020). Additionally, these changes may have multiple causes, including genetic factors, failures in the molting process, parasitism, mechanical injuries or environmental pressures such as pollution and reduced availability of food resources (SCELZO, 1998; CAMPOS-CAMPOS; DUEÑAS-RAMÍREZ; GENES, 2015; SILVA; SHINOZAKI-MENDES, 2018).

Deformities in crustaceans are frequently reported in marine shrimps, such as *Glyphocrangon aculeata* (A. Milne-Edwards, 1881), *Metapenaeus affinis* (H. Milne Edwards, 1837), *Mierspenaeopsis hardwickii* (Miers, 1878), *Penaeus (Litopenaeus) vannamei* Boone, 1931, *Penaeus (Farfantepenaeus) duorarum* Burkenroad, 1939 among other penaeid shrimps (SIVAGAM; RAO, 1968; SAKAEW et al., 2008; RAIJKUMAR et al., 2016; ALVES-JÚNIOR et al., 2018; WAKIDA-KUSUNOKI et al., 2020). Recently, some investigations have reported anomalies in freshwater shrimp, such as the studies performed by Martins et al. (2022) and Calandrini et al. (2025), which documented morphological changes in *M. amazonicum* in the state of Pará (Northern Brazil), revealing deformities in structures in the rostrum and telson.

The Belém metropolitan area (Pará State) represents a region of intense anthropic pressure, characterized by disorderly urban growth, the discharge of domestic and industrial effluents, siltation, and changes in the water quality of rivers and streams (SANTOS et al., 2014; LIMA; LIMA; KUBOTA, 2021).

These factors, combined with continuous fishing (SILVA, FRÉDOU, ROSA-FILHO, 2007), may contribute to the emergence of morphological changes in aquatic organisms, especially due to environmental degradation.

Thus, we describe the morphological anomalies observed in the Amazon river prawn *Macrobrachium amazonicum*, collected from the Guamá River, in Belém metropolitan area, Pará State.

2 Material and Methods

The samples were collected in a floodplain area on the banks of the Guamá River (01°27'54.2"S; 048°26'02.6"W), one of the main rivers that flows through the city of Belém in the state of Pará (Figure 1).

The Guamá River basin occupies approximately 12,584 km², covering nineteen municipalities (ROCHA; LIMA, 2020).

In addition, it receives constant inputs of domestic waste from Belém metropolitan area, as well as chemical elements from mining activities, showing a high degree of eutrophication, characterized by waters rich in suspended particles of silt and clay (PAIVA et al., 2006; SANTOS et al., 2014; SANTOS et al., 2020; LIMA; LIMA; KUBOTA, 2021).

Belém has a humid equatorial climate, characterized by high temperatures and high humidity throughout the year. The average annual temperature is approximately 26.7 °C, accompanied by rainfall reaching around 3,000 mm per year, with a dry season from June to November and a rainy season from December to May (SILVA-JÚNIOR et al., 2012; SANTOS et al., 2019).

The specimens of *M. amazonicum* were collected monthly between January 2022 and August 2025, using four traditional local traps called “matapi”, baited with babassu bran *Attalea speciosa* Martius, 1826.

After sampling, the individuals were transported to the *Laboratório de Crustáceos* (LabCrus) at the *Universidade Federal Rural da Amazônia* (UFRA).

In the laboratory, the shrimps were identified following Melo (2003), sexed and measured with analog vernier calipers (0.05 mm) in total length (TL), carapace length (CL) and wet weight (WW) (g).

The anomalous specimens were photographed using a Nikon D5300 camera, and then they were stored in 70% alcohol and deposited in the Carcinological Collection of the LabCrus-UFRA under voucher number 74.1.1 Z.

