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**Invertebrados aquáticos: biodiversidade, interações e
funções nos ecossistemas da Amazônia**

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Ciências Naturais



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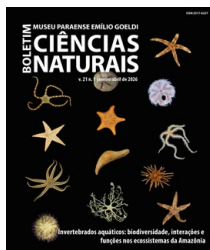


IMAGEM DA CAPA
Equinodermos da Coleção
de Invertebrados do
Museu Paraense Emílio
Goeldi, Belém, Pará, Brasil.
Autor: Costa et al. (2026).

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CARTA DOS EDITORES

O primeiro número de 2026 do **Boletim do Museu Paraense Emílio Goeldi. Ciências Naturais** traz o resultado da chamada especial para recebimento de artigos sobre “Invertebrados aquáticos: biodiversidade, interações e funções nos ecossistemas da Amazônia”. Oito artigos científicos foram aprovados para publicação nesta edição especial. A edição temática apresenta informações inéditas e relevantes a respeito da taxonomia, da biogeografia e da ecologia de populações e comunidades de invertebrados, abrangendo estudos realizados em ambientes dulcícolas, estuarinos e marinhos da região amazônica.

O primeiro artigo, de autoria de Magalhães e colaboradores, descreve e ilustra uma nova espécie de caranguejo do gênero *Kingsleya* Ortmann, 1897 (família Pseudoscorpionidae), com ocorrência na bacia superior do rio Essequibo, na Guiana. A nova espécie (*Kingsleya marthacamposae*) foi confirmada por meio de uma abordagem integrada, combinando evidências morfológicas e moleculares contextualizadas filogeneticamente.

O segundo artigo, de autoria de Costa e colaboradores, apresenta um inventário de Echinodermata para a região Norte do Brasil, baseado no levantamento de espécimes do acervo do Museu Paraense Emílio Goeldi. Um total de 32 espécies, incluindo 15 novos registros para a Amazônia, é apresentado. Os registros abrangem uma variedade de *habitats*, que vão desde a zona entremarés de praias arenosas até o Grande Sistema Recifal da Amazônia. Além da lista taxonômica, o artigo fornece imagens de todas as espécies identificadas, notas ecológicas e dados biogeográficos.

Ainda com foco na taxonomia, Santos e Ramos apresentam *Perissocytheridea materterrae* sp. nov., uma nova espécie de Ostracoda da família Cytheridae, típica de águas salobras. A descrição foi baseada em espécimes coletados na zona entremarés da ilha de Algodão, no nordeste do Pará. Os autores apresentam uma diagnose detalhada da carapaça e dos apêndices corporais de machos, fêmeas e juvenis, utilizando imagens obtidas por microscopia óptica e eletrônica de varredura. O estudo destaca-se por fornecer um dos poucos registros de espécimes vivos de *Perissocytheridea* para a região Neotropical.

Em outro estudo sobre coleções biológicas, Almeida e colaboradores detalham a estrutura e a diversidade taxonômica da Coleção de Invertebrados Marinhos da Universidade Federal do Pará (CZIM-UFPA). Os resultados revelaram o potencial do acervo como base para investigações sobre a biodiversidade marinha regional. Os autores destacam, ainda, o papel da coleção como ferramenta didática na educação básica e superior, além de sua contribuição para projetos de extensão universitária e ações de popularização das ciências do mar na Amazônia.

No quinto artigo, Santos e colaboradores apresentam uma revisão sistemática da biodiversidade bentônica na plataforma continental e no talude da Margem Continental Equatorial do Brasil, abrangendo os estados do Maranhão, do Pará e do Amapá. Com base em estudos científicos publicados entre 1986 e 2024, o trabalho compila um total de 498 espécies bentônicas entre os componentes do fitobentos e do zoobentos para a região. Por meio de uma abordagem cienciométrica, os autores analisam as tendências do progresso científico na região amazônica, destacando lacunas de conhecimento e áreas prioritárias para pesquisa e conservação.

O estudo conduzido por Neves Neto e colaboradores avalia a influência da vegetação de *Spartina alterniflora* Loisel. sobre a comunidade de caranguejos braquiúros em uma praia arenosa do estado do Pará. Utilizando análises estatísticas, os autores avaliaram a relação entre os atributos da vegetação e a abundância, a riqueza e a densidade de tocas dos organismos. Os resultados revelam que a distribuição dos caranguejos é influenciada pela complexidade da vegetação, reiterando o papel ecológico das marismas na manutenção da biodiversidade costeira.

No sétimo artigo, de autoria de Ferreira-Ramos e colaboradores, foi avaliada a influência do cultivo de ostras *Crassostrea gasar* (Dautzenberg, 1891) sobre a estrutura da comunidade meiofaunística, composta por metazoários que habitam os interstícios dos sedimentos aquáticos. O estudo foi desenvolvido no estuário do rio Curuçá, no nordeste paraense. Efeitos sutis do cultivo de ostras foram identificados sobre a meiofauna, com respostas seletivas de alguns táxons. Os resultados mostram o potencial uso da meiofauna como indicadora dos impactos da aquicultura nos estuários amazônicos.

No último artigo deste número especial, Gadelha e colaboradores apresentam um levantamento taxonômico da comunidade zooplancônica em ambientes aquáticos da região de Parintins, no estado do Amazonas, na margem direita do rio Amazonas. As amostragens ocorreram durante os períodos chuvoso e seco, resultando na identificação de pelo menos 118 espécies. A maior riqueza de táxons ocorreu em ambientes lênticos e durante o período seco. Setenta e nove táxons representam registros inéditos para a região do baixo Amazonas, destacando a importância dos inventários taxonômicos em áreas ainda pouco exploradas da Amazônia.

Encerrando esta nota editorial, expressamos nossos sinceros agradecimentos aos avaliadores de diversas instituições do Brasil pela dedicação na revisão dos artigos publicados nesta edição, bem como a Diana Gomes Lopes, Júlia Modesto, Rafael Lima e Talita do Vale, pelo profissionalismo e empenho dedicados ao trabalho de editoração.

Cleverson Rannieri Meira dos Santos, Daiane Aviz & Ewertton Souza Gadelha
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CARTA DO EDITOR
EDITOR'S NOTE

DOSSIÊ INVERTEBRADOS AQUÁTICOS: BIODIVERSIDADE, INTERAÇÕES E FUNÇÕES NOS ECOSISTEMAS DA AMAZÔNIA

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Resposta da meiofauna bentônica à criação de ostras-do-mangue (*Crassostrea gasar*) em um estuário amazônico

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Zooplankton diversity in freshwater environments of Parintins, Amazonas, Brazil

Diversidade do zooplâncton em ambientes de água doce de Parintins, Amazonas, Brasil

Ewertton Souza Gadelha | João Marcos Souza Coêlho | Mayara Ribeiro Casartelli |

Elton Augusto Lehmkuhl | Angela Maria da Silva-Lehmkuhl



DOSSIÊ
INVERTEBRADOS AQUÁTICOS:
BIODIVERSIDADE, INTERAÇÕES E FUNÇÕES NOS
ECOSSISTEMAS DA AMAZÔNIA

**A new species of freshwater crab, genus *Kingsleya* Ortmann, 1897
(Decapoda: Brachyura: Pseudothelphusidae), from the remote southern Guyana**
Uma nova espécie de caranguejo de água doce do gênero *Kingsleya* Ortmann,
1897 (Decapoda: Brachyura: Pseudothelphusidae) do extremo sul da Guyana

Célio Magalhães¹  | Tiago Arantes¹  | Fernando L. Mantelatto¹ 

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Zoobank: <http://zoobank.org/pub:B6D97847-F98F-4EA5-9377-4F44279E2BF1>

Abstract: Only one species of the genus *Kingsleya* Ortmann, 1897, was known from Guyana. An expedition of the Rapid Biological Assessment Program conducted in the Konashen Community Owned Conservation Area in the upper Essequibo River basin in the southern tip of the country, resulted in the discovery of an undescribed species of this genus, which is described, illustrated and phylogenetic contextualized herein. The new species, supported by morphological and molecular evidences, belongs to *Kingsleya* mainly due to distinctive features of the first male gonopod (G1). The new species is molecularly compared with sequences of some congeners and, based on a single marker and reduced set of samples, is positioned close to *K. attenboroughi*. When compared with its closest congeners, the new species can be distinguished by a suite of characters of the G1, especially the narrow proximal portion of the apical plate's mesial margin, the apical plate's mesial lamella much shorter than the lateral lamella and strongly recurved apically at about 90° in lateral view, and the transverse positioning of the short field of apical spines. A comparative analysis of the new species with congeners is made and zoogeographic aspects concerning the *Kingsleya* species from northern South America are briefly discussed.

Keywords: Amazon region. Essequibo River basin. Kingsleyinae. Molecular markers. Neotropical region. Taxonomy.

Resumo: Apenas uma espécie de *Kingsleya* Ortmann, 1897 era conhecida na Guiana. Uma expedição do Programa de Avaliação Biológica Rápida conduzida na Área de Conservação Comunitária de Konashen, no alto rio Essequibo, no sul do país, resultou na descoberta de uma nova espécie, que é descrita, ilustrada e filogeneticamente contextualizada. A nova espécie, reconhecida com base tanto em evidências morfológicas quanto moleculares, pertence a *Kingsleya* principalmente devido a caracteres distintivos do primeiro gonópode do macho (G1). A nova espécie foi comparada molecularmente com algumas congêneres e, com base em apenas um marcador e com reduzido conjunto de amostras, está relacionada a *K. attenboroughi*. Quando comparada morfológicamente com seus congêneres mais próximos, a nova espécie pode ser distinguida por um conjunto de caracteres do G1, especialmente pela porção proximal da margem mesial da placa apical estreita, pela lamela mesial da placa apical muito mais curta do que a lamela lateral e fortemente recurvada apicalmente em cerca de 90° em vista lateral e pelo posicionamento transversal do pequeno campo de espinhos apicais. Uma análise comparativa da morfologia do G1 da nova espécie com as congêneres é feita e aspectos zoogeográficos referentes às espécies de *Kingsleya* do norte da América do Sul são brevemente discutidos.

Palavras-chave: Região amazônica. Bacia do rio Essequibo. Kingsleyinae. Marcadores moleculares. Região Neotropical. Taxonomia.

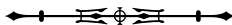
Magalhães, C., Arantes, T., & Mantelatto, F. L. (2026). A new species of freshwater crab, genus *Kingsleya* Ortmann, 1897 (Decapoda: Brachyura: Pseudothelphusidae), from the remote southern Guyana. *Boletim do Museu Paraense Emílio Goeldi. Ciências Naturais*, 21(1), e2026-1083. <http://doi.org/10.46357/bcnaturais.v21i1.1083>

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INTRODUCTION

The Guyanese fauna of pseudothelphusid freshwater crabs is fairly well known and currently comprises ten species belonging to four genera: *Fredius* Pretzmann, 1967 (five species), *Microthelphusa* Pretzmann, 1968 (three species), *Kingsleya* Ortmann, 1897, and *Kunziana* Pretzmann, 1971, with one species each (Rodríguez, 1982; Magalhães & Rodríguez, 2002; Cumberlidge, 2007; Magalhães et al., 2009; Pedraza & Tavares, 2015; Magalhães & Wehrtmann, 2025). Although *Kingsleya* has a wide geographic distribution in northern South America, encompassing a large portion of the Amazon basin, the upper Orinoco basin, and some coastal river basins of the northern and northeastern South America (Holthuis, 1959; Rodríguez, 1982; Magalhães & Türkay, 2008; Pedraza & Tavares, 2015; Pedraza et al., 2015; Pinheiro & Santana, 2016; Pralon et al., 2020), the only species of this genus so far known from Guyana was *Kingsleya latifrons* (Randall, 1840) (Rodríguez, 1982; Magalhães & Türkay, 2008).

In October 2006, a team coordinated by the Conservation International (n.d.) conducted an expedition of the Rapid Biological Assessment Program (RAP) to carry out an inventory of the natural resources of the Konashen Community Owned Conservation Area, an area of undisturbed forest in the remote southern region of Guyana that encompasses the headwaters of the Essequibo River and its tributaries, including the Sipu River (Alonso et al., 2008). The crustaceans collected in the inventory of the aquatic fauna were deposited in the natural history museum of the Fundación La Salle de Ciencias Naturales (Caracas, Venezuela) and, during a visit in March 2008 to the museum's crustacean collection to study this material, the senior author found specimens that proved to be an undescribed species of the genus *Kingsleya*, which is described and illustrated herein.

MATERIAL AND METHODS

SAMPLING AND MORPHOLOGICAL ANALYSIS

The specimens were hand-collected. The specimens examined, both type and comparative material, are

deposited in the following institutions: *Coleção de Crustáceos do Departamento de Biologia* (CCDB), *Faculdade de Filosofia, Ciências e Letras de Ribeirão Preto, Universidade de São Paulo*, Ribeirão Preto; *Instituto Nacional de Pesquisas da Amazônia* (INPA), Manaus; *Fundación La Salle de Ciencias Naturales, Museo de Historia Natural* (MHNLS), Caracas; *Museu de Zoologia da Universidade de São Paulo*, São Paulo (MZUSP); Naturalis Biodiversity Center, Leiden (RMNH). Line drawings were made by C.M. with the aid of a stereoscopic microscope (Wild M8) equipped with a drawing tube, then scanned at 600 dpi and edited in Adobe Photoshop® CS 2 software at 600 dpi. Computerized photographs of the first gonopod were taken using a Leica® M205 C stereomicroscope equipped with a Leica® DFC295 digital camera, along with image capture software (Leica Application Suite v. 3.8.0). The plates were mounted in CorelDraw® X3 software. Geographic coordinates in square brackets represent data that were not originally acquired in the field but obtained from subsequent georeferencing using online gazetteers (e.g., GeoNames, n.d.) and/or Google Earth®. The geographic distribution map was made using the software QGIS 3.34 Prizren.

The following measurements, in millimeters, were taken: carapace length (cl, measured along the midline, from the frontal to the posterior margin); carapace width (cw, measured at the level of its widest point); chelae length (chl, measured along the ventral margin of the propodus); maximum width of sternum (sw); and minimum distance between female vulvae (vd). Measurements for the female sternum and vulvae follow Pati (2021). Measurements of carapace length and width are presented as (cw × cl). Other abbreviations used in the text are: coll. = collector(s); G1 and G2 = male first and second gonopods, respectively; Mxp3, third maxilliped; P1, pereopod 1 or cheliped; P2–P5, pereopods 2 to 5; s = sternal sulcus between adjacent thoracic sternites (e.g., s5/s6); bp = base pairs. Terminology used in the morphological description of the G1 and G2 was adapted from Smalley (1964) and



Pedraza et al. (2016), with “sternal” and “pleonal” for the surfaces and views facing, respectively, the thoracic sternum and the pleon are used instead of “cephalic” or “dorsal” and “abdominal” or “ventral”.

The taxonomic determination was based on the G1 morphology with particular attention to the examination of the following character: shape of apical plate; presence, situation and position of the apical lamellae; shape and situation of the marginal process; shape, situation and position of the mesial process; and shape and position of the field of apical spines.

DNA EXTRACTION, AMPLIFICATION, AND SEQUENCING

Genomic DNA extraction was performed using a QIAamp DNA Micro Kit (QIAGEN®) following the manufacturers' instruction. In general, the protocol followed the methodology established by Mantelatto et al. (2007, 2018) and Álvarez et al. (2020), including appropriate modifications (adjustments in the concentration of DNA sample and temperature of annealing) for specific material. DNA concentration was measured with a NanoDrop™ 2000/2000c spectrophotometer (Thermo Scientific™).

A fragment of the mitochondrial cytochrome c oxidase subunit I gene (COI, approximately 600 bp) was amplified using the primers LCOI and HCOI (Folmer et al., 1994). PCR conditions consisted of an initial denaturation at 96 °C for 3 min, followed by 40 cycles of 95 °C for 1 min, 48 °C for 1 min, and 72 °C for 1 min, and a final extension at 72 °C for 5 min. PCR products were visualized on a 1.5% agarose gel, and the results were photographed under ultraviolet light using an L-Pix EX photodocumentation system (Loccus®). The amplified products were purified with the Universal DNA Purification Kit (TIANGEN®) according to the manufacturer's protocol, and their concentrations were measured using a Qubit™ 4 fluorometer (Invitrogen™) [20 ng/μl]. Sequencing reactions were performed independently for both strands using the

Big Dye Terminator v3.1 kit (Applied Biosystems), and the resulting products were analyzed on an ABI 3500 XL automated sequencer (Applied Biosystems Inc., CA, USA). Sequences were aligned and edited in Geneious Prime version 2024.0.4 (Geneious, n.d.) (Kearse et al., 2012). Low-quality ends were trimmed, and consensus sequences were generated from forward and reverse reads (de novo assembly). The final sequences were compared against the GenBank database using the Basic Local Alignment Search Tool (BLAST) implemented on the National Center for Biotechnology Information (NCBI) website.

MOLECULAR DATA ANALYSES

The outgroup was selected according to the phylogenetic hypothesis proposed by Álvarez et al. (2020). All sequences generated in this study were deposited in GenBank and made publicly available (Table 1). To test the hypothesis of a new species, three species delimitation methods were applied: the Bayesian Poisson Tree Processes method (bPTP; Zhang et al., 2013), the Generalized Mixed Yule–Coalescent model (GMYC; Pons et al., 2006), and the Assemble Species by Automatic Partitioning (ASAP; Puillandre et al., 2021) method, performed on the online platform (<https://itaxotools.org>; Vences et al., 2021) using Kimura (K80) distance matrices, with all other parameters set to default.

Sequences were aligned (MUSCLE) implemented in MEGA version 12 (Kumar et al., 2024). For bPTP and GMYC analyses (Zhang, 2013-2015), an ultrametric tree was inferred using Bayesian inference implemented in BEAST v. 2.6.2 (Bouckaert et al., 2019) under a Relaxed Lognormal Clock and a Birth–Death model (Heled & Drummond, 2010). The best-fit evolutionary model was GTR (proportion of invariant sites = 0.5760; substitution rates: AC and CG = 2.6609, AG and CT = 15.4853, AT and GT = 1.0), as determined by the Bayesian Information Criterion (BIC) in jModelTest2 (Darriba et al., 2012).



Table 1. Species of Pseudothelphusidae included in the molecular analyses. For each species, collection number, its locality, GenBank number to the accessed COI sequence are presented. Abbreviations: CCDB = *Coleção de Crustáceos do Departamento de Biologia, Faculdade de Filosofia Ciências e Letras de Ribeirão Preto, Universidade de São Paulo*, Ribeirão Preto, Brazil; INPA = *Instituto Nacional de Pesquisas da Amazônia*, Manaus, Brazil; MHNLS = *Fundación La Salle de Ciencias Naturales, Museo de Historia Natural*, Caracas, Venezuela; RMNH = Naturalis Biodiversity Center, Leiden, The Netherlands; UCR-MZ = *Museo de Zoología de la Universidad de Costa Rica*, Costa Rica.

Species	Collection number	Locality	GenBank Number (COI)	Reference
<i>Kingsleya marthacamposae</i> sp. nov.	MHNLS 2392	Guyana	PX913411	Present study
<i>K. attenboroughi</i>	INPA 2208	Brazil, Ceará	PX913413	Present study
<i>K. latifrons</i>	RMNH 41765	Dadanawa, Guyana	KU578938	Álvarez et al. (2020)
<i>K. latifrons</i>	INPA 329	Brazil, Pará	PX913413	Present study
<i>K. ytipora</i>	INPA 1269	Brazil, Pará	PX913412	Present study
<i>Fredius fittkai</i>	INPA 1330	Brazil, Amazonas	MZ462184.1	Mantelatto et al. (2022)
<i>F. fittkai</i>	INPA 1546	Brazil, Amazonas	MZ462185.1	Mantelatto et al. (2022)
<i>F. buritizatillis</i>	CCDB 2951	Brazil, Rondônia	MZ462207.1	Mantelatto et al. (2022)
<i>F. buritizatillis</i>	CCDB 342	Brazil, Rondônia	MZ462212.1	Mantelatto et al. (2022)
<i>Achlidon agrestis</i>	CCDB 4556	Costa Rica, Limón	MZ462213.1	Mantelatto et al. (2022)
<i>Ptychophallus uncinatus</i>	UCR-MZ 170	Costa Rica	MZ462214.1	Mantelatto et al. (2022)

Analyses were run for 50 million generations, sampling one tree every 1,000 generations. TRACER v. 1.5 (part of the BEAST package) was used to assess convergence and ensure sufficient effective sample size (ESS > 200). Trees were summarized and visualized using TREEANNOTATOR 1.5.3 and FIGTREE 1.3.1, respectively (Drummond & Rambaut, 2007; Rambaut, 2009). GMYC and bPTP input files were generated using the online platform (Zhang, 2013-2015).

A genetic distance matrix was calculated to evaluate intra- and interspecific divergence among congeners. The matrix was based on Kimura 2-parameter (K2P) distances (Kimura, 1980), computed in MEGA v. 12.

RESULTS

TAXONOMY

Family Pseudothelphusidae Ortmann, 1893

Subfamily Kingsleyinae Bott, 1970

Genus *Kingsleya* Ortmann, 1897

Kingsleya marthacamposae sp. nov.

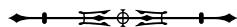
(Figures 1-4)

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Type material (see note on Taxonomic remarks). Holotype: male (43.3 × 24.6), MHNLS 2392a, Guyana, Upper Takutu/Upper Essequibo, Acarai Mountains, Acarai Creek, tributary of Sipu River, Essequibo River basin, 01° 23' 12.2" N, 58° 56' 45.7" W, elevation 251 m, in marginal pool, collected manually, 17.x.2006, C.A. Lasso, C.J. Señaris & E. Alexander leg.

Paratypes: 2 males (27.7 × 16.5; 40.6 × 23.2) 3 females (33.6 × 19.7; 43.2 × 24.7; 55.0 × 30.4), MHNLS 2392b, same data as holotype.

Comparative material examined. *Kingsleya attenboroughi* Pinheiro & Santana, 2016: 1 male, 1 female, paratypes, INPA 2208, Brazil, Ceará, municipality of de Barbalha, district of Arajara, 07° 20' 07.6" S, 39° 23' 58.8" W, 4.v.2016, A. P. Pinheiro et al. colls. — *Kingsleya besti* Magalhães, 1990: male, holotype, RMNH D 37401, Brazil, Amazonas, Curicuriari Mountains, Upper Negro River basin, elev. 300 m a.s.l., 04.xi.1971, P.J.M. Mars coll. — *Kingsleya castrensis* Pedraza, Martinelli-Filho & Magalhães, 2015: male, holotype, INPA 2010, Brazil, Pará,



municipality of Altamira, 51° B.I.S. - Batalhão de Infantaria de Selva camp area, [03° 11' 47" S, 52° 09' 58" W], 16.VIII.2011, J.E. Martinelli-Filho & C. S. de Sousa colls.; 1 male, INPA 2577, Brazil, Pará, municipality of Altamira, local road 5 [03° 19' 01.9" S, 52° 22' 25.0" W], 24.iii.2012, D. A. Bastos coll. — *Kingsleya gustavoi* Magalhães, 2005: male, holotype, INPA 1320, Brazil, Pará, Rio Parauapebas, Canaã dos Carajás [06° 30' S, 49° 50' W], 25.iv.2002, R.P. Ribeiro coll. — *Kingsleya hewashimi* Magalhães & Turkey, 2008: 1 male, paratype, INPA 1534, Venezuela, Amazonas, upper Orinoco River basin, small tributary of Bacón River, 02° 19.570' N, 64° 43.366' W, iv.1996, G. Herzog-Schröder coll. — *Kingsleya junki* Magalhães, 2003: 1 male, INPA 2012, Brazil, Pará, municipality of Vitória do Xingu, Agrovila Lenardo da Vinci [03° 10' 15.5" S, 52° 04' 01.9" W], 26.iii.2012, C. S. de Sousa coll. — *Kingsleya latifrons* (Randall, 1840): 1 male, INPA 389, French Guiana, Trois Sauts [02° 15' 22.1" N, 52° 52' 20.3" W, upper rio Oyapoque], 1985, coll. Grenard; 1 male, INPA 289, Brazil, Amazonas, Uatumã River, cachoeira [= rapids] Balbina, 16.vii.1985, C. Magalhães coll.; 1 male, INPA 329, Brazil, Pará, Trombetas River, Cachoeira Porteira, 4–22.x.1985, C. Magalhães coll.; 2 males, 1 female, INPA 2411, Brazil, Roraima, municipality of São Luiz do Anauá, Peixes River, fazenda [= farm] Água Limpa [00° 41' N, 060° 11' W], 05.ii.2015, F. Zanetti, M.A.L. Santos, I.R. Almeida and S.C. Emidio colls. — *Kingsleya siolii* (Bott, 1967): 1 male, 1 female, RMNH D.5346, Suriname, Sipaliwini, Bakhuis Range, near Coppename River, line V [04° 20' 44" N, 56° 42' 33" W], 11.xii.1943, D.C. Geijskes coll.; 1 male, RMNH D.12117, Suriname, Sipaliwini, Wilhelmina Range, near Linker Coppename River, line I [03° 53' 27" N, 56° 42' 33" W], viii-ix.1943, D.C. Geijskes coll.; 4 males, 2 females, RMNH D.37350, Suriname, Sipaliwini, road from Avanavero to Amotopo (near mouth of Lucie River [03° 32' 56.7" N, 57° 38' 41.3" W]), 212 km of Avanavero, 22.v.1981, M.S. Hoogmoed & D.G. Reeder colls.; 1 male, INPA 391, Brazil, Pará, upper Rio Paru do Oeste, igarapé [= stream] Akahé, Missão Tiriyo, iii–iv.1962, E.-].

Fittkau coll.; 1 male, 1 female, CCDB 8582, Brazil: Amapá, municipality of Laranjal do Jari, Santo Antônio da Cachoeira, 00° 38' 41.7" S, 52° 30' 30.1" W, 5.viii.2011, A. Pes, P. Cruz, A. Fernandes & N. Hamada colls. — *Kingsleya ytupora* Magalhães, 1986: 1 male, INPA 2571, Brazil: Pará, Altamira, Xingu River, cachoeira [rapids] do Tiririca, 03° 22' 56" S, 51° 44' 11" W, 13.x.2012, M. Sabaj, L.M. Souza & M. Arces colls.; 1 male, MZUSP 49064, Brazil: Pará, Altamira, Xingu River, Tapuama, 03° 36' 29" S, 52° 20' 57" W, 08.x.2012, M. Sabaj, L.M. Souza & M. Arces colls.

Diagnosis. G1 straight, with well-developed apical processes; marginal suture on mesial surface; marginal process distinctly long, narrower distally, distal margin rounded in mesial and pleonal views, arched in sternal view, not projecting distally beyond the field of apical spines area; pleonal surface ending distally in subterminal rounded lobe, separated from distosternal lobe along laterosternal surface by deep, wide sulcus; mesial process well developed, approximately 1.9 × longer than apical plate; apical plate well developed, narrow, with 2 distinct apical lobes; mesial (or proximal) lobe stretching diagonally over apical plate, distal portion strongly recurved laterally, distinctly shorter (approximately 0.7 × length) than lateral lobe in mesial view. Field of apical spines short, narrow, situated somewhat transversely along lateral side of apical plate, closed distally by sharp curvature (about 90°) of distal portion of mesial and lateral lobes.

Description of holotype. Carapace outline ellipsoid, widest at middle (cw/cl 1.76); dorsal surface smooth, nearly flat, regions ill-defined; dorsal surface punctuated by minute bristles better seen under magnification, irregularly distributed, denser along metabranchial region (Figure 1A). Gastric pits barely visible, close to each other, on metagastric region. Cervical grooves shallow, rather wide, nearly straight, faint proximally, distal end failing to reach anterolateral margin. Postfrontal lobules small, as very low elevations; median groove wide, shallow. Surface of carapace between front and postfrontal lobules smooth, slightly inclined anteriorly. Upper margin of front angulate,



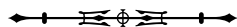
faintly crenated, slightly convex in dorsal view, median notch absent; lower margin carinate, slightly sinuous in dorsal view, with shallow median concavity in frontal view, slightly more projected anteriorly than upper one; frontal surface between upper and lower margins moderately wide, smooth. Orbital contour rhomboid-shaped in frontal view (Figure 1C–1D); supraorbital margin very shallow, slightly concave in dorsal view, faintly crenated, nearly continuous with upper margin of front; infraorbital margin slightly more projected anteriorly than upper one, faintly crenated; exorbital angle low, obtuse. Eyes (Figure 1C, 1D) normal, loosely filling orbital cavity; eyestalk subcylindrical, cornea well developed; internal orbital tooth small, low, subquadrate. Anterolateral margin of carapace lined with set of minute teeth slightly increasing in size from anterior to posterior portion; postorbital notch absent; posterolateral margin smooth, barely defined (Figure 1A). Antennular fossae somewhat wide, deep, subretangular in frontal view, divided by distinct low, longitudinal middle crest (Figure 1D). Epistome narrow, somewhat deep; dorsal margin nearly straight, crested, epistome ventral margins between median epistomial tooth distinctly arched over first article of mxp3's palps, faintly crenated and irregular row of minute bristles; epistomial tooth subtriangular, obliquely directed upwards (Figure 1D). Suborbital and subhepatic regions of carapace sidewall smooth; pterygostomial regions covered by somewhat dense pilose patches along outer borders of buccal frame (Figure 1C, 1D). Aperture of efferent branchial chamber wide, subretangular in frontal view, upper margin glabrous (Figure 1D).

Mxp3 (Figure 1C) endopod with ischium and merus subtrapezoidal, with outer surface with few minute bristles scattered along mostly smooth surface; ischium lateral margin slightly convex, mesial margin mostly straight, bearing row of corneous teeth and setae of varying sizes; merus lateral margin broadly rounded, mesial margin straight, bearing row of corneous teeth and setae of varying sizes and bearing distinct longitudinal

sulcus receiving 2nd and 3rd articles of palp; distal margin short, oblique, bearing 3-articulated palp; palp 2nd article inner margin with subdistal tuft of long setae, 3rd article with row of setae increasing size distally. Mxp3 exopod subtriangular, very short (approximately 0.2 × length of ischium lateral margin).

P1 distinctly heterochelous, similarly armed (Figure 1A, 1B). Left cheliped larger. Merus subtriangular in cross section, inner surface somewhat concave, outer surface rounded, smooth; upper margin rounded with irregular row of faint tubercles, fainter distally; mesial margin lined with longitudinal row of tubercles, increasing in size distally; lateral margin marked by row of low tubercles, regular proximally, irregular distally; distal margin with upper and lateral margins smooth, arched; lower margin with straight row of faint tubercles. Carpus inner margin with short row of distinct tubercles proximally, followed by short median conical tooth, distal margin oblique and lined with few faint tubercles; outer surface widely rounded. Palm moderately swollen (length/width = 1.57), smooth on both sides, finely punctuated by minute bristles better seen under magnification (Figure 1F). Fingers slightly gaping, tips not crossing; both fingers ornated with longitudinal parallel rows of faint granules bearing minute bristles along outer, upper and inner surfaces; pollex cutting surface with large triangular teeth sometimes interspaced with small ones, smaller distally. Dactylus slightly arched, approximately 1.4 × longer than palm (measured dorsally) (Figure 1F). P2–5 slender (Figure 1A, 1B), ratios dactylus/propodus, dactylus/carpus, dactylus/merus (left legs measured), respectively, approximately as follows: P2 = 1.72, 1.62, 0.80; P3 = 1.63, 1.70, 0.78; P4 = 1.57, 1.57, 0.83; P5 = 1.70, 1.33, 0.84. P2–5 with dactyli bearing 5 longitudinal rows of sharp, corneous spines, increasing in size distally.