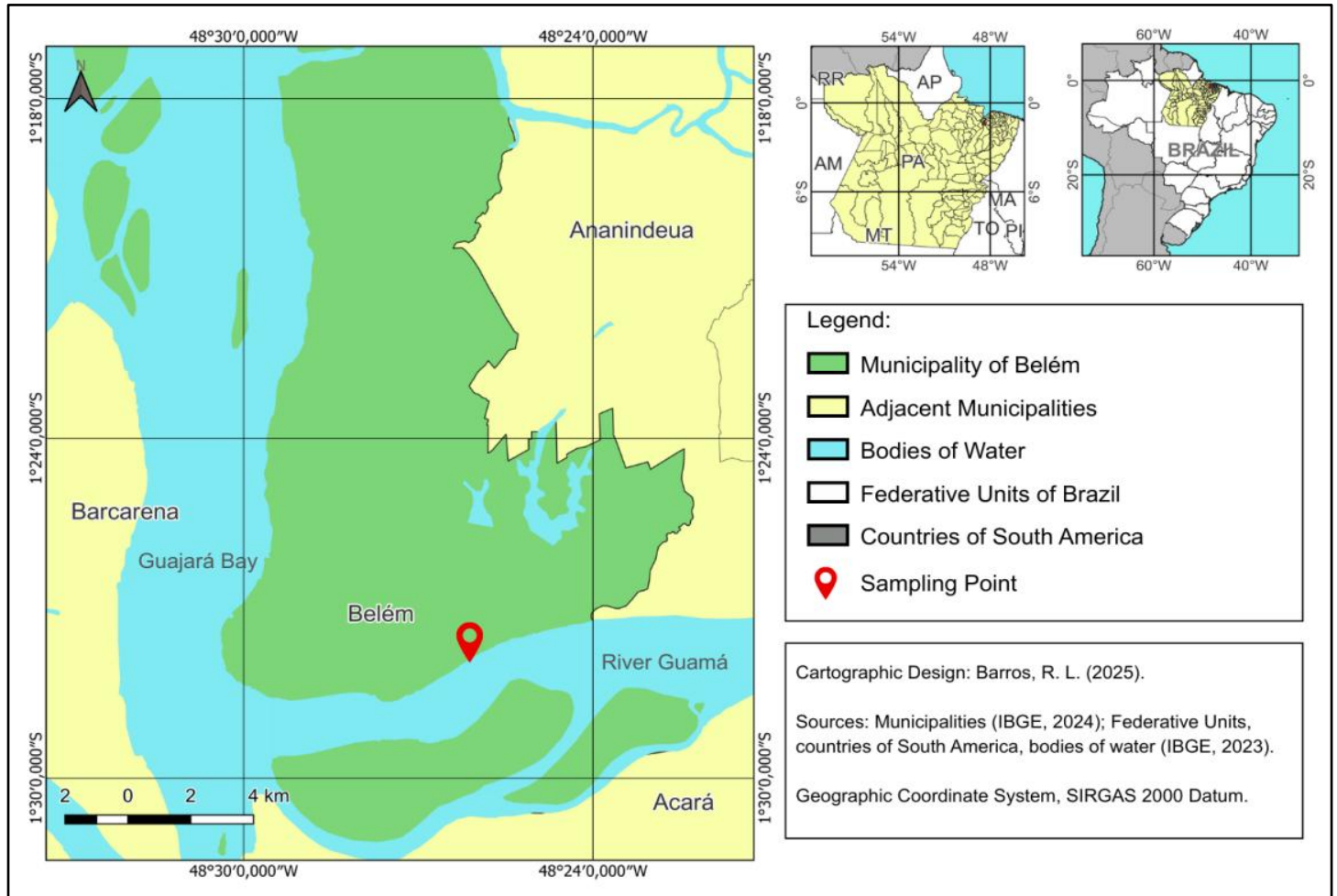


Figure 1. Map of the study area (Belém-PA), showing the sampling location of the Amazon river prawn *Macrobrachium amazonicum* (Heller, 1862) on the banks of the Guamá River.

3 Results and Discussion

We collected 4,830 individuals of *M. amazonicum*, of which 54 (8 males and 46 females) showed morphological anomalies, corresponding to 1.12% of the total samples. Among the abnormal specimens, the females were predominant, with the sex ratio of 1M:5.75F. In natural Amazonian populations, several studies have indicated that females are more abundant than males, reaching up to 85% of inland water populations (ODINETZ-COLLART, 1887; GARCÍA-DÁVILA et al., 2000; MONTOYA, 2003; COSTA; MATOS; MACHADO, 2016); this observation may justify a higher prevalence of anomalies in females of *M. amazonicum* in the Guamá River. The analysis of the temporal distribution of the occurrences of morphological anomalies revealed that the records were not continuous throughout the sampled years, showing the highest incidence of abnormal females in August 2023; while the abnormal males were more abundant in July 2024 and August 2025 (Figure 2).

Along the sampled months, a low incidence of these anomalies in the Guamá River was observed (between one and two individuals). Similar results were observed by Martins et al. (2022) and Calandrini et al. (2025), which indicated that specific events of environmental impact (sewage or chemical compounds) may be associated with a high prevalence of anomalies in the population.

In studies developed by Fransozo et al. (2012), the authors observed external anomalies in crabs *Callinectes ornatus* (Ordway, 1863), *Arenaeus cribrarius* (Lamarck, 1818) and *Leurocyclus tuberculatus* (H. Milne Edwards & Lucas, 1843), from the state of São Paulo, which indicated that morphological anomalies may be associated with highly impacted environments.

Additionally, Silva and Shinozaki-Mendes (2018) analyzed abnormalities in *Minuca rapax* (Smith, 1870), with one male specimen showing bilateral hypertrophy.

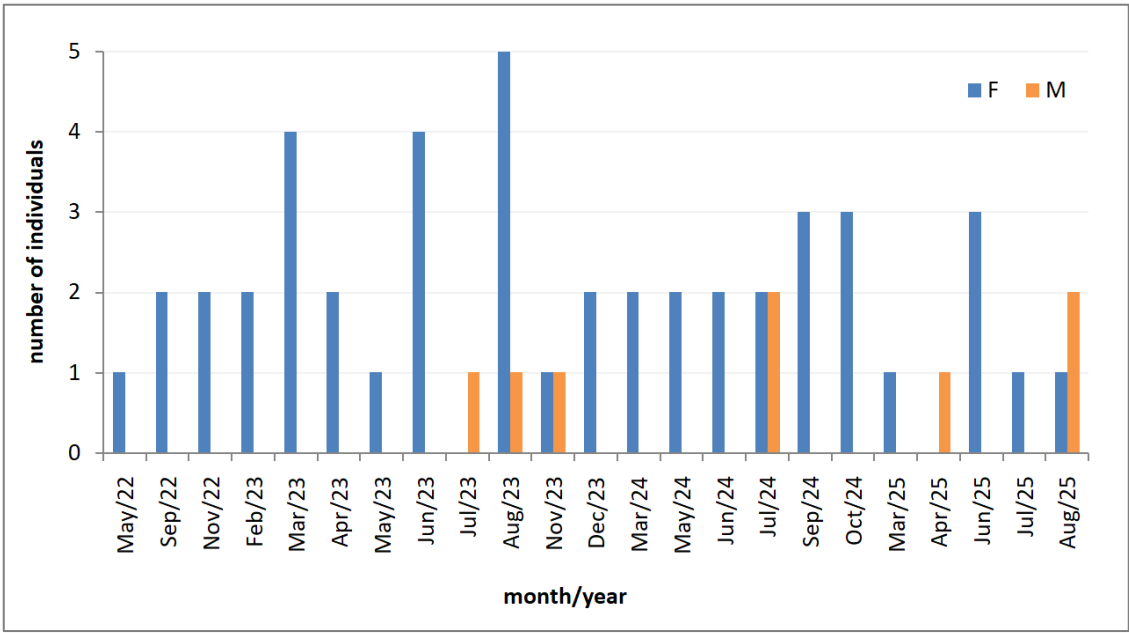


Figure 2. Occurrence of morphological anomalies in *Macrobrachium amazonicum* (Heller, 1862), collected between 2022 and 2025, in the Guamá River, Belém metropolitan area, Pará.

Low incidences of these anomalies have been reported in several studies (AGUIRRE; HENDRICKX, 2005; GREGATI; NEGREIROS-FRANSOZO, 2009; ALVES-JÚNIOR et al., 2018), which suggested that these anomalies may be associated with specific factors (e.g. nutritional, genetic changes or bacteriological/viral presence) and physicochemical changes in water, affecting some individuals in the population.