Thoracic sternum nearly as wide as long (width/length 1.08) (Figure 1B, 1E). Thoracic sternites of third maxillipeds and first pereopods completely fused, except for small notches at lateral edges of sternum;



sulci marking sternal sutures s4/s5, s5/s6, s6/s7, s7/s8 distinct, reaching midline of thoracic sternum. Midline of thoracic sternum wide, flat between s5–s6, marked by deep groove between s7–s8, deeper at s7. Episternites 4–7 subtriangular posteriorly; separation from corresponding sternite barely visible. Sternopleonal cavity subtriangular, somewhat narrow, deep, with dense pubescence along inner walls of s5–s6, few, scattered pubescence along rest of sternopleonal cavity. Pleon locking mechanism as small bud situated on s5 right next to sternal suture s5/s6, near outer edge of sternopleonal cavity. Penis well developed,

membranous, emerging from nearby coxo-sternal condyle articulation, located in shallow depression on sternite 8; proximal portion wider and flatter, distal portion narrower, subcylindrical, recurved proximally, tapering.

Pleon+telson set subtriangular (Figure 1A). All pleonites free; pleonite 3 widest, pleonite 6 slightly longer than other pleonites; lateral margins slightly concave, lined with row of short setae. Telson subtriangular, lateral margins slightly concave, weakly crenulate, with row of short setae denser proximally and medially; tip rounded (Figure 1A, 1B).

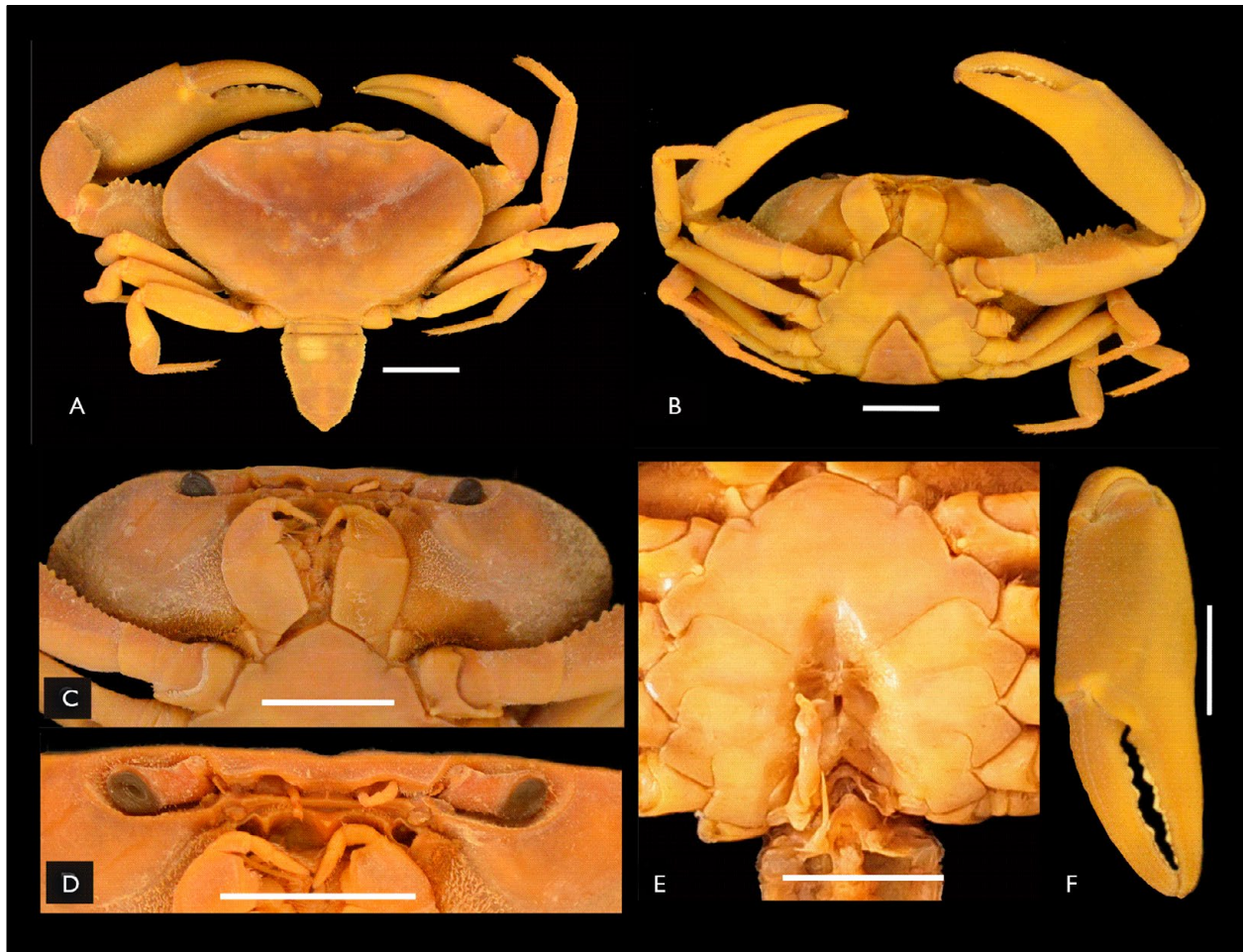


Figure 1. *Kingsleya marthacamposae* sp. nov., holotype, male (cw 43.3; cl 24.6), MHNLS 2392a: A) overall dorsal habitus, showing pleon plus telson open; B) ventral surface of cephalothorax with pleon plus telson closed; C) cephalothorax, detail of the buccal frame and pterygostomial region, ventral-frontal view; D) cephalothorax, frontal view; E) thoracic sternum and sternopleonal cavity, with right first and second gonopods *in situ* (left ones dissected); F) left (larger) chela. Scale bars: 10 mm. Image credits: C. Magalhães (2025).

G1 (Figures 1E, 2A–2G, 3) stout, straight, slightly constricted medially, distal third slightly broader due to well-developed distal processes. Marginal suture on mesial surface, straight on proximal half, somewhat concave on distal half, bearing path of several short and long setae placed along proximal portion of marginal suture and between it and proximal portion of lateral suture. Lateral suture well marked along first $\frac{2}{3}$ of stem, deeper proximally, shallower distally, not reaching

marginal process. Marginal process distinctly longer than rounded subdistal lobe of pleonal surface; marginal process narrower distally, distal margin rounded in mesial and pleonal views, arched in sternal view, not projected distally beyond the field of apical spines area, surface of subterminal portion with shallow depression on pleonal surface. Pleonal surface distal portion with subterminal rounded lobe, clearly separated from distal lobe of lateral surface by deep, wide sulcus. Mesial process well

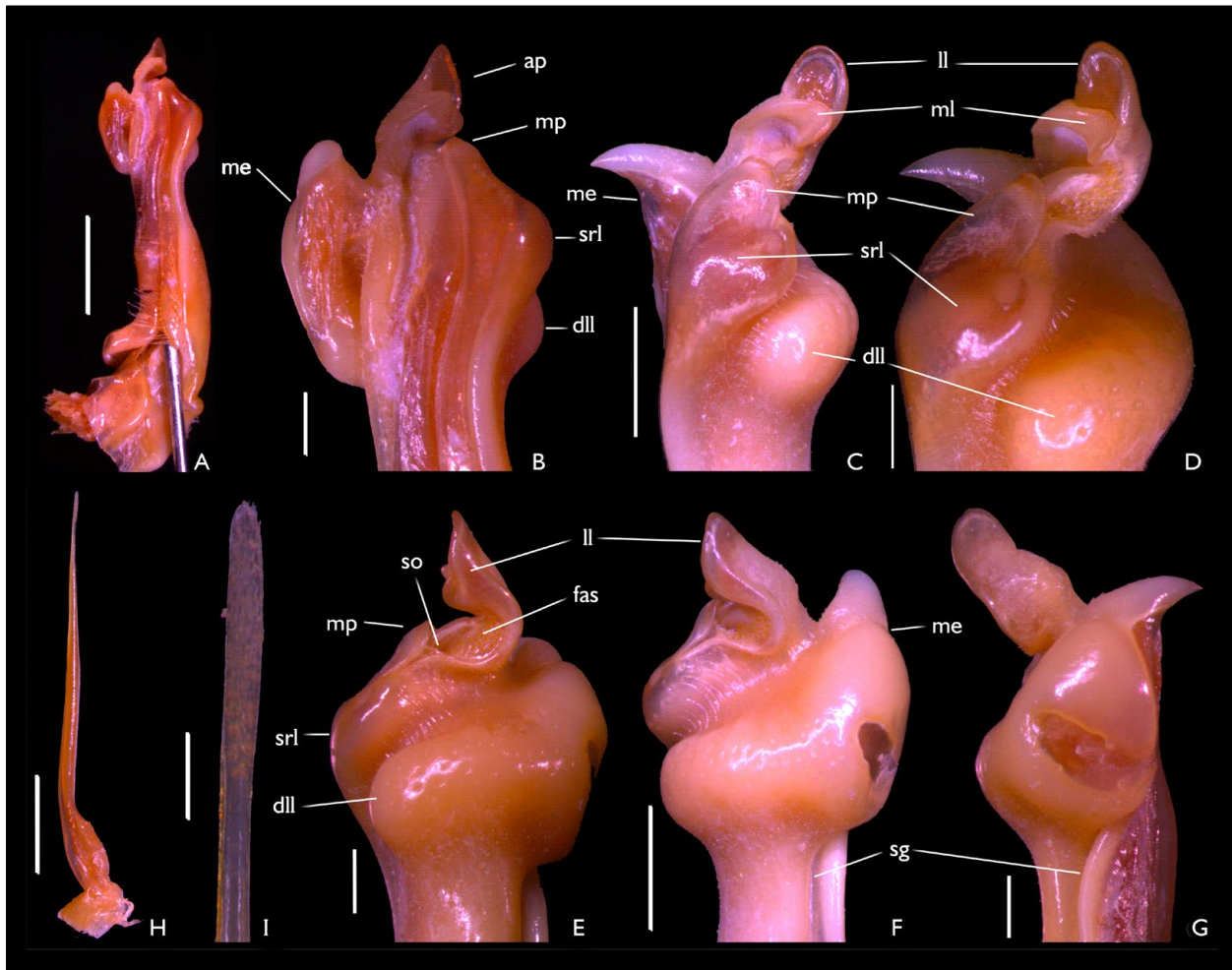


Figure 2. *Kingsleya marthacamposae* sp. nov., holotype, male, MHNLS 2392a, photographs of the left first gonopod: A) whole organ, mesial view; B) distal portion, mesial view; C) distal portion, pleonal view; D) distal portion, lateropleonal view; E) distal portion, lateral view; F) distal portion, laterosternal view; G) distal portion, sternal view. Second left gonopod: H = whole organ; I = detail of the apex. Abbreviations: ap = apical plate; dll = distal lobe of the lateral surface; fas = field of apical spines; ll = lateral lamella; ls = lateral suture; me, mesial process; ml = mesial lamella; mp = marginal process; ms = marginal suture; sg = sternal groove; so = sperm channel terminal opening; srl = subterminal rounded lobe of the pleonal surface. Scale bars: A, H = 2 mm; B–G, I = 500 μ m. Image credits: C. Magalhães (2025).

developed, approximately $1.9 \times$ longer than apical plate (measured in mesial view), proximal portion sternal face rounded, pleonal face concave, distal portion produced into sharp conical spine pointing in mesial direction; mesial process well separated from apical plate by deep incision. Sternal and mesial surfaces bearing distinct longitudinal sternal groove, wide and shallow proximally, narrow and

deep distally on sternal surface, with its distal portion twisted to mesial surface, ending at base of mesial process. Apical plate well developed, narrow, approximately $2.1 \times$ longer than wide (measured in mesial view), proximal portion of mesial margin narrow, not expanded along mesolateral axis, with 2 distinct apical lamellae; mesial (or proximal) lamella situated subterminally on mesopleonal

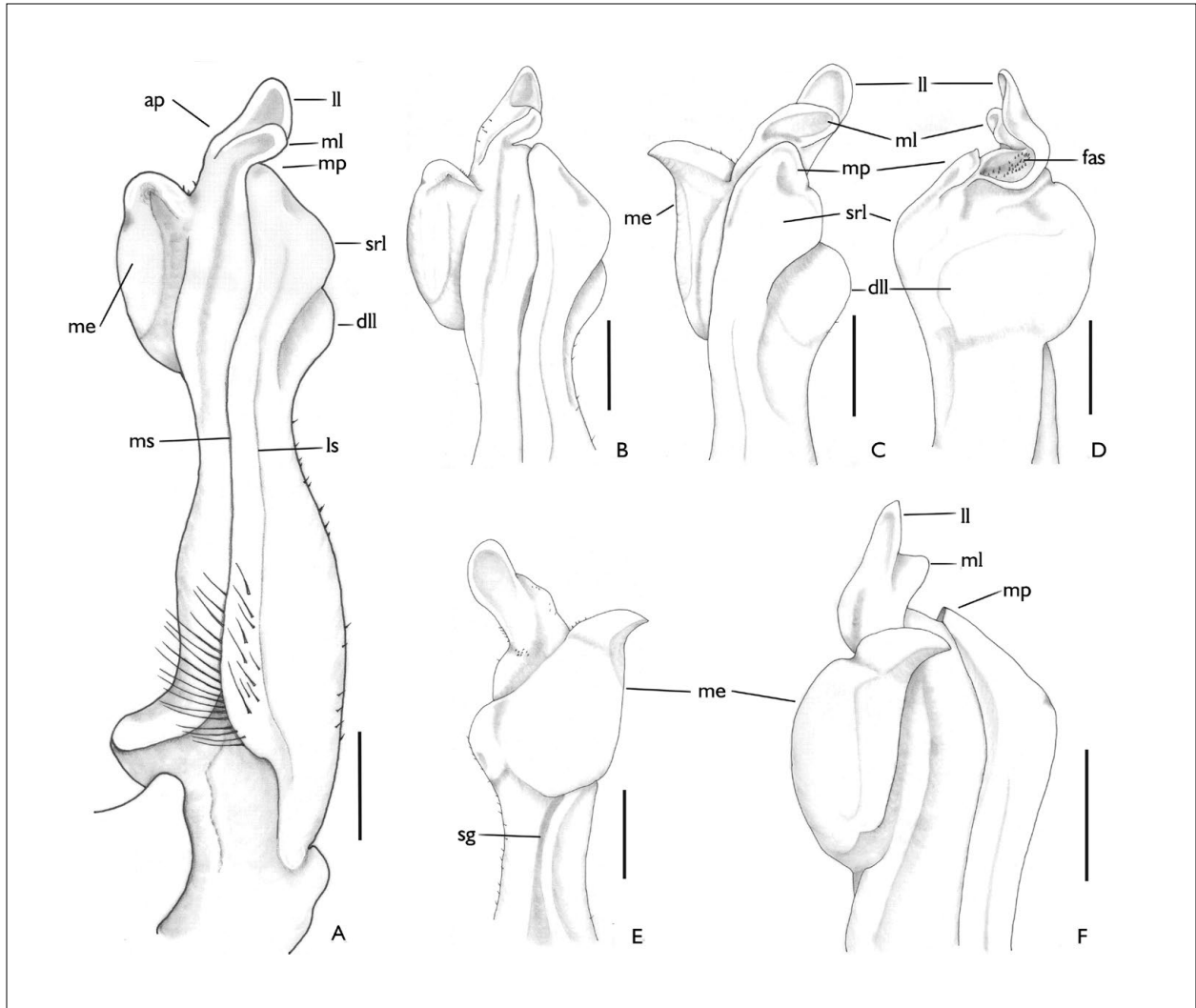


Figure 3. *Kingsleya marthacamposae* sp. nov., holotype, male, MHNLS 2392a, illustrations of left first gonopod: A = whole organ, mesial view; B = distal portion, mesial view; C = distal portion, pleonal view; D = distal portion, lateral view; E = distal portion, sternal view; F = distal portion, sternomesial view. Second left gonopod: H = whole organ; I = detail of the apex. Abbreviations: ap = apical plate; dll = distal lobe of the lateral surface; fas = field of apical spines; ll = lateral lamella; ls = lateral suture; me = mesial process; ml = mesial lamella; mp = marginal process; ms = marginal suture; sg = sternal groove; so = sperm channel terminal opening; srl = subterminal rounded lobe of the pleonal surface. Scale bars = 1 mm. Illustrations: C. Magalhães (2025).

side, stretching diagonally over apical plate with its distal portion strongly recurved laterally and distinctly concave on mesial and pleonal views, nearly as wide as lateral (or distal) lamella proximally, distinctly shorter (approximately $0.7 \times$ length) than lateral lamella in mesial view, distal margin rounded; lateral lamella, in lateral view, strongly arched apically in approximately 90° angle, pleonal surface slightly concave, distal margin broadly rounded in most views, narrow in lateral view. Field of apical spines moderately developed as short, narrow patch of small spines situated somewhat transversely on deep depression along lateral side of apical plate, delimited by

proximal portion of lateral margins of apical plate lamellae, closed distally by sharp curvature (about 90°) of distal portion of mesial and lateral lamellae. Spermatic channel terminal opening situated at base of apical field of spine.

G2 (Figure 2H, 2I) slightly shorter than G1; terminal segment as styliform, slender flagellum, proximal $\frac{1}{3}$ wider and slightly sinuous, distal two-thirds subcylindrical, tapering; tip flattened, provided with short spinules on sternal surface.

Females. The pleon+telson set of the two larger, spawned females is broadly oval, slightly longer than wide (average length/width ratio 1.08; $n = 2$)

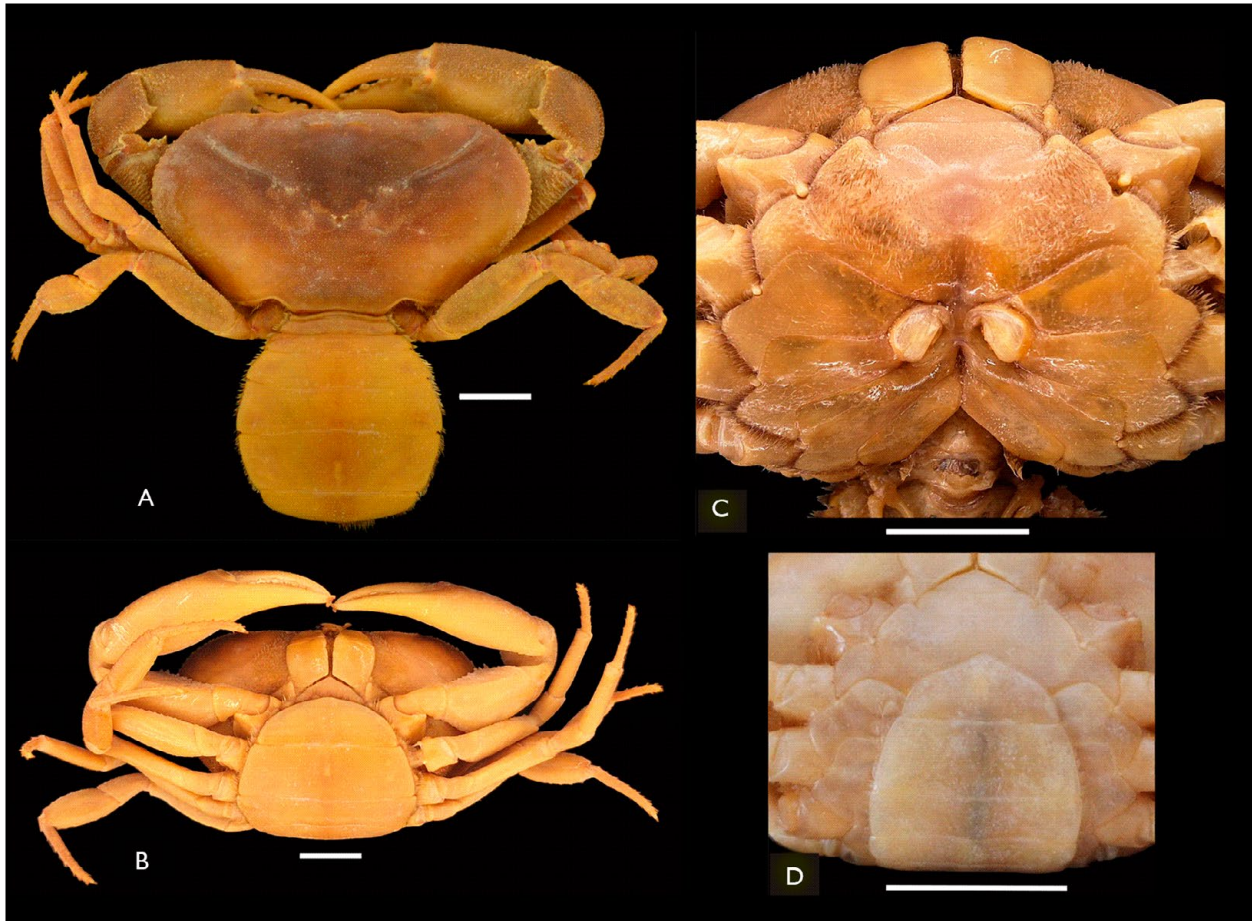


Figure 4. *Kingsleya marthacamposae* sp. nov., female paratypes, MHNLS 2392b. Larger female, spawned (55.0 \times 30.4 mm): A) overall dorsal habitus, showing pleon and telson open; B) ventral surface of cephalothorax, with pleon plus telson closed; C) thoracic sternum, sternopleonal cavity, and vulvae. Smaller female (33.6 \times 19.7 mm): D) thoracic sternum, with pleon and telson closed. Scale bars: 10 mm. Image credits: C. Magalhães (2025).

and, except for the s1 anterior tip, covers the entire sternum, including the episternites (Figure 4A, 4B), whereas in the smaller female the telson+pleon is narrower (length/width 1.25), not covering the lateral edges of the sternal somites when closed (Figure 2D). Pleonite length increases progressively from pleonite 1 to 6, being pleonite 1 the shortest and pleonite 6 the longest; pleonite 6 distinctly broader than long and slightly longer ($1.08 \times$ longer, $n = 3$) than telson. Telson broadly subtriangular, $2.5 \times$ wider than long ($n = 3$), with gently rounded lateral margins (Figure 4B, 4C). The vulvae are situated adjacent to the thoracic sternum midline, shaped as a subovate opening obliquely directed mesoposteriorly, slightly longer than wide (length/width approximately 1.1, $n = 3$), positioned very close to each other (vd/sw 0.05, $n = 3$) along s5–s6 and spanning the entire length of the inner portion of both somites, with anterior and lateral margins surrounded by a semicircular low rim; about two-thirds of each vulva is covered by a somewhat thick membrane projected from the anterior and lateral margins, with inner portion remaining uncovered (Figure 4C). In the spawned females, the lateral and posterior portion of the s4 has a dense patch of bristles, which is barely visible in the smaller female and the males (Figure 4C, 4D).

Variation. The male paratypes did not exhibit noteworthy modifications in relation to the somatic and gonopodal characters that were described for the holotype. Most of the female paratypes somatic characters also resemble those of the males, except for the sexual characters.

Specimens of both sexes exhibit heterochely, but it is less pronounced in the females. In the two larger females, the right cheliped is slightly larger than the left (Figure 4A, 4B); among the males, the larger specimen (holotype) has the left cheliped distinctly larger than the right (Figure 1A, 1B), whereas in the intermediate-sized male, the larger cheliped is the right one. The rates between the length of both left and right chelae and the carapace width for the specimens examined are presented in Table 2. In the smaller male and female specimens, both chelipeds are absent, so that in these the existence of heterochely could not be assessed.

It's also worth noting a slight allometry in the growth of carapace width relative to carapace length. Considering males and females together, the ratio carapace width/length increases from smaller to larger specimens (cw/cl 1.68–1.81), but the sample size is only six specimens.

Etymology. This new species is dedicated to the distinguished Colombian carcinologist, Martha Rocha de Campos, in honor of her exceptional work that has greatly contributed to increasing knowledge about the Neotropical freshwater decapod fauna.

Type locality. Acarai creek, tributary of Sipu River, headwaters of the Essequibo River, Upper Takutu/Upper Essequibo Region, Guyana. The specimens were collected during the RAP Expedition to the Konashen Community Owned Conservation Areas (COCA), which lies within the Konashen Indigenous District, a remote wilderness area in southern Guyana (Alonso et al., 2008).

Table 2. The rates between the length of both left and right chelae and the carapace width for the examined male and female specimens of *Kingsleya marthacamposae* sp. nov. Measurements are in millimeters. Abbreviations: chl, chela length; cw, carapace width.

Specimen	cw	chl (left)	chl (right)	Rate chl/cw	
				Left chela	Rigth chela
Male holotype	43.3	37.6	25.7	0.87	0.59
Male paratype	40.6	24.4	29.3	0.60	0.72
Female paratype	55.0	36.8	40.3	0.67	0.73
Female paratype	43.2	28.9	31.5	0.67	0.73



Distribution. The species is currently known only from the type locality, in the Acarai Mountains, in southern tip of Guyana, near the border with Brazil (Figure 5).

Ecological notes. According to the data on the collection label and the areas surveyed during the October 2006 Southern Guyana RAP Expedition (Alonso et al., 2008), this species was found within the Site 1, situated at the foothills of the Acarai Mountains, at an elevation of approximately 270 m along the Sipu River (see map in Alonso et al., 2008, p. 21). This area is characterized by sandy, oligotrophic soils, with lowland evergreen, deciduous forests that do not inundate seasonally or throughout the year. The specimens were

found in a marginal pool of the Acarai Creek (Figure 6), a small forest stream with clear, nutrient-poor waters, with very low conductivity, barely close to 1 $\mu\text{s}/\text{cm}$, temperature 23.9 °C, acidic waters (pH = 5.34), with 8 mg/l of dissolved oxygen content (C. A. Lasso, personal communication, 2025).

MOLECULAR ANALYSES

The genetic distance matrix showed a range of 0.34–22.6% among the species available for this study (Table 3). When comparing *K. marthacamposae* sp. nov. with its congeners, the smallest distance was 12.6% from *K. latifrons*, and the greatest was 16.1% from *K. attenboroughi*.

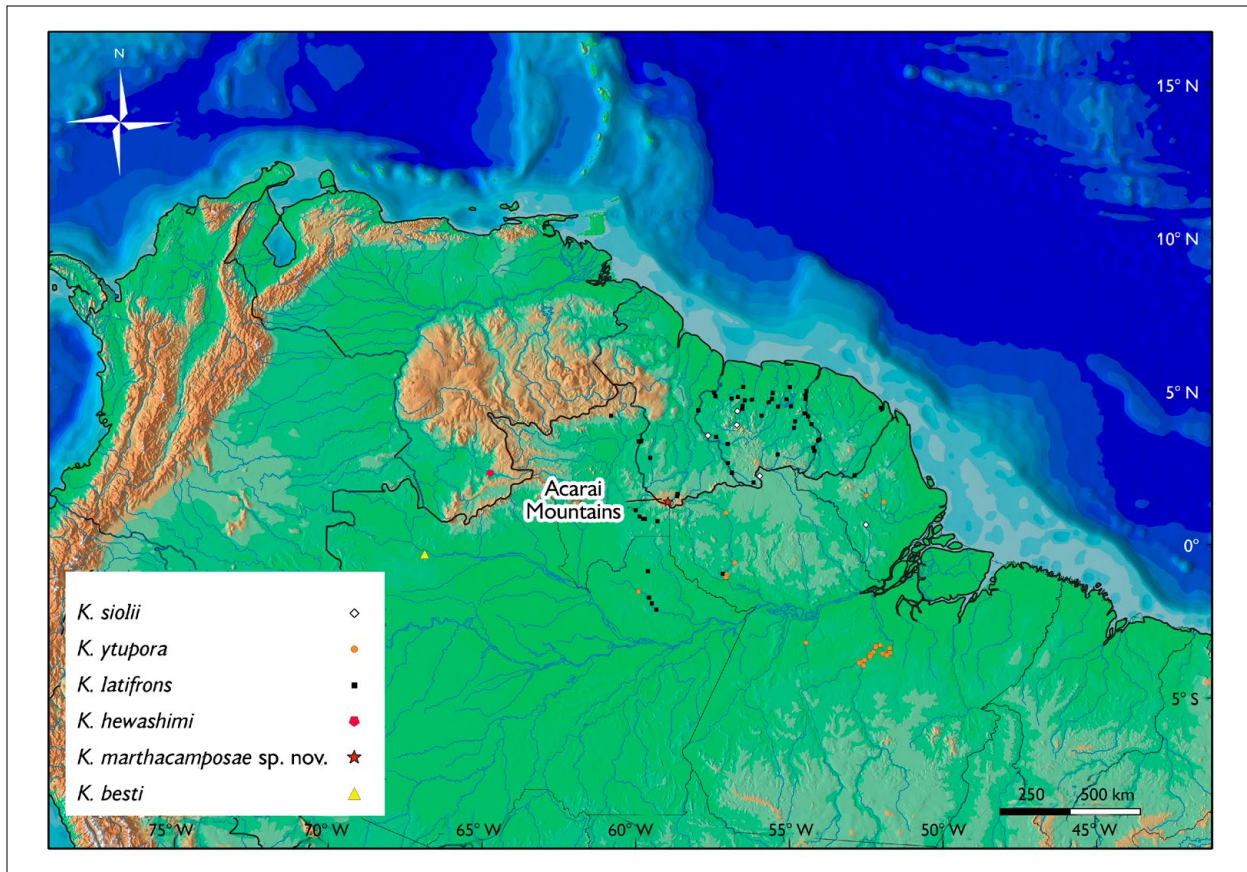


Figure 5. Map of northern South America depicting the geographic distribution of *Kingsleya* species occurring in the northern tributaries of the Amazon River, upper Orinoco River basin, and coastal basins of northern South America as recorded by Holthuis (1959), Rodriguez (1982), Magalhães (1986, 1990), Magalhães and Türkay (2008), Magalhães et al. (2014), Lasso et al. (2008), Vieira (2008), Zanetti et al. (2018) and present work (*K. ytuporta* also occurs in southern tributaries of the Amazon River). Map: C. Magalhães (2025).





Figure 6. Collection locality of the type specimens of *Kingsleya marthacamposae* sp. nov. from a forest stream on the Acarai Mountains, southern Guyana: A) Acarai Creek; B) marginal pool where the specimens were found. Image credits: Celsi Señaris (2006).

Table 3. Genetic distance values for the COI gene between sequences of *Kingsleya marthacamposae* sp. nov., and some from congeners either available in GenBank or new generated in this study (with an asterisk*).

Species	1	2	3	4	5	6	7	8	9	10
<i>Kingsleya marthacamposae</i> n. sp. *										
<i>K. attenboroughi</i> INPA 2208 *	16.1									
<i>K. latifrons</i> RMNH 41765	12.6	15.0								
<i>K. latifrons</i> INPA 329 *	13.2	15.0	9.57							
<i>K. ytupora</i> INPA 1269 *	14.0	15.4	9.94	8.71						
<i>Fredius fittkai</i> INPA 1330	14.5	16.8	13.2	12.8	13.4					
<i>F. fittkai</i> INPA 1546	14.5	17.2	12.3	11.9	13.0	3.00				
<i>F. buritizatillis</i> CCDB 2951	14.4	16.5	11.8	12.6	12.7	8.40	9.98			
<i>F. buritizatillis</i> CCDB 342	14.0	16.1	11.4	12.4	12.3	8.40	9.98	0.34		
<i>Achlidon agrestis</i> CCDB 4556	19.2	21.0	19.2	18.9	18.7	14.8	16.1	15.4	15.4	
<i>Ptychophalus uncinatus</i> UCR-MZ 170	17.1	22.6	16.3	18.1	16.1	16.2	16.8	15.0	15.0	9.39

The phylogenetic hypothesis tree based on the COI gene and obtained by Bayesian Inference (Figure 7) recovered *K. marthacamposae* sp. nov. as a sister group with *K. attenboroughi*, and together they form a sister clade to *K. latifrons* and *K. ytupora*. The three species delimitation analyses (Figure 7) produced similar topological

results, identifying nine valid entities. Among the partitions suggested by ASAP, we selected the one with the lowest score, 1.5, which is the most indicated by the algorithm itself. This partition showed congruence with the diagnostic morphological data, and the monophyletic grouping in the phylogenetic analyses better reflects the reality of the data.