Biometric analysis of anomalous specimens of *M. amazonicum* revealed differences between the sexes (Table 1). The females showed higher mean values across all variables (TL: 63.6 mm, CL: 29.5 mm and WW: 2.32 g), while the males showed lower mean values (TL: 52.8 mm, CL: 22.5 mm and WW: 15.2 g), all variables including mean and standard deviation, are placed in Table 1.

The larger body size of females is consistent with observations already reported for Palaemonidae, a pattern related to reproductive biology, especially the need for greater body volume to accommodate egg development and incubation (MULLER et al., 1996; PASCHOAL; GUIMARÃES; COUTO, 2013).

However, other studies on *M. amazonicum* reported opposite results, showing that males reach greater lengths, especially in adults, with similar growth observed in both sexes only until they reach sexual maturity (SILVA; SOUZA; CINTRA, 2002; FLEXA; SILVA; CINTRA, 2005; SILVA; FRÉDOU; ROSA FILHO, 2007; COSTA et al., 2016).

Table 1. Total length (TL), carapace length (CL) and wet weight (WW) per sexes, including minimum (Min.), maximum (Max.) mean, median and standard deviation (Stand. Dev.) of anomalous specimens of *Macrobrachium amazonicum* (Heller, 1862) collected in the Guamá River (Belém-PA) between 2022 and 2025.

Variables	Sex	Min.	Max.	Mean	Median	Stand. Dev.
TL (mm)	Males	37.4	68.6	52.8	51.3	1.17
	Females	42.5	92.0	63.6	64.2	1.06
CL (mm)	Males	15.3	34.5	22.5	21.8	0.63
	Females	17.1	47.0	29.5	29.6	0.68
WW (g)	Males	0.45	3.8	1.52	1.43	1.05
	Females	0.61	4.99	2.32	2.15	1.00

These sexual differences may reflect adaptive strategies related to survival and reproductive success, since males and females allocate energy differently between growth, reproduction, and physiological maintenance. In addition, the type of environment, such as freshwater (lotic or lentic) or estuarine areas, may influence the relative growth of the species, which may indicate fluctuations in size due to the natural environment or anthropogenic impacts in the region (ODINETZ-COLLART; 1988, 1991; ODINETZ-COLLART; MOREIRA, 1993; RODRIGUES et al., 2025).

We observed morphological anomalies in two body regions: the rostrum and the telson. Most occurrences were identified in the rostrum, accounting for 68.5% of all anomalies (Figure 3A-I), while the telson was anomalous in 31.5% of the specimens analyzed (Figure 4A-I). No specimens presented anomalies in both structures.

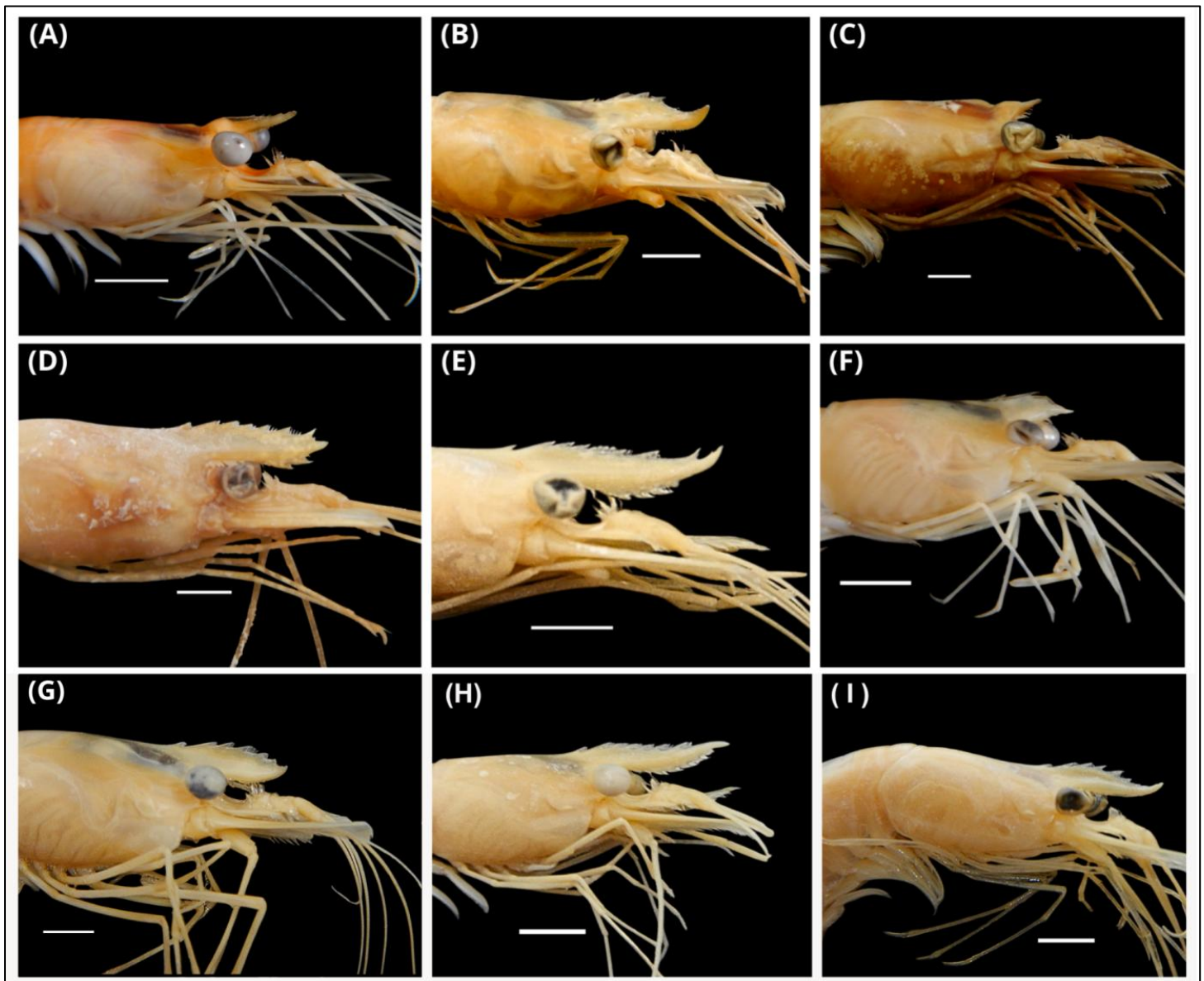


Figure 3.(A-I) - Records of rostral anomalies in Amazon river prawn *Macrobrachium amazonicum* (Heller, 1862), collected in the Guamá River (Belém-PA), between 2022 and 2025. Scale bar = 5 mm.

The occurrence of morphological deformities in crustaceans is a relatively undocumented phenomenon in Amazonian freshwater environments. For *M. amazonicum*, especially in Northern Brazil, there are only two recent studies describing morphological abnormalities (MARTINS et al., 2022; CALANDRINI et al., 2025). Martins et al. (2022) provided the first description of abnormalities from this species, indicating body changes in three specimens from the low Tocantins River (Cametá, state of Pará). Their specimens showed a short rostrum with strong curvature and changes in rostral spines, in addition to the first descriptions of the bifid telson for the species.

Recently, Calandrini et al. (2025) reported 20 anomalous specimens (corresponding to 0.9% of the total sampled), showing a large variation in the rostrum shape, from the Xingu River (also state of Pará), the authors observed a reduction in rostrum length and a decrease in the number of rostral teeth (covering 1-7 in superior margin and 1-5 in ventral margin).

Both studies mentioned above emphasize that these deformities may be associated with environmental impacts or genetic/nutritional alterations; however, further studies are needed to understand their origin.

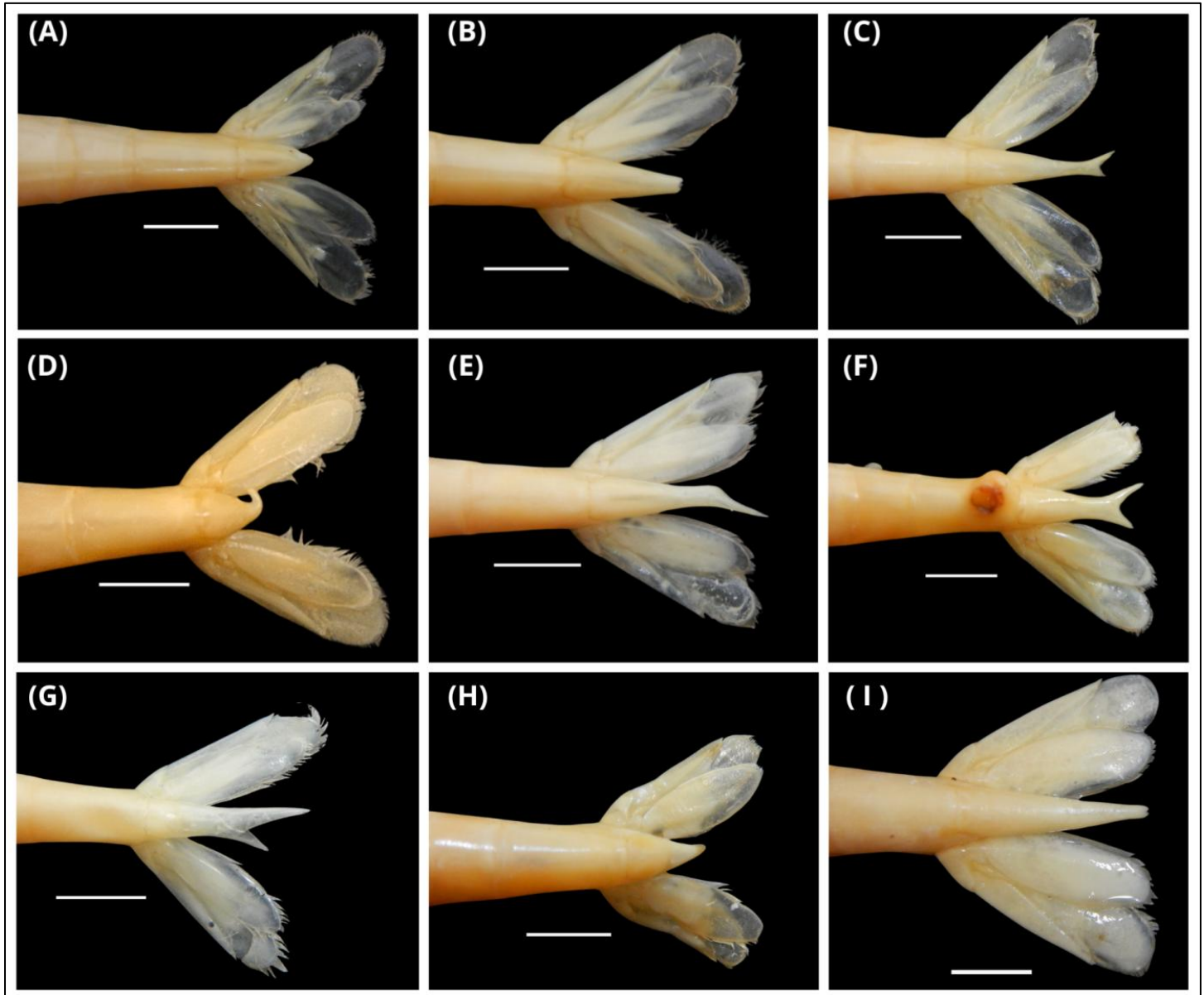


Figure 4. (A-I) - Records of telson anomalies in Amazon river prawn *Macrobrachium amazonicum* (Heller, 1862), collected in the Guamá River (Belém-PA), between 2022 and 2025. Scale bar = 5 mm.

Anomalies are commonly reported in estuarine and marine (including deep-sea) caridean shrimps; these observations usually include a shortened rostrum with strong curvature, absence or reduction in the number of spines, and a bifid telson or one that is strongly curved to the side (SIVAGAM; RAO, 1968; SAKAEW et al., 2008; ALVES-JÚNIOR et al., 2018).