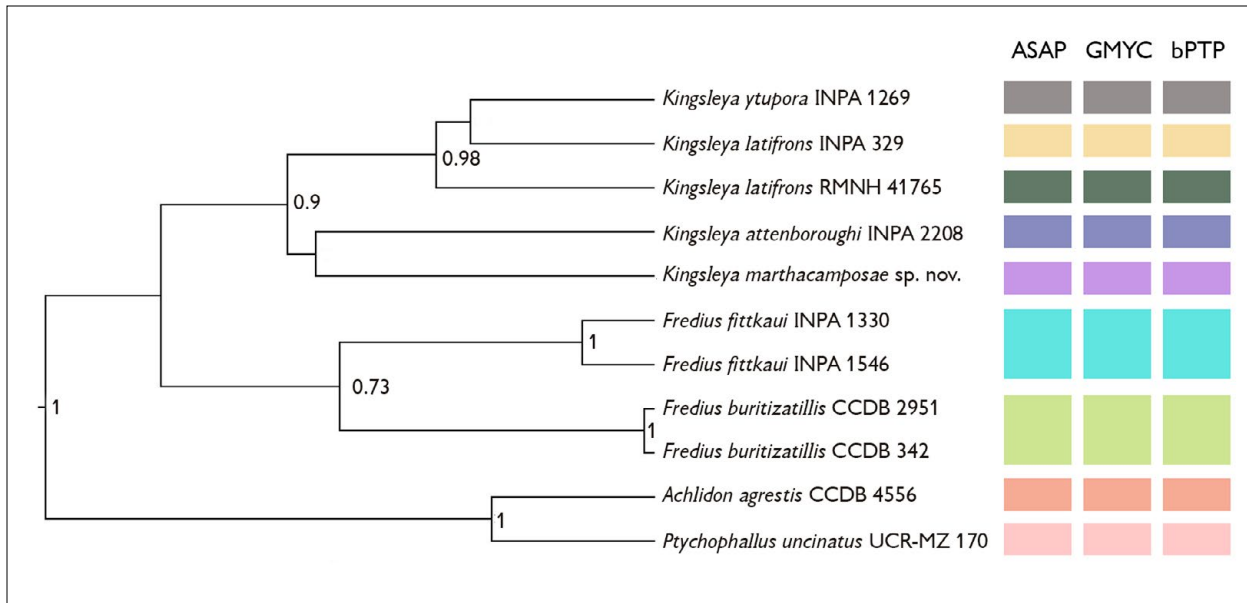


Figure 7. Phylogenetic hypothesis inferred by Bayesian Inference, based on sequences of the COI gene including *Kingsleya marthacamposae* sp. nov. and other congeneric and related species (Álvarez et al., 2020). Branch supports are posterior probability values. Only values equal to or greater than 0.7 are shown. Species delimitation by Assemble Species by Automatic Partitioning (ASAP) (genetic distance analysis), Generalized Mixed Yule Coalescent (GMYC) (Bayesian analysis), and Bayesian Poisson Tree Processes (bPTP). The vertical bars, from left to right, indicate ASAP, GMYC, and bPTP, respectively. Image credit: T. Arantes (2026).

DISCUSSION

MOLECULAR APPROACH

The phylogenetic reconstruction resulting from the COI gene clearly supported the positioning of *K. marthacamposae* sp. nov. as a valid species. However, the *K. attenboroughi* as the closest related species of *K. marthacamposae* sp. nov. (Figure 7) is not quite congruent with the morphological aspects (see below). This incongruity may reflect the heterogeneity of rates among lineages and their distinct evolutionary histories, as discussed for pseudothelphusid freshwater crabs by Álvarez et al. (2020). Moreover, freshwater crab species that are most similar morphologically lack genetic data in gene banks, or vice-versa, leading to important gaps for more accurate results as exemplified by the recent integrative studies on trichodactylid genus *Dilocarcinus* carried out by França et al. (2024, 2025) and the pseudothelphusid genus *Fredius* by Mantelatto et al. (2022)

and Magalhães et al. (2024). Furthermore, paired genetic distances reflect overall sequence similarity rather than shared ancestry, while phylogenetic analyses explicitly model evolutionary processes, which may result in different interpretations of relatedness. *Kingsleya* is a rather diverse genus, and the present analysis is limited to sequences of four species, including the new one herein described, only one-third of its current species composition, and based on a single marker, which is not enough to make conclusive analysis regarding its phylogeny and could account for such discrepancy. A more comprehensive phylogenetic study could better elucidate the relationships within the genus.

TAXONOMIC REMARKS

The new species belongs to the genus *Kingsleya* due to the follow generic diagnostic features present in its G1: apical plate bearing two lamellae, with the mesial (or proximal) lamellae obliquely superimposed to the lateral (or distal) one; marginal process not surpassing the field of apical

spines; mesial process well developed and clearly separated from the apical plate, with the distal portion produced into a conical spine; and the field of apical spines situated laterally.

Some characters of the G1s indicate that *K. marthacamposae* sp. nov. would be morphologically closer to *K. siolii*, *K. hewashimi*, and *K. gustavoii* due to similarities in their marginal process and in the configuration of the mesopleonal surface distal portion. In these species, the marginal process is, relatively to that of other congeneric species, long and rather narrow distally (Figures 2B–2E, 3A–3F; also see Magalhães, 2004, p. 101, figure 1E, 1F [“ma”] for *K. gustavoii*; and Magalhães & Türkay, 2008, p. 234, figure 2a–2d, for *K. hewashimi*), and the distal portion of the pleonal surface ends distally in a subterminal rounded lobe (“sr1” in Figures 2B–2F, 3A–3D), which is clearly separated from the distal lobe of the laterosternal surface (“dl1” in Figures 2B–2F, 3A–3E) by a distinct sulcus that is deeper in *K. marthacamposae* sp. nov., *K. siolii* (see Magalhães 1986, p. 628, figure 5; “lobo lateral” [“ll”]), and *K. hewashimi* (see Magalhães & Türkay, 2008, figure 2b) or shallow in *K. gustavoii* (see Magalhães, 2004, p. 101, figure 1F).

The following unique characters exhibited by the G1's apical plate, however, differentiate *K. marthacamposae* sp. nov. from these three morphologically closest species: (a) the narrowing of the proximal portion of the apical plate's mesial margin (Figures 2A–2G, 3), whereas in *K. gustavoii* and *K. siolii* this portion is enlarged (see Magalhães, 2004, p. 101, figure 1H, 1F and 1I [“cb”], respectively); (b) mesial lamella much shorter, whose length reaches about $0.6 \times$ that of the lateral lamella (Figures 2A–2D, 3A–3D, 3F), whereas in *K. gustavoii* and *K. siolii* the mesial lamella is just a little shorter than the lateral lamella (about $0.9 \times$ and $0.7 \times$ — see Magalhães, 2004, p. 101, figure 1E, 1I, respectively); (c) mesial lamella sharply curved laterally and presenting its mesopleonal surface distinctly concave (Figures 2A–2D, 3A–3D), whereas in *K. gustavoii* and *K. siolii* the mesial lamella is obliquely directed distally [see Magalhães, 2004, p. 101, figure 1E, 1F, 1H and 1I (“pr”), respectively]; (d) lateral lamella

strongly recurved apically at about 90° in lateral view (Figures 2D–2F, 3A–3D), whereas in *K. gustavoii* and *K. siolii* this lamella is positioned nearly straight [see Magalhães, 2004, p. 101, figure 1E, 1H (“dl”) for *K. gustavoii*; and Magalhães, 1986, p. 628, figure 5 for *K. siolii*]; and (e) the short field of apical spines, limited by the strong apical torsion of the lateral lamellae, and positioned almost transversely in the apical plate's lateral surface (Figures 2D, 2E, 3D), whereas in *K. gustavoii* and *K. siolii* the field of apical spines is larger and positioned longitudinally [see Magalhães, 2004, p. 101, figure 1H; and Magalhães, 1986, p. 628, figure 5, respectively].

A narrow apical plate (about $2.7 \times$ longer than wide), a short mesial lamella (about $0.7 \times$ the length of the lateral lamella), and a short field of apical spines limited distally by the strong folding of the lateral lamella are also characters found in the G1 of *K. besti* (see Magalhães, 1990, p. 278, figures 1–3). The notable difference in relation to G1 of *K. marthacamposae* sp. nov. (and all other species of the genus) is that, in *K. besti*, the mesial lobe involves the proximal portion of the lateral lamella along its mesial and (partially) sternal surfaces. These species also differ from each other regarding (a) the mesial process with a subtriangular shape and the sharp spine is situated medially in *K. besti*, whereas it is rounded, with the sharp spine positioned distally in the new species, and (b) the marginal process, which is short and broad, with its inner side turned upwards, in *K. besti*, whereas in the new species it is long and narrow distally, and not turned upwards (*i.e.*, not overlapping the basal portion of the apical plate's mesial lamella).

The narrow apical plate and the somewhat arched field of apical spines are characters also observed in the G1 of *K. hewashimi*, but the G1 of this species clearly differs morphologically from that of *K. marthacamposae* sp. nov. by presenting: (a) a small spine at the base of the proximal portion of the mesial margin of the apical plate (see Magalhães & Türkay, 2008, p. 234, figure 2a, 2d, 2e [“cs”]); (b) the mesial lamella of the apical plate only slightly shorter than the lateral lamella (see Magalhães & Türkay, 2008, p. 234, figure 2c, 2d [“pl” and “dl”]); (c) the field of



apical spines somewhat long and positioned longitudinally in lateral view (see Magalhães & Türkay, 2008, p. 234, figure 2c–2e [“ap”]); and (d) a large, semicircular mesial process with a pointed proximal portion in mesial view (see Magalhães & Türkay, 2008, p. 234, figure 2a [“mp”]) vs. mesial process with rounded proximal portion (Figures 2A, 2B, 2F, 2G, 3A–3C, 3F).

The remaining congeneric species can also be distinguished from *K. marthacamposae* sp. nov. mainly by the characters of the G1’s apical plate. In *K. attenboroughi*, *K. parnaiba* Pralon, Pinheiro & Santana, 2020, *K. latifrons*, and *K. ytupora*, the proximal portion of the apical plate’s mesial margin is enlarged, the mesial lamella is juxtaposed in an oblique position regarding the lateral lamella and its length is only slightly less than that of the lateral lamella, and the apical field of spines is positioned longitudinally on the lateral surface (see Pralon et al., 2020, figure 4, for the first two species, and Magalhães, 1986, figures 7, 8, 11, for the last two). In addition, *K. latifrons* and *K. ytupora* are readily distinguished from the new species by having sharp teeth along the lateral margins of the carapace (see Magalhães, 1986, p. 634, figures 28 and 30, respectively) vs. minute teeth in *K. marthacamposae* sp. nov. (Figure 1A). *Kingsleya castrensis*, *K. celioi* Pedraza & Tavares, 2015, and *K. junki*, all occurring in southern Amazonia, are also easily separated from the new species by exhibiting a very distinct configuration of the apical plate in which it is as wide as it is long, or even slightly wider, with a very widened lateral lamella, and with the proximal margin of the mesial portion of the apical plate rounded or bearing one or more projections (see Pedraza et al., 2015, p. 43, figure 1; Pedraza & Tavares, 2015, p. 447, figure 2A, 2D; Magalhães, 2003, p. 384, figure 1B, 1D, respectively).

It is worth mentioning that the type material of *K. marthacamposae* sp. nov., which belongs to the MHNLS (Caracas, Venezuela), was loaned to the senior author in March 2008. Unfortunately, the MHNLS is currently unable to receive this material back due to momentary political circumstances that are beyond the scope of scientific research. For the time being, it will remain safely

and housed in the crustacean collection of INPA (Manaus, Brazil) until its return to the MHNLS is possible.

ZOOGEOGRAPHIC REMARKS

The discovery of *K. marthacamposae* sp. nov. adds a second species of *Kingsleya* to the Guyanese fauna of pseudothelphusid crabs after 185 years from the first description. Until now, only *K. latifrons* was known to occur in Guyana. Both species are distributed in the upper reaches of the Essequibo River basin. The new species is so far restricted to the Acarai Mountains, in the Sipu River basin, headwater area of the Essequibo River, whereas *K. latifrons* is more widely distributed, having been recorded in the southwest (Dadanawa Crossing, in the upper reaches of the Rupununi River — Rodriguez, 1982) and south (Akuthopono rapids, in the upper Essequibo River — Lasso et al., 2008) of the country (Figure 5). The sympatry of both species in the upper Essequibo River region might be explained by their habitat preferences. *Kingsleya latifrons* is commonly found in rapids and rocky beds of larger rivers (Magalhães, 1986) and, in the upper Essequibo River, it was found in this type of habitat (Lasso et al., 2008). On the other hand, *K. marthacamposae* sp. nov. seems to inhabit small, shadowed streams of upland forests (unaffected by periodic flooding of larger rivers) or in wet, leaf litter-covered areas on the forest floor (Figure 6).

The *Kingsleya* species whose geographic distributions encompass the Guayana Precambrian Shield occur in northern tributaries of the Amazon basin in Brazil, in the upper Orinoco basin in Venezuela, and in Atlantic coastal river basins of Guyana, Suriname and French Guiana. In addition to this new species, five others are distributed in this region: *K. latifrons*, *K. siolii*, *K. besti*, *K. hewashimi*, and *K. ytupora*, although the latter was also recorded from southern tributaries of the Amazon River (Magalhães, 1986, 2003; Magalhães et al., 2018) (Figure 5). *Kingsleya latifrons* has a wide distribution in northern South America, extending into basins draining both the northern and southern slopes of the Guayana Shield in Suriname, French Guiana, and the

Brazilian states of Amazonas, Pará, and Amapá (Rathbun, 1905; Holthuis, 1959, 1993; Bott, 1967; Magalhães, 1986; Vieira, 2008; Magalhães et al., 2009; Zanetti et al., 2018; Poupin, 2024). *Kingsleya siolii* is another species of the genus that exhibits a transbasinal distribution, occurring in basins draining both the northern and southern slopes of the Guayana Shield in Suriname and in Brazil (states of Pará and Amapá) (Holthuis, 1959, in part as *Pseudothelphusa wymani* Rathbun, 1905; Bott, 1967; Magalhães, 1986; Vieira, 2008). *Kingsleya ytuporta* is the only species that, besides occurring in northern tributaries of the Amazon basin, also occur in southern ones (Magalhães, 1986, 2003; Vieira, 2008; Magalhães et al., 2018) (Figure 5). *Kingsleya besti* and *K. hewashimi* are so far only known from their type localities in the Curicuriari Mountains (upper Negro River basin, Brazil) and upper Orinoco River basin (Venezuela), respectively.

The only available record of *K. marthacamposae* sp. nov. points to a restricted distribution, currently limited to the northern slope of the Acarai Mountains range whose drainage area encompasses the headwaters of the Essequibo River (Figure 5). The Acarai Mountains are a low range running in east-west direction for about 130 km along the Guyana/Brazil border, reaching an elevation a little over 1,000 m and constituting a water divide between the Essequibo basin to the north and the Amazon basin to the south and southwest, where it is the source of some northern tributaries of Amazon basin (e.g., Anauá River, which flows into the lower Branco River basin, or Jatapu River, an affluent of the Uatumã River, a tributary of the Amazon River). Since *K. latifrons* occurs in these basins (Zanetti et al., 2018; Figure 5), it would not be at all unlikely that the new species would also be found in the headwater region of these tributaries belonging to the Amazon basin.

The diversity of *Kingsleya* is now constituted by 12 species in the Neotropical region (DecaNet, 2026), but we are convinced that it is underestimated. In addition, the phylogenetic knowledge of this genus is very limited to the contextualization carried out by Álvarez et al. (2020) using only two species of the genus to compound the definition

of the subfamily Kingsleyinae. In this way, this is the first and preliminary molecular approach devoted to the genus and a more complete phylogenetic study is necessary to elucidate the relationship between species and the evolution of the genus in the Neotropic.

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AUTHOR'S CONTRIBUTION

C. Magalhães contributed to conceptualization, data curation, formal analysis, investigation, methodology, validation, and writing (original draft, review & editing); T. Arantes contributed to formal analysis and writing (review and editing); and F. L. Mantelatto contributed to project administration, funding acquisition, formal analysis and writing (review and editing).