According to Melo (2003), the Amazon river prawn *M. amazonicum* has a long and slender rostrum, surpassing the scaphocerite, with the middle portion curved upward; containing 9 to 13 dorsal spines and 8 to 10 in ventral margin.

In our specimens, all anomalous shrimps presented a shortened rostrum, with reduced number of spines (ranging from 1-7 dorsal spines and 1-5 ventral spines), or without spines in some specimens (see Fig. 3A and C). These morphological changes may compromise their survival in the natural environment, as the animals have reduced or absent defenses against predators (BENETTI; NEGREIROS-FRANZOZO, 2003; GREGATI; NEGREIROS-FRANZOZO, 2009; PINHEIRO; TOLEDO, 2009; WAKIDA-KUSUNOKI et al., 2020). Normal specimens of *M. amazonicum* have a conical telson, with the posterior margin ending in an acute median point, surrounded by four spines (two long and two reduced) and two pairs of dorsal spines (MELO, 2003).

Nonetheless, most of our individuals showed a bifid telson, with some specimens presenting curved forms or absence of telson tip (see Fig. 4). These modifications reduce the protective function against predators and also compromise swimming mobility (AYUB; AHMED, 2004; ALVES-JÚNIOR et al., 2018; MARTINS et al., 2022).

4 Conclusions

In conclusion, our results reveal a continual yet reduced presence of morphological abnormalities in *M. amazonicum* collected from the Guamá River (54 individuals, 1.12% of the total sampled), showing a high range of rostrum and telson shape forms. Despite the environmental degradation observed in the Guamá River, these morphological anomalies may also be related to nutritional or genetic factors, as well as to the presence of microorganisms (fungi, bacteria, and viruses) that could have a negative effect on the shrimp morphology. In this scenario, we expanded knowledge about anomalies in shrimp in northern Brazil, highlighting the need for further studies to identify the causes of the morphological anomalies reported for Amazon river prawn *M. amazonicum*, and how anthropogenic actions are impacting aquatic populations along the urbanized areas of the Guamá River.

CREDIT AUTHORSHIP CONTRIBUTION STATEMENT

Conceptualization: R.L.B., D.E.G.M., G.F.S.V., I.H.A.C. and F.A.A.J. Research, development and writing: R.L.B., D.E.G.M., I.H.A.C. and F.A.A.J. Sample Analysis: R.L.B., D.E.G.M. and F.A.A.J. Map and images development: R.L.B. and D.E.G.M. Review: D.E.G.M., G.F.S.V., and F.A.A.J. Review and correction: D.E.G.M. and F.A.A.J. Translation to English: D.E.G.M and F.A.A.J.

DECLARATION OF INTEREST

The authors disclose that they have no known competing financial interests or personal relationships that could have appeared to influence the study reported in this manuscript.

FUNDING SOURCE

The author Israel Cintra has the productivity grant award, reference number: 304401/2025-0 by the *Conselho Nacional de Desenvolvimento Científico e Tecnológico* - CNPq (Brasil).

ACKNOWLEDGEMENTS

The authors would like to thank the *Centro Nacional de Pesquisa e Conservação da Biodiversidade Marinha do Norte, Instituto Chico Mendes de Conservação da Biodiversidade* (CEPNOR/ICMBIO) for the support in the laboratory. Additionally, we would like to thank the anonymous reviewers for all comments throughout the manuscript.

REFERENCES

- AGUIRRE, H.; HENDRICKX, M. E. Abnormal rostrum and telson in two species of penaeid shrimp (Decapoda, Dendrobranchiata, Penaeidae) from the Pacific coast of Mexico. *Crustaceana*, v. 78, n. 1, p. 113-119, 2005. Available from: <https://doi.org/10.1163/1568540054024501>
- ALCÂNTARA, G.D.L.C.; KATO, H.C.A. Good handling practices of fresh shrimp sold in street fairs of Belém, PA, Brazil. *Journal of Bioenergy and Food Science*, v. 3, p. 139-148, 2016. Available from: <https://doi.org/10.18067/jbfs.v3i3.98>
- ALVES-JÚNIOR, F.A.; NEUMANN-LEITÃO, S.; ARAÚJO, M.S.L.C.; SOUZA-FILHO, J.F. An anomalous specimen of the deep-sea shrimp *Glyphocrangon aculeata* A. Milne-Edwards, 1881 (Decapoda, Caridea) from the South Atlantic Ocean. *Crustaceana*, v. 91, n. 11, p. 1381-1387, 2018. Available from: <https://doi.org/10.1163/15685403-00003845>
- AYUB, Z.; AHMED, M. Study on the host-parasite relationship of *Parapenaeopsis stylifera* (H. Milne Edwards) (Decapoda: Penaeidae) and *Parapenaeon japonica* (Thielemann); (Isopoda: Bopyridae). *Hydrobiologia*, v. 523, p. 225-228, 2004. Available from: <https://doi.org/10.1023/B:HYDR.0000033140.45174.ce>
- BENETTI, A.S.; NEGREIROS-FRANZOZO, M.L. Symmetric chelipeds in males of the fiddler crab *Uca burgersi* Holthuis, 1967 (Decapoda, Brachyura, Ocypodidae). *Nauplius*, v. 11, n. 2, p. 141-144, 2003. Available from: <https://crustacea.org.br/wpcontent/uploads/2014/02/nauplius-v11n2a10.BenettiNegreiros-Fransozo.pdf>. Accessed on: 08 Nov. 2025.
- CALANDRINI, G.S.M.; ROCHA, Y.A.S.; LIMA, P.J.C.M.; MACHADO, F.S.; FREITAS, D.T.H.; ALVES-JÚNIOR, F.A. Records of rostral anomalies in *Macrobrachium amazonicum* (Heller, 1862) (Decapoda: Palaemonidae) collected along the Great Amazon River Basin. *Environmental Smoke*, v. 8, p. 1-7, 2025. Available from: <https://doi.org/10.32435/envsmoke-2025-0001>

CAMPOS-CAMPOS, N.H.; DUEÑAS-RAMÍREZ, P.R.; GENES, N. Malformación en cangrejos de la superfamilia Xanthoidea (Crustacea: Brachyura) en la bahía de Cispatá (Córdoba, Colombia). *Revista de la Academia Colombiana de Ciencias Exactas, Físicas y Naturales*, v. 39, n. 150, p. 91-99, 2015. Available from: <https://doi.org/10.18257/raccefyn.172>

CARDENAS-CAMACHO, J.; GONZÁLEZ-REINA, A.E.; VELASCO-SANTAMARÍA, Y.M. Identificación de biomarcadores en camarones expuestos a hidrocarburos aromáticos policíclicos. *Caldasia*, v. 46, n. 3, p. 502-516, 2024. Available from: <https://doi.org/10.15446/caldasia.v46n3.99553>

COSTA, D.A.D.S.; MARTINS, J.C.; SILVA, K.C.D.A.; KLAUTAU, A.G.C.D.M.; CINTRA, I.H.A. Selectivity of matapi used in catching *Macrobrachium amazonicum* in the lower Rio Tocantins, Amazon, Brazil. *Boletim do Instituto de Pesca*, v. 42, n. 2, p. 403-417, 2016. Available from: <https://doi.org/10.20950/1678-2305.2016v42n2p403>

COSTA, T.V.; MATTOS, L.A.; MACHADO, N.J.B. Estrutura populacional de *Macrobrachium amazonicum* em dois lagos de várzea da Amazônia. *Boletim do Instituto de Pesca*, v. 42, n. 2, p. 281-293, 2016. Available from: <https://doi.org/10.20950/1678-2305.2016v42n2p281>

FLEXA, C.E.; SILVA, K.C.A.; CINTRA, I.H.A. Morfometria do camarão-canela, *Macrobrachium amazonicum* (Heller, 1862), no município de Cametá-Pará. *Boletim Técnico-Científico do Cepnor*, v. 5, n. 1, p. 41-54, 2005. Available from: https://www.researchgate.net/publication/276332366_MORFOMETRIA_DO_CAMARAO-CANELA_Macrobrachium_amazonicumHELLER_1862_NO_MUNICIPIO_DE_CAMETA_-_PARA. Available from: 30 Oct. 2025.

FRANSOZO, A.; TEIXEIRA, G.M.; GOMES, R. R.; SILVA, J. C.; BOLLA JUNIOR, E.A. Ocorrência de anormalidades morfológicas externas em caranguejos marinhos (Decapoda, Brachyura) no litoral norte do Estado de São Paulo. *Acta Scientiarum. Biological Sciences. Maringá*, v. 34, n. 1, p. 101-104, 2012. Available from: <https://doi.org/10.4025/actasciobiolsci.v34i1.8618>

GARCÍA-DÁVILA, C.R.; ALCANTÁRA, B.F.; VASQUEZ, R.E.; CHUJANDAMA, S.M. Biología reproductiva do camarão *Macrobrachium brasiliense* (Heller, 1862) (Crustacea: Decapoda: Palaemonidae). *Acta Amazônica*, v. 30, n. 4, p. 653-664, 2000. Available from: <https://doi.org/10.1590/1809-43922000304664>

GREGATI, R.A.; NEGREIROS-FRANSOZO, M.L. Occurrence of shell disease and carapace abnormalities on natural population of *Neohelice granulata* (Crustacea: Varunidae) from a tropical mangrove forest, Brazil. *Marine Biodiversity Records*, v. 2, p. e60, 2009. Available from: <https://doi.org/10.1017/S1755267209000839>

HOLTHUIS, L.B. A general revision of the Palaemonidae (Crustacea Decapoda Natantia) of the Americas. II. The subfamily Palaemoninae. Occasional Paper number 12. Allan Hancock Foundations Publications, 396p, 1952. Available from: <https://decapoda.nhm.org/pdfs/25763/25763.pdf>. Accessed on: 14 Nov 2025.

LOPES, M.J.N.; SILVA, M.S.R.; SAMPAIO, R.T.M.; BELMONT, E.L.L.; SANTOS-NETO, C.R. Avaliação preliminar da qualidade da água de bacias hidrográficas de Manaus utilizando macroinvertebrados como bioindicadores. *SaBios-Revista de Saúde e Biologia*, v. 3, n. 2, 2008. Available from: <https://revista2.grupointegrado.br/revista/index.php/sabios/article/view/96>. Accessed on: 02 Nov 2025.

LIMA, I.F.; LIMA, A.M.M.; KUBOTA, N.A. Voçorocas em áreas de mineração como componente da paisagem da bacia hidrográfica do rio Guamá, Amazônia oriental. *Revista Geonorte*, v. 12, n. 39, p. 149-169, 2021. Available from: <https://doi.org/10.21170/geonorte.2021.V.12.N.39.149.169>

MACIEL, C.R.; VALENTI, W.C. Biology, fisheries, and aquaculture of the amazon river prawn *Macrobrachium amazonicum*: a review. *Nauplius*, v. 17, n. 2, p. 61-79, 2009. Available from: <https://www.crustacea.org.br/wp-content/uploads/2014/02/naupliusv17n2a01.MacielValenti.pdf>. Accessed on: 16 Oct 2025.

MAGALHÃES, C. Abbreviated development of *Macrobrachium jelskii* (Miers, 1977) (Crustacea: Decapoda: Palaemonidae) from the Rio Solimões floodplain, Brazil reared in the laboratory. *Nauplius*, v. 8, n. 1, p. 1-14, 2000. Available from: <https://crustacea.org.br/wpcontent/uploads/2014/02/nauplius-v08n1a01.Magalhaes.pdf>. Accessed on: 22 Oct 2025.