Echinodermata Collection from the Museu Paraense Emílio Goeldi: new research on the Amazonian biodiversity heritage

Coleção de Echinodermata do Museu Paraense Emílio Goeldi: uma nova pesquisa sobre o patrimônio da biodiversidade amazônica

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Abstract: Natural history museums play a vital role in biodiversity research and conservation by preserving the natural heritage and documenting historical and current biodiversity. The *Museu Paraense Emílio Goeldi* (MPEG) is the oldest scientific institution in the Amazon, and one of its main focuses is the maintenance of scientific collections with a strong regional character. This study introduces the first data on echinoderms from the MPEG scientific collection, including valuable information for the northern region of Brazil. In preparing the checklist, a thorough inventory of all echinoderms specimens in the collection was conducted. The taxonomy was reviewed, and specimens were identified at the lowest possible taxonomic level. The survey recorded 281 specimens belonging to five classes, 13 orders, 20 families, 24 genera, and 32 species, with 15 new records for the Amazon. Specimens were recorded from a variety of habitats, ranging from the intertidal zone of sandy beaches to the Great Amazon Reef System. The taxonomic list (including images for each identified species) and ecological information provided on echinoderms are an important base for future research in the Atlantic Amazon, representing the first catalogue in this biome, which is a strategic area for conservation of global marine biodiversity.

Keywords: Amazon coast. Catalogue. Checklist. Marine invertebrates. Mouth of the Amazon. Echinoderms.

Resumo: Os museus de história natural desempenham um papel vital na pesquisa e conservação da biodiversidade, preservando o patrimônio natural e documentando a biodiversidade histórica e atual. O Museu Paraense Emílio Goeldi (MPEG) é a instituição científica mais antiga da Amazônia e um de seus principais focos é a manutenção de coleções científicas de forte caráter regional. Este estudo apresenta os primeiros dados sobre equinodermos da coleção científica do MPEG, representando o primeiro inventário oficial de espécies para a região Norte do Brasil. Para a elaboração da lista, foi realizado um levantamento completo de todos os espécimes de equinodermos da coleção. A taxonomia foi revisada, e os espécimes foram identificados no nível taxonômico mais baixo possível. O levantamento registrou 281 espécimes pertencentes a cinco classes, 13 ordens, 20 famílias, 24 gêneros e 32 espécies, com 15 novos registros para a Amazônia. Os espécimes foram registrados em uma variedade de *habitats*, que vão desde a zona entre-marés de praias arenosas até o Grande Sistema Recifal da Amazônia. A lista taxonômica (incluindo imagens para cada espécie identificada) e as informações ecológicas fornecidas sobre os equinodermos são uma base importante para futuras pesquisas no Atlântico amazônico, representando o primeiro catálogo neste bioma, que é uma área estratégica para a conservação da biodiversidade marinha global.

Palavras-chave: Costa amazônica. Catálogo. *Checklist*. Invertebrados marinhos. Foz do Amazonas. Equinodermos.

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INTRODUCTION

The phylum Echinodermata (from the Greek echino = spine and derma = skin) comprises coelomate, non-segmented, deuterostome, and exclusively marine invertebrates (Giribet & Edgecombe, 2020; Pawson, 2007). The synapomorphies of the group include calcareous endoskeleton, pentaradial symmetry in adults, water vascular system, and the presence of mutable connective tissue (Benavides-Serrato et al., 2011; Pawson, 2007). This phylum is a diverse and cosmopolitan group of marine animals, widely distributed across various latitudinal and depth gradients, and are classified as benthic fauna (Pawson, 2007). They inhabit a variety of substrates and many species live on rocky coasts, beaches, bays, and subtidal zones, including the deep-sea. Small species are usually found associated with algae, rhodolith beds, and coral reefs, where young and adult specimens can coexist (Silva et al., 2025; Stevenson et al., 2025).

Echinodermata has about 7,300 extant species and 15,000 extinct species (Appeltans et al., 2012; WoRMS Editorial Board, 2025). Living echinoderms are classified into the classes Crinoidea (sea lilies and feather stars), Asteroidea (sea stars), Ophiuroidea (brittle stars and basket stars), Echinoidea (sea urchins, sand dollars and heart urchins), and Holothuroidea (sea cucumbers) (Pawson, 2007; WoRMS Editorial Board, 2025). Along the Brazilian coast, about 380 species occur (R. B. Moura et al., 2025), most of them reported for the Southeastern coast and the eastern coast of the Northeastern region (Barboza & Borges, 2012; R. B. Moura et al., 2025; Ventura et al., 2013), whereas information on species from the northern region remains scarce. Overall, the number of echinoderm species recorded in Brazil is relatively low considering the extent of the country's coastline, which may be attributed to the limited number of specialists as well as to the insufficient knowledge regarding species occurrence and distribution.

Few studies have been conducted addressing the distribution of echinoderms from Brazil; this is partly because there is a dearth of trustworthy data on taxonomy and distribution ranges (Ventura et al., 2013). Some inventories with a broad taxonomic scope, along with initiatives aimed at developing reliable databases supported by specialists in the group, such as the *Catálogo Taxonômico da Fauna Brasileira* [Taxonomic Catalog of the Brazilian Fauna] (CTFB) (Boeger et al., 2024) and the *Banco de Dados da Biodiversidade de Equinodermos da Paraíba* [Echinoderm Biodiversity Database of Paraíba] (DataPB – *Biodiversidade da Paraíba*) (Prata et al., 2025), may soon change this scenario. Nonetheless, there is no research specifically focused on echinoderms from the Amazon coast.

Natural history museums and their biological collections are essential for biodiversity research and conservation (Costa et al., 2021). They serve as repositories of taxonomic, genetic, and biogeographical knowledge, documenting the natural heritage and evolution of species (Andreone et al., 2024; Schmid et al., 2025). When well-organized, these collections provide valuable data for a variety of studies, from taxonomy and the conservation of endangered species to predicting the spread of invasive species and the impact of climate change on biodiversity (Sigwart et al., 2025; Suarez & Tsutsui, 2004; Vilović et al., 2020). Furthermore, technical advances allow samples collected in the past to be reanalysed, answering new scientific questions and reaching a wider audience (Keklikoglou et al., 2019; Schmid et al., 2025).

The *Museu Paraense Emílio Goeldi* (MPEG), founded in 1866, is the oldest museum in the Amazon region and the second oldest in Brazil. It is a Brazilian research institution, dependent to the Ministry of Science, Technology, Innovations, and Communications (MCTI) that focuses on studying the natural and sociocultural systems of the Amazon, while also sharing knowledge and collections related to the



region (Santos et al., 2019). The Zoological Collections of the MPEG cover all major groups of vertebrates and invertebrates, totalling more than one million records (Santos et al., 2019). Despite the MPEG having a large collection of invertebrates, about 95% of these records correspond to terrestrial insects (Santos et al., 2019). In particular, the collections of marine invertebrates are recent and still lack greater taxonomic accuracy, since there are few specialists in the region (Santos et al., 2019), a reality that is repeated across most of Brazil (Marinoni et al., 2024).

This study introduces the first data on echinoderms from the *Museu Paraense Emílio Goeldi's* scientific collection, in which specimens were identified at the lowest possible taxonomic level, based on the Brazilian Amazon coast, mainly including records from the Great Amazon Reef System (GARS).

MATERIAL AND METHODS

The samples in this study come from the MPEG Echinodermata scientific collection, voucher numbers 0001 to 0065, including the acronym MPEG.ECH (in the internal database, the labels have this designation). The Scientific Biological Collections of the MPEG are subdivided into several collections and, as it is one of the Brazilian institutions with the largest amount of computerised and published data on biodiversity platforms, with more than 844,000 records (SiBBR, 2026). It has an organisational structure in its database that uses three letters after the institutional acronym when it is necessary to distinguish between collections. In this case, the Echinodermata Collection is registered with the acronym 'MPEG' followed by '.ECH' which will not be used throughout this study as it is the only collection being analysed.

The specimens are stored in sliding steel cabinets, separated by class, arranged in alphabetical order. The organisms are preserved in 70% ethanol, except for one specimen (MPEG.ECH 0055) which is preserved dry.

The Echinodermata specimens in the MPEG collection were collected in the northern region of Brazil, especially from the Great Amazon Reef System (GARS) (Figure 1). Additionally, some specimens have been recorded from the intertidal zones of sandy beaches and estuaries. Specimens from the continental shelf were captured as bycatch during fishing for pink shrimp [*Penaeus (Farfantepenaeus) subtilis* Pérez Farfante, 1967] between the years 2015 and 2017, and the fish red snapper (*Lutjanus* spp.) in 2022. Other records are from the samplings of the PIATAM-Oceano Project (*Potenciais Impactos Ambientais da Exploração, Produção e Transporte do Petróleo e Derivados na Região Oceânica Equatorial Brasileira*) that had expeditions carried out in 2008.

The specimens were identified at the lowest possible taxonomic level. Inaccuracies in the specimen data were corrected, new labels were prepared, and the collection was systematically organized. The list of Echinodermata at the MPEG was organized by the systematic arrangements of World Register of Marine Species database (WoRMS Editorial Board, 2025), with genera and species following alphabetical order.

RESULTS

The collection of Echinodermata at the MPEG comprises 281 catalogued specimens (65 records), representing 32 species across the five extant classes of echinoderms: Crinoidea, Asteroidea, Ophiuroidea, Echinoidea, and Holothuroidea (Table 1). The class Ophiuroidea (121 specimens; 26 records, and 13 species), Echinoidea (134 specimens, 17 records, and 5 species), and Asteroidea (15 specimens, 13 records, and 9 species) are the most represented. Most Echinodermata records in the MPEG collection (~75%; 49 records) come from the continental shelf, notably off the Amapá and Pará coastlines. Regarding species richness, 22 species were recorded off the coast of Amapá, followed by 12 species in Pará, and nine species in Maranhão (Table 1).



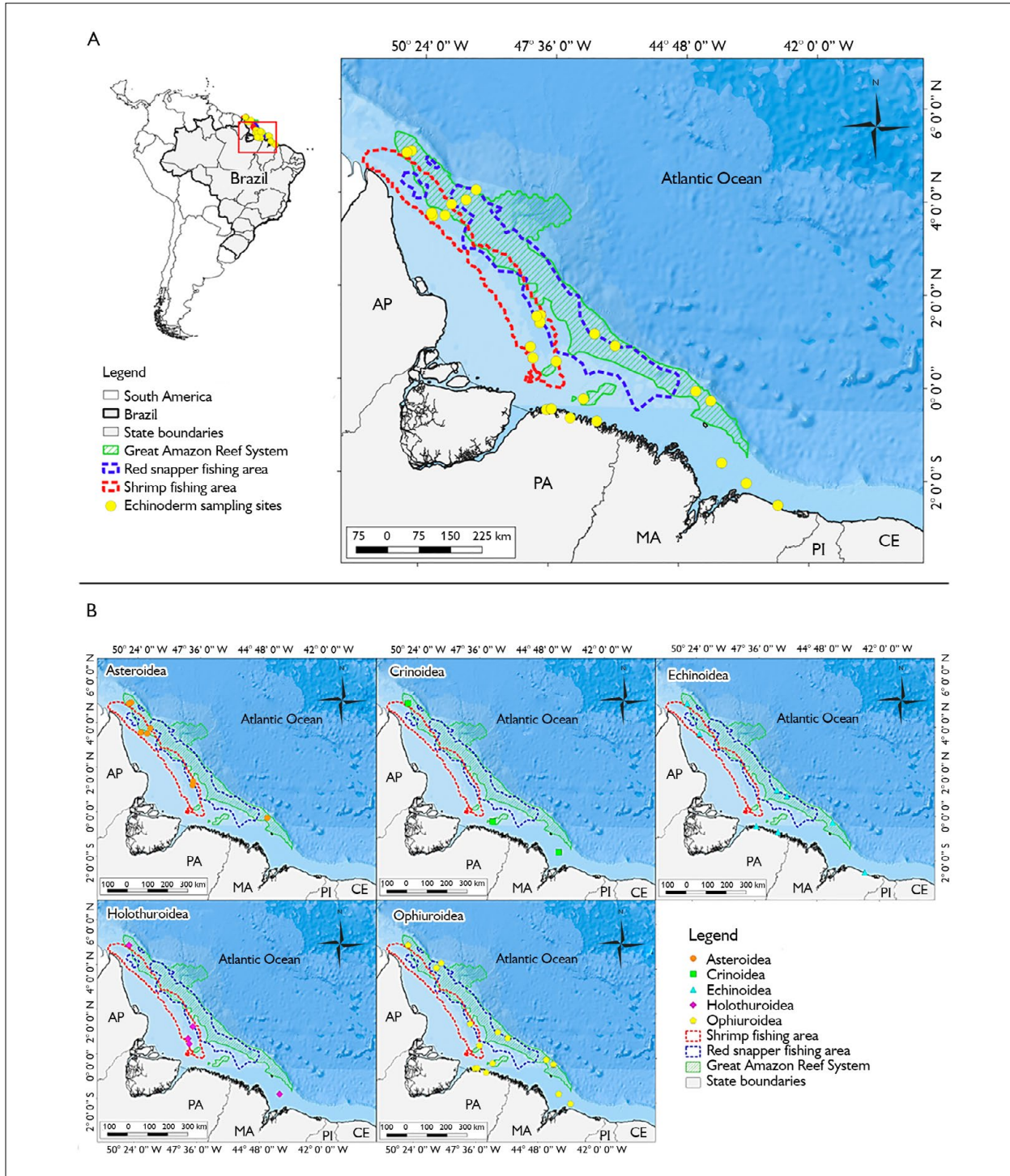


Figure 1. Map of the Brazilian Amazonian Coast, showing the locations of echinoderms sampling stations from the MPEG scientific collection: A) general overview of sampling stations; B) sampling stations identified by taxonomic class. Brazilian states are represented by acronyms: AP = Amapá, PA = Pará, MA = Maranhão. Source: Authors (2025).