MANTELATTO, F.L.M.; AVELAR, W.E.P.; SILVA, D.M.L.; TOMAZELLI, A.C.; LOPEZ, J.L.C.; SHUHAMA, T. Heavy metals in the shrimp *Xiphopenaeus kroyeri* (Heller, 1862) (Crustacea, Penaeidae) from Ubatuba Bay, São Paulo, Brazil. *Bulletin of Environmental Contamination and Toxicology*, v. 62, n. 2, p. 152-159, 1999. Available from: <https://doi.org/10.1007/s001289900854>

MARQUES, M.B.L.; AMÉRICO-PINHEIRO, J.H.P. Ocorrência de clorpirifós em ambientes aquáticos e seus efeitos ecotoxicológicos em bioindicadores. *Revista Nacional de Gerenciamento de Cidades*, v. 8, n. 65, 2020. Available from: <https://doi.org/10.17271/2318847286520202734>

MARTINS, D.E.G.; SILVA, K.C.A.; KLAUTAU, A.G.C.M.; CINTRA, I.H.A.; ALVES-JÚNIOR, F.A. Report of morphological abnormalities in *Macrobrachium amazonicum* (Heller, 1862) (Caridea, Palaemonidae) from the Brazilian Amazon province, *Crustaceana*, v. 95, n.4, p.497-504, 2022. Available from: <https://doi.org/10.1163/15685403-bja10197>

MELO, G.A.S. *Manual de identificação dos Crustacea Decapoda de água doce do Brasil*. São Paulo, Editora Loyola, Museu de Zoologia, Universidade de São Paulo - USP, 429p, 2003. Available from: <https://repositorio.usp.br/item/000921427>. Accessed on: 17 Oct 2025.

MONTOYA, J.V. Freshwater shrimps of the Genus *Macrobrachium* Associated with roots of *Eichhornia crassipes* (Water Hyacinth) in the Orinoco Delta (Venezuela). *Caribbean Journal of Science*, v. 39, n. 1, p. 155-159, 2003. Available from: <https://www.semanticscholar.org/paper/Freshwater-Shrimps-of-the-Genus-Macrobrachium-with-Montoya/32ed9605188443bb1063f7224d1733cfed32a6ff>. Accessed on: 12 Oct 2025.

MULLER, Y.M.R.; NAZARI, E.M.; BRESSAN, C.; AMMAR, D. Aspectos da reprodução de *Palaemon pandaliformis* (Stimpson) (Decapoda, Palaemonidae) no Manguezal de Ratoes, Florianópolis, Santa Catarina. *Revista Brasileira de Zoologia*, v. 13, n. 3, p. 633-642, 1996. Available from: <https://doi.org/10.1590/S0101-81751996000300013>

ODINETZ-COLLART, O. La pêche crevettière de *Macrobrachium amazonicum* (Palaemonidae) dans le Bas Tocantins, après la fermeture du barrage de Tucuruí (Brésil). *Revista de Hydrobiologia Tropical*, v. 20, n. 2, p. 134-144, 1987. Available from: https://horizon.documentation.ird.fr/exl-doc/pleins_textes/cahiers/hydrob-trop/25176.pdf. Accessed on: 18 Oct 2025.

ODINETZ-COLLART, O. Aspectos ecológicos do camarão *Macrobrachium amazonicum* (Heller, 1862) no Baixo Tocantins (PA-Brasil). *Memória Sociedad de Ciencias Naturales La Salle*, v. 48, p. 341-353, 1988. Available from: <https://files.core.ac.uk/download/pdf/39867962.pdf>. Accessed on: 14 Oct 2025.

ODINETZ COLLART, O. Tucuruí dam and the populations of the prawn *Macrobrachium amazonicum* in the Lower Tocantins (Pa-Brazil): a four years study. *Archive für*

Hidrobiologie, v. 122, p. 213-228. 1991. Available from: <https://doi.org/10.1127/archiv-hydrobiol/122/1991/213>

ODINETZ-COLLART, O.; MOREIRA, L.C. Potencial Pesqueiro do camarão *Macrobrachium* na Amazônia Central (Ilha do Careiro). *Amazoniana*, Manaus-AM, v. 12, n. 4, p. 399-413, 1993. Available from: https://horizon.documentation.ird.fr/exl-doc/pleins_textes/pleins_textes_6/b_fdi_35-36/40804.pdf. Accessed on: 04 Oct 2025.

PAIVA, R.; ESKINAZI-LEÇA, E.; PASSAVANTE, J.Z.O.; SILVA-CUNHA, M.G.G.; MELO, N.F. Considerações ecológicas sobre o fitoplâncton da baía do Guajará e foz do rio Guamá (Pará, Brasil). *Boletim Do Museu Paraense Emílio Goeldi - Ciências Naturais*, v. 1, n. 2, p. 133-146, 2006. Available from: <https://doi.org/10.46357/bcnaturais.v1i2.748>

PASCHOAL, L.R.P.; GUIMARÃES, F.J.; COUTO, E.C.G. Relative growth and sexual maturity of the freshwater shrimp *Palaemon pandaliformis* (Crustacea, Palaemonidae) in northeastern of Brazil (Canavieiras, Bahia). *Iheringia, Série Zoologia*, v. 103, n. 1, p.31-36, 2013. Available from: <https://doi.org/10.1590/S0073-47212013000100004>

PINHEIRO, M.A.A.; TOLEDO, T.R. Malformation in the crab *Ucides cordatus* (Linnaeus, 1763) (Crustacea, Brachyura, Ocypodidae), in São Vicente, State of São Paulo, Brazil. *Revista CEPSUL - Biodiversidade e Conservação Marinha*, v. 1, n. 1, p. 1-5, 2009. Available from: <https://doi.org/10.37002/revistacepsul.vol1.29961-65>

RAJKUMAR, M.; SARAVANAN, R.; MAHESWARUDU, G.; NAZAR, A.K.A. A record of a bifid rostrum in the penaeid shrimp *Parapenaeopsis hardwickii* (Miers, 1878) (Decapoda, Penaeidae) from Palk Bay, Tamil Nadu, India. *Crustaceana*, v.89, n.14, p.1733-1737. 2016. Available from: <https://doi.org/10.1163/15685403-00003603>

ROCHA, N.C.V.; LIMA, A.M.M. Water sustainability of the Guamá river basin, Eastern Amazonia/Brazil. *Sociedade e Natureza*, v. 32, p. 141-160, 2020. Available from: <https://doi.org/10.14393/sn-v32-2020-45694>