Table 1. Species catalogued in the Echinodermata collection of MPEG. Information is provided on specimen counts (N° ind.), collection records (N. records), *habitat*, and occurrence (x) across the states of the Brazilian Amazon coast (AP = Amapá; PA = Pará; MA = Maranhão). Source: Author (2025). (Continue)

<i>Taxa</i>	N° ind.	N° records	Habitat informations	AP	PA	MA
CLASS CRINOIDEA						
Comatulidae						
<i>Comactinia echinoptera</i> (Müller, 1840)	3	2	Continental shelf, biogenic substrates (rhodoliths), at 31 and 122 meters	x		x
Tropiometridae						
<i>Tropiometra carinata</i> (Lamarck, 1816)	1	1	Continental shelf, at 27 meters		x	
CLASS ASTEROIDEA						
Luidiidae						
<i>Luidia alternata</i> (Say, 1825)	1	1	Continental shelf, biogenic substrates (rhodoliths), at 122 meters	x		
<i>Luidia clathrata</i> (Say, 1825)	2	2	Continental shelf, muddy bottom, biogenic substrates (rhodoliths), at 122 meters	x		
<i>Luidia senegalensis</i> (Lamarck, 1816)	1	1	Continental shelf, muddy bottom	x		
Astropectinidae						
<i>Astropecten brasiliensis</i> Müller & Troschel, 1842	1	1	Continental shelf, muddy bottom	x		
<i>Astropecten marginatus</i> Gray, 1840	1	1	Continental shelf, muddy bottom		x	
Goniasteridae						
<i>Goniaster tessellatus</i> (Lamarck, 1816)	3	2	Continental shelf, muddy bottom, biogenic substrates (rhodoliths), at 122 meters	x		
Ophidiasteridae						
<i>Narcissia trigonaria</i> Sladen, 1889	2	1	Continental shelf, biogenic substrates (rhodoliths), at 80 meters	x		
Echinasteridae						
<i>Echinaster (Othilia) guyanensis</i> A. M. Clark, 1987	2	2	Continental shelf, muddy bottom, biogenic substrates (rhodoliths), at 80 meters	x	x	
<i>Echinaster (Othilia) spinulosus</i> Verrill, 186	1	1	Continental shelf, muddy bottom; biogenic substrates (rhodoliths), at 80 meters	x		
CLASS OPHIUROIDEA						
Gorgonocephalidae						
<i>Asteroporpa (Asteroporpa) annulata</i> Örsted & Lütken, 1856	4	1	Continental shelf, biogenic substrates (rhodoliths), at 122 meters	x		
<i>Asteroporpa</i> sp.	1	1	Continental shelf, biogenic substrates (rhodoliths), at 122 meters	x		
<i>Astrophyton muricatum</i> (Lamarck, 1816)	2	2	Continental shelf, biogenic substrates (rhodoliths), at 122 meters	x		
<i>Gorgonocephalidae</i> sp.	1	1	Continental shelf, muddy bottom	x		
Ophiomyxidae						
<i>Ophiomyxa</i> sp.	1	1	Continental shelf, biogenic substrates (rhodoliths), at 122 meters	x		

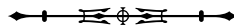
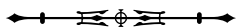


Table 1. (Conclusion)

<i>Taxa</i>	Nº ind.	Nº records	Habitat informations	AP	PA	MA
Amphiuridae						
<i>Amphiodia planispina</i> (von Martens, 1867)	1	1	Continental shelf, at 63 meters		x	
<i>Ophiocnida scabriuscula</i> (Lütken, 1859)	1	1	Continental shelf, at 27 meters		x	
<i>Ophiostigma isocanthum</i> (Say, 1825)	1	1	Continental shelf, at 50 meters			x
Ophiactidae						
<i>Ophiactis lymani</i> Ljungman, 1872	21	2	Continental shelf, muddy bottom; intertidal zone (Sabellariidae reef)	x	x	
<i>Ophiactis savignyi</i> (Müller & Troschel, 1842)	10	2	Continental shelf, biogenic substrates (rhodoliths), at 31 and 122 meters	x		x
<i>Ophiactis</i> sp.	2	2	Continental shelf, at 63 meters		x	
Ophiotrichidae						
<i>Ophiotrix tommasii</i> Santana, Manso, Almeida & Alves, 2020	66	5	Estuaries; continental shelf, muddy bottom, at 31 meters		x	x
Ophiodermatidae						
<i>Ophioderma cinereum</i> Müller & Troschel, 1842	9	5	Estuaries; continental shelf, muddy bottom, biogenic substrates (rhodoliths), at 55 and 122 meters	x	x	x
CLASS ECHINOIDEA						
Cidaridae						
<i>Eucidaris tribuloides</i> (Lamarck, 1816)	3	3	Estuaries; continental shelf, muddy bottom, biogenic substrates (rhodoliths), at 55 and 122 meters	x		x
Toxopneustidae						
<i>Lytechinus variegatus</i> (Lamarck, 1816)	1	1	Continental shelf, biogenic substrates (rhodoliths), at 122 meters	x		
Mellitidae						
<i>Encope michelini</i> Agassiz, 1841	123	6	Intertidal zone of sandy beach; continental shelf, at 63 meters		x	x
<i>Mellita quinquiesperforata</i> (Leske, 1778)	6	6	Intertidal zone of sandy beaches		x	x
Brissidae						
<i>Meoma ventricosa</i> (Lamarck, 1816)	1	1	Continental shelf, biogenic substrates (rhodoliths), at 122 meters	x		
CLASS HOLOTHUROIDEA						
Cucumariidae						
<i>Thyonella pervicax</i> (Théel, 1886)	4	3	Continental shelf, biogenic substrates (rhodoliths), at 122 meters	x	x	
Phylloporidae						
<i>Stolus pseudofusus</i> (Deichmann, 1930)	1	1	Continental shelf, at 31 meters			x
Synaptidae						
<i>Protankyra</i> sp.	1	1	Continental shelf, muddy bottom	x		



ECHINODERMATA SPECIMENS REGISTERED IN THE MPEG COLLECTION

Phylum Echinodermata Klein, 1778
Class Crinoidea Miller, 1821
Order Comatulida Clark, 1908
Family Comatulidae Fleming, 1828
Genus *Comactinia* Clark, 1909

Comactinia echinopectera (Müller, 1840)
(Figure 2)

Original designation: *Alecto echinopectera* Müller, 1840.

Material examined: Amazon continental shelf (Amapá), 04° 52,668' N, 50° 46,916' W, XI.2022, CEPNOR-ICMBio, collected as bycatch from a red snapper (*Lutjanus* spp.) fishery, 122 meters, biogenic substrates (rhodoliths), 2 ind., MPEG 0013; Continental shelf (Maranhão), 01° 40,687' S, 43° 54,572' W, XI.2008, PIATAM-Oceano Project (#305), NHOc Amorim do Valle, sandy bottom, 31 meters, 1 ind., MPEG 0065.

Distribution: New Caledonia, Indonesia and the Philippines, and the Western Atlantic Ocean, from the USA (at least as far as North Carolina) to Brazil (from the North to the Southeast).

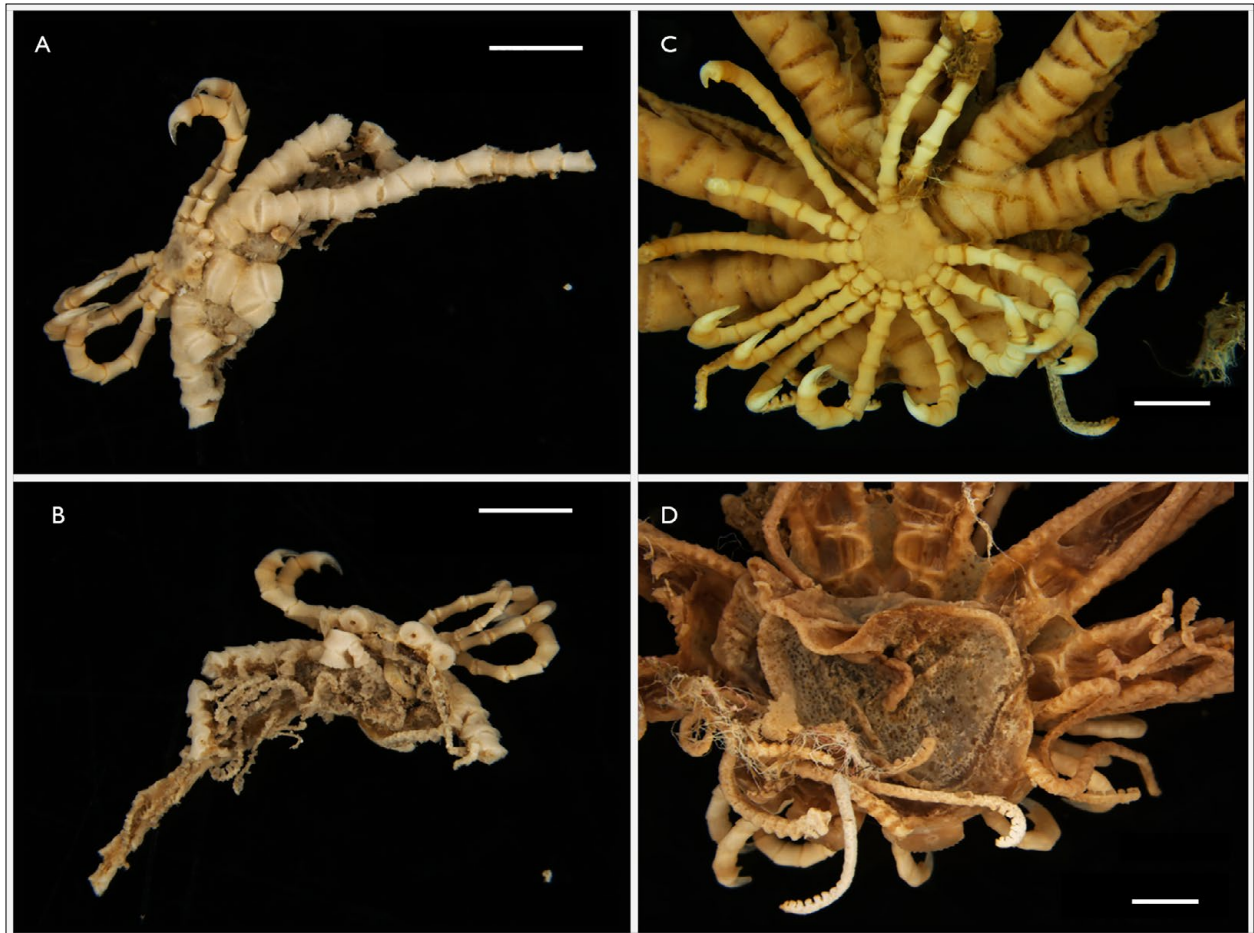


Figure 2. Crinoidea, *Comactinia echinopectera* (A, B: MPEG 0065; C, D: MPEG 0013). General aboral view (A); oral view (B); view of the centrodorsal plate (C); oral view of the central disk (D). Scale bars: 2 mm (A, B); 1 mm (C, D). Source: Authors (2025).

Family Tropiometridae Clark, 1908

Genus *Tropiometra* Clark, 1907

Tropiometra carinata (Lamarck, 1816)

(Figure 3)

Original designation: *Comatula carinata* Lamarck, 1816.

Material examined: Continental shelf (Pará), 0° 21,242' S, 46° 53,949' W, X.2008, PIATAM-Oceano Project (#310), NHOc Amorim do Valle, sandy bottom, 27 meters, 1 ind., MPEG 0060.

Distribution: Indian Ocean, North Coast of South Africa, Egypt, India, from Sri Lanka to South Ninépin Island. Western Atlantic Ocean, Dominican Republic, Lesser Antilles Trinidad and Tobago, Venezuela, North Coast of Brazil (from Amapá to São Paulo, Santa Catarina).

Class Asterozoa De Blainville, 1830

Order Paxillosida Perrier, 1884

Family Luidiidae Sladen, 1889

Genus *Luidia* Forbes, 1839

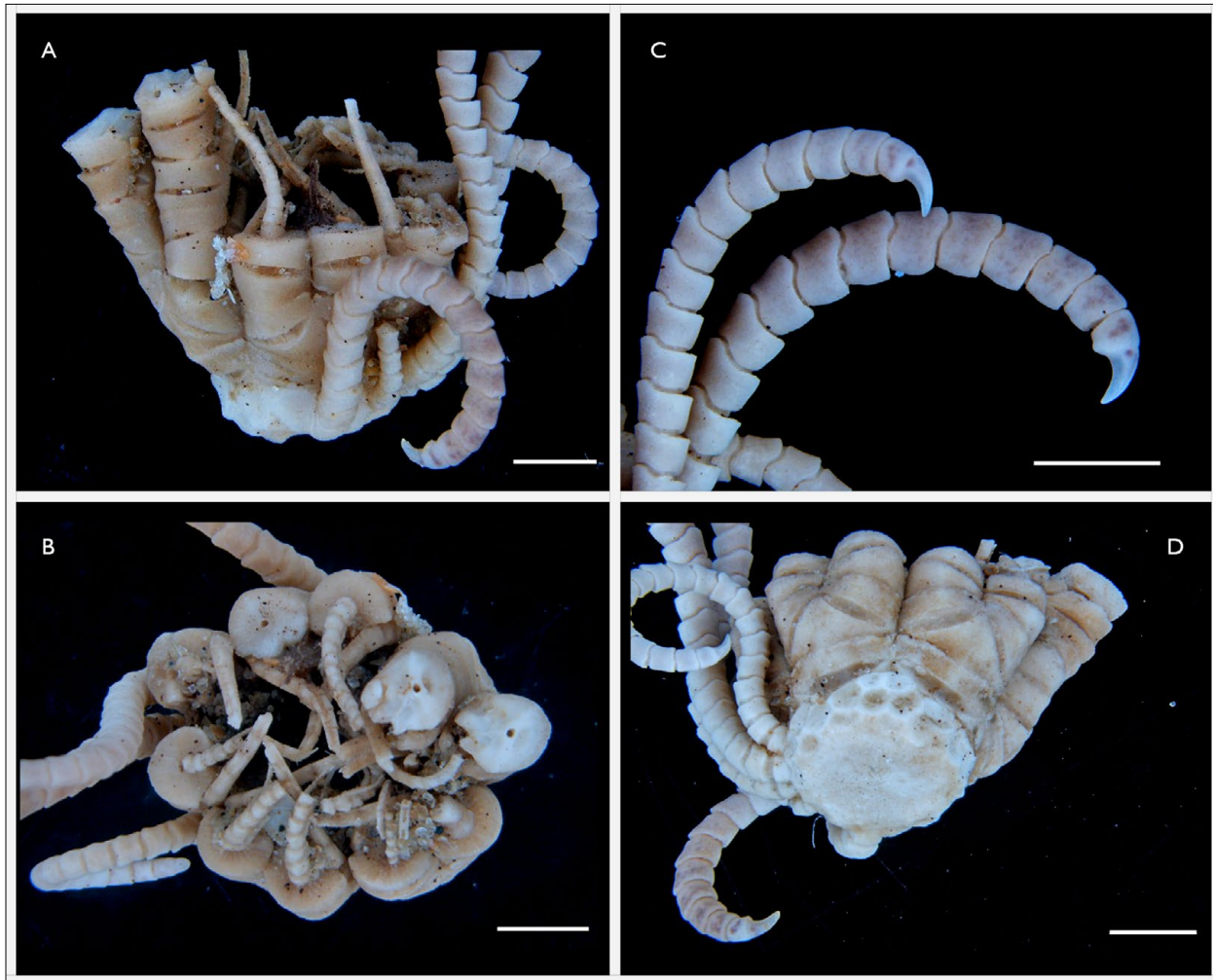


Figure 3. Crinoidea, *Tropiometra carinata* (MPEG 0060). Lateral general view (A); oral view; aboral view (D); detail of the peripheral cirrus (C). Scale bars: 2 mm (A, B); 1 mm (C, D). Source: Authors (2025).

Luidia alternata (Say, 1825)
(Figure 4)

Original designation: *Asterias alternata* Say, 1825.

Material examined: Amazon continental shelf (Amapá), 04°52,668' N, 50° 46,916' W, 01.XI.2022, CEPNOR-ICMBio, collected as bycatch from a red

snapper (*Lutjanus* spp.) fishery, 122 m, biogenic substrate (rhodoliths), 1 ind., MPEG 0054.

Distribution: Vietnam. Western Atlantic from North Carolina, and the Gulf of Mexico to at least Venezuela, Guyana, Suriname, Brazil (Amapá, Rio de Janeiro, Espírito Santo, Bahia), Uruguay (Coastal region, near Castellanos), and Argentina (Mar del Plata, Bahía Blanca).