RODRIGUES, L.S.; SILVA, T.A.; MUNIZ, J.L.; FREIRE, F.A.M.; PINHEIRO, A.P.; MORAES, S.A.S.N.; ALENCAR, C.E.R. *Macrobrachium amazonicum* (Decapoda, Palaemonidae): geographic distribution, new occurrences and biogeographic insights. *Aquatic Biology*, v. 34, p. 15-26, 2025. Available from: <https://doi.org/10.3354/ab00772>

SANTOS, L.F.; MARINHO, E.R.; ANDRADE, M.F.D.S.; CARNEIRO, B.S.; FAIAL, K.D. C.F. Avaliação da qualidade

da água da baía do Guajará em Belém/PA. *Revista Ibero-Americana de Ciências Ambientais*, v. 11, n. 2, p.367-380, 2020. Available from: <https://doi.org/10.6008/CBPC2179-6858.2020.002.0034>

SANTOS, J.S.; ROCHA, E.J.P.; JUNIOR, J.A.S.; SANTOS, J.S.S.; SANTOS, F.A.A. Climatologia da Amazônia Oriental: Uso de prognósticos climáticos como ferramenta de prevenção de ameaças naturais. *Revista Brasileira de Geografia Física*, v. 12, n. 05, p.1853-1871, 2019. Available from: <https://doi.org/10.26848/rbgf.v12.5.p1853-1871>

SANTOS, M.L.S.; HOLANDA, P.; PEREIRA, I.; RODRIGUES, S.; PEREIRA, J.A.R.; MESQUITA, K. Influência das condições da maré na qualidade de água do rio Guamá e baía do Guajará. *Boletim Técnico Científico do CEPNOR*, Belém, v.14, n.1, p.17-25, 2014. Available from: https://www-periodicos-capes.gov.br/ez3.periodicos.capes.gov.br/index.php/acervo/busca_dor.html?task=detalhes&source=all&id=W2954053257. Accessed on: 30 Oct. 2025.

SAKAEW, W.; PRATOOMTHAI, B.; ANANTASOMBOM, G.; ASUVAPONGPATANA, S.; SRIURAIRATTANA, S.; WINTHYACHUMNARNKUL, B. Abdominal segment deformity disease (ASDD) of the white leg shrimp *Penaeus vannamei* reared in Thailand. *Aquaculture*, v. 284, n. 1, p. 46-52, 2008. Available from: <https://doi.org/10.1016/j.aquaculture.2008.07.041>

SCELZO, M. Efecto del EDTA (Acido Etilendiamino tetracético) sobre desoves y larvas del camarón *Artemesia longinaris* (Crustacea, Decapoda, Penaeidae). *Frente Marítimo*, v. 17, p. 115-120, 1998. Available from: <https://ctmfm.org/upload/archivoSeccion/scelzo142616781810.pdf>. Accessed on: 03 Oct 2025.

SILVA, F.N.L.; SILVA, F.R.; MANGAS, T.P.; OLIVEIRA, L.C.; MACEDO, A.R.G.; MEDEIROS, L.R.; CORDEIRO, C.A.M. O comércio do camarão-da-Amazônia (*Macrobrachium amazonicum*) na cidade de Breves-Pará-Brasil. *Pubvet*, v. 11, n. 4, p. 313-423, 2017. Available from: <https://doi.org/10.22256/PUBVET.V11N4.320-326>

SIVAGAM, D.; RAO, P.V. A case of abnormal petasma in the penaeid prawn, *Metapenaeus affinis* (H. Milne-Edwards). *Journal of the Marine Biological Association of India*, v. 10, n. 2, p. 386-387, 1968. Available from: https://eprints.cmfri.org.in/1731/1/Sivalingam_386-387.pdf. Accessed on: 05 Oct. 2025.

SILVA-JÚNIOR, J.A.; COSTA, A.C.L.; PEZZUTI, J.C.B.; COSTA, R.F.; GALBRAITH, D. Análises do conforto térmico em uma cidade de grande porte na Região Amazônica: O Caso de Belém, Pará. *Revista Brasileira de Geografia Física*, v. 2, p. 218-232, 2012. Available from: <https://doi.org/10.26848/rbgf.v5i2.232777>

SILVA, K.C.A.; SOUZA, R.A.L.; CINTRA, I.H.A. Camarão-cascudo *Macrobrachium amazonicum* (Heller, 1862) (Crustacea, Decapoda, Palaemonidae) no município de Vigia-Pará-Brasil. *Boletim Técnico-Científico do Cpnor*, v. 2, p. 41-73, 2002. Available from: https://scholar.google.com/citations?view_op=view_citation&hl=en&user=194OG1EAAAJ&citation_for_view=194OG1EAAAJ:xtRiw3GOFMkC. Accessed on: 07 Oct 2025.

SILVA, L.N.; SHINOZAKI-MENDES, R.A. A case of bilateral hypertrophy in the chelae of a male specimen of *Minuca rapax* (Smith, 1870) (Decapoda, Brachyura, Ocypodidae). *Nauplius*, v. 26, p. e2018032. 2018. Available from: <https://doi.org/10.1590/2358-2936e2018032>

SILVA, M.C.N.; FRÉDOU, F.L.; ROSA-FILHO, J.S. Estudo do crescimento do camarão *Macrobrachium amazonicum* (Heller, 1862) da Ilha de Combú, Belém, Estado do Pará. *Amazônia, Ciência & Desenvolvimento*, v. 2, n. 4, p. 85-104, 2007. Available from: https://www.researchgate.net/publication/228734514_Estudo_do_crescimento_do_camarao_Macrobrachium_amazonicum_Heller_1862_da_Ilha_de_Combu_Belem_Estado_do_Para. Accessed on: 10 Oct 2025.

WAKIDA-KUSUNOKI, T.A.; CRUZ-SÁNCHEZ, J.L.; MAY-KÚ, M.A.; ARDISSON, P.L. An abnormal rostrum in a wild subadult shrimp *Farfantepenaeus duorarum* (Burkeroad, 1939) (Decapoda, Penaeidae), from the southern Gulf of Mexico. *Crustaceana*, v. 93, n. 9-10, p. 989-997, 2020. Available from: <https://doi.org/10.1163/15685403-bja10043>