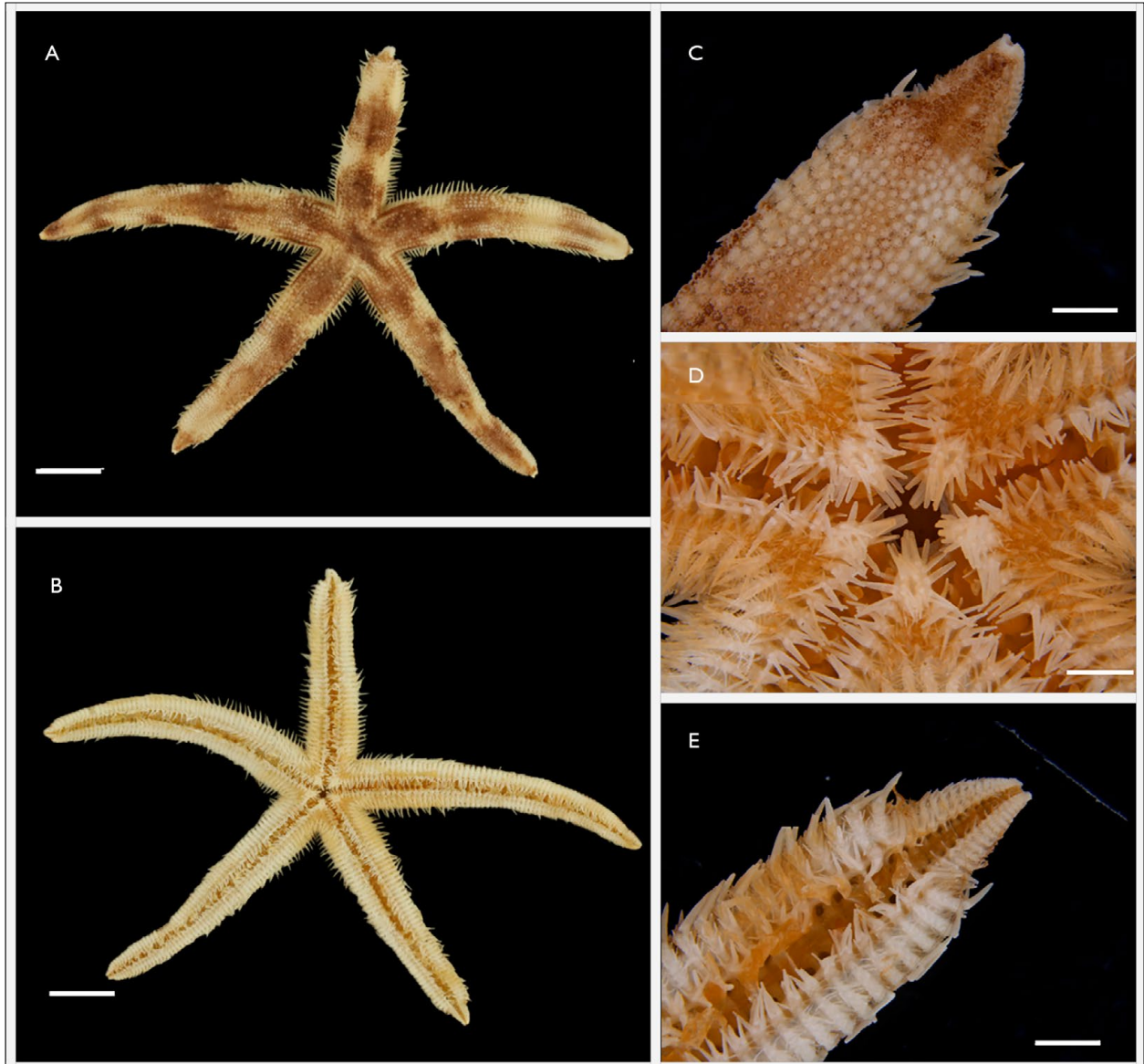


Figure 4. Asteroidea, *Luidia alternata* (MPEG 0054). Abactinal general view (A, C); actinal general view (B); abactinal view of the arm (C); actinal view of the arm (E); in detail the mouth (D). Scale bars: 10 mm (A, B); 2 mm (C-E). Source: Authors (2025).

Luidia clathrata (Say, 1825)
(Figure 5)

Original designation: *Asterias clathrata* Say, 1825.

Material examined: Amazon continental shelf (Amapá), 03° 32,230' N, 49° 56,438' W, 04.VII.2016, Muniz, M., collected as bycatch during pink shrimp (*P. subtilis*), muddy bottom, 1 ind., MPEG 0010; Continental shelf (Amapá), 04° 52,668' N, 50° 46,916' W, 01.XI.2022, CEPNOR-ICMBio, collected as bycatch from a red snapper

(*Lutjanus* spp.) fishery, 122 meters, biogenic substrates (rhodoliths), 1 ind., MPEG 0051.

Distribution: Pacific Ocean, near Teraina Island, and Nha Trang. Western Atlantic Ocean, from Morocco to Gabon, North Carolina (USA) to surrounding the Gulf of Mexico. Venezuela, and Brazil (from the North to the South).

Luidia senegalensis (Lamarck, 1816)
(Figure 6)



Figure 5. Asteroidea, *Luidia clathrata* (A, B: MPEG 0010; C, D: MPEG 0051). Abactinal general view (A); actinal view, in detail the mouth (B); abactinal general view (C); actinal general view (D). Scale bars: 10 mm (A, C, D); 1 mm (B). Source: Authors (2025).



Figure 6. Asteroidea, *Luidia senegalensis* (MPEG 0004). Abactinal general view (A); actinal general view (B); in detail the mouth (C); actinal view of the arm (D); abactinal view of the arm (E). Scale bars: 10 mm (A, B); 2 mm (C-E). Source: Authors (2025).

Original designation: *Asterias senegalensis* Lamarck, 1816.

Material examined: Amazon continental shelf (Amapá), 03° 35,304' N, 50° 13,272' W, 02.VIII.2015, collected as bycatch during pink shrimp (*P. subtilis*), muddy bottom, 1 ind., MPEG 0004.

Distribution: Eastern Atlantic Ocean, Cabinda, Democratic Republic of Congo (near Kibati). Western Atlantic Ocean, from Salt Run, Jacksonville, Gulf of Mexico

to at least French Guiana, Brazil (Amapá, Maranhão, Santa Catarina).

Family Astropectinidae Gray, 1840

Genus *Astropecten* Gray, 1840

Astropecten brasiliensis Müller & Troschel, 1842

(Figure 7)



Original designation: *Astropecten brasiliensis* Müller & Troschel, 1842.

Material examined: Amazon continental shelf (Amapá), 03° 46,80' N, 49° 48,240' W, 05.IX.2016, collected as bycatch during pink shrimp (*P. subtilis*), muddy bottom, 1 ind., MPEG 0008.

Distribution: Antarctica (South Orkney Islands). South Pacific Ocean (Peru). Western Atlantic Ocean, USA (Gulf of California (San Catalina and Monterey Bay), Panama, Mexico, French Guiana, Venezuela (Boca de Aroa), Brazil (Amapá, Ceará, Rio Grande do Norte, Fernando de Noronha, Alagoas, Bahia,

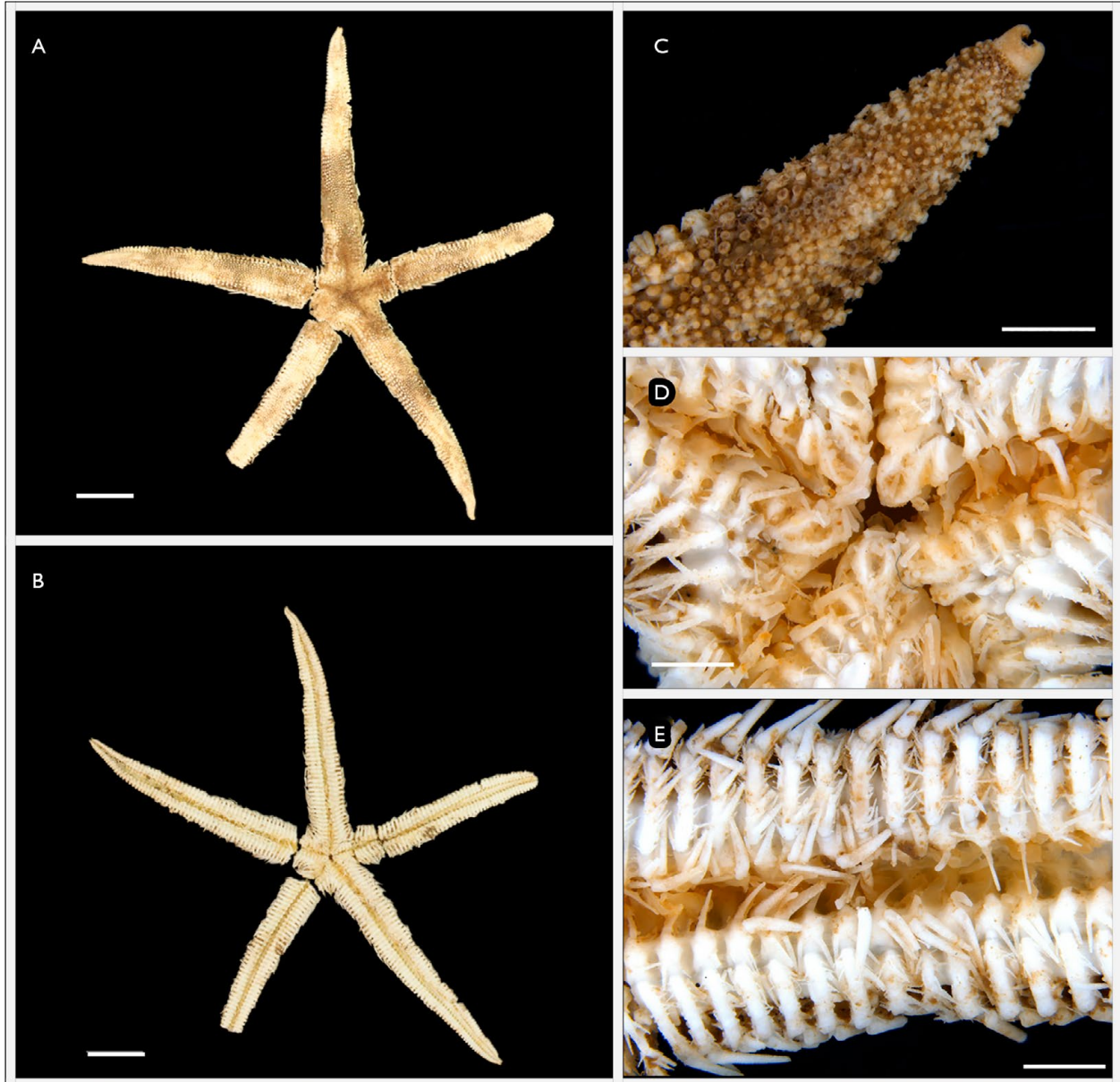


Figure 7. Asteroidea, *Astropecten brasiliensis* (MPEG 0008). Abactinal general view (A); actinal general view (B); in detail the mouth (D); abactinal view of the arm (C); actinal view of the arm (E). Scale bars: 10 mm (A, B); 2 mm (C-E). Source: Authors (2025).

Trindade Island, Rio de Janeiro, São Paulo, Santa Catarina and Rio Grande do Sul), Uruguay (coastal region, Juan Lacaze), and Argentina (Mar del Plata, Costa Bonita, Rio Quequén Grande).

Remark: This is the first record of *Astropecten brasiliensis* on the Amazonian coast.

Astropecten marginatus Gray, 1840
(Figure 8)

Original designation: *Astropecten marginatus* Gray, 1840.

Material examined: Amazon continental shelf (Pará), 01° 15,678' N, 47° 51,923' W, 22.II.2017, collected as



Figure 8. Asteroidea, *Astropecten marginatus* (MPEG 0012). Abactinal general view (A); actinal general view (B); in detail the mouth (E); abactinal view of the arm (C); actinal view of the arm (D). Scale bars: 10 mm (A, B); 2 mm (C-E). Source: Authors (2025).

bycatch during pink shrimp (*P. subtilis*), muddy bottom, 1 ind., MPEG 00012.

Distribution: Indian Ocean (Rwanda). Western Atlantic Ocean, USA (California), North Gulf of Mexico from Suriname, Brazil (Amapá, Pará, from Fortaleza to Santa Catarina), and Uruguay.

Order Valvatida Perrier, 1884
Family Goniasteridae Forbes, 1841

Genus *Goniaster* Agassiz, 1836

Goniaster tessellatus (Lamarck, 1816)

(Figure 9)

Original designation: *Asterias tessellata* Lamarck, 1816.

Material examined: Amazon continental shelf (Amapá), 03° 34,800' N, 50° 14,016' W, 30.VII.2015, collected as bycatch during pink shrimp (*P. subtilis*),

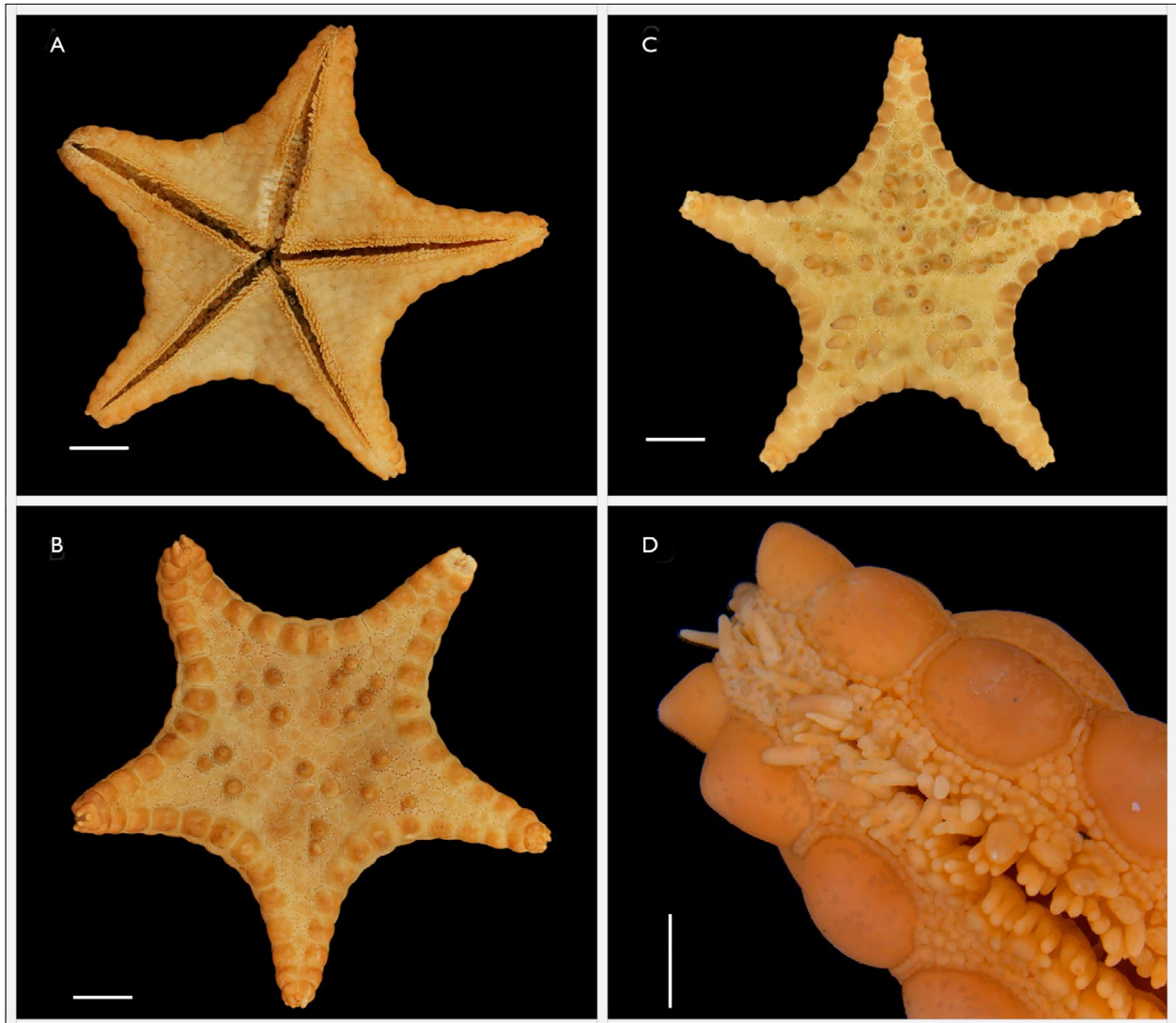


Figure 9. Asteroidea, *Goniaster tessellatus* (A, B: MPEG 0009; C, D: MPEG 0052). Actinal general view (A); abactinal general view (B, C); actinal view of the arm (D). Scale bars: 10 mm (A-B); 2 mm (D). Source: Authors (2025).

muddy bottom, 1 ind., MPEG 00009; Amazon continental shelf (Amapá), 04° 52,668' N, 50° 46,916' W, 01.XI.2022, CEPNOR-ICMBio, collected as bycatch from a red snapper (*Lutjanus* spp.) fishery, 122 meters, biogenic substrates (rhodoliths), 2 ind., MPEG 0052.

Distribution: Eastern Atlantic, Madeira Island, Mauritania to at least Gabon, South Africa. Western Atlantic, from North Carolina to Brazil (Amapá), including the West Indies and Gulf of Mexico.

Family Ophidiasteridae Verrill, 1870

Genus *Narcissia* Gray, 1840

Narcissia trigonaria Sladen, 1889

(Figure 10)

Original designation: *Narcissia trigonaria* Sladen, 1889.

Material examined: Amazon continental shelf (Amapá), 04° 54,894' N, 50° 40,887' W, 06.XI.2022,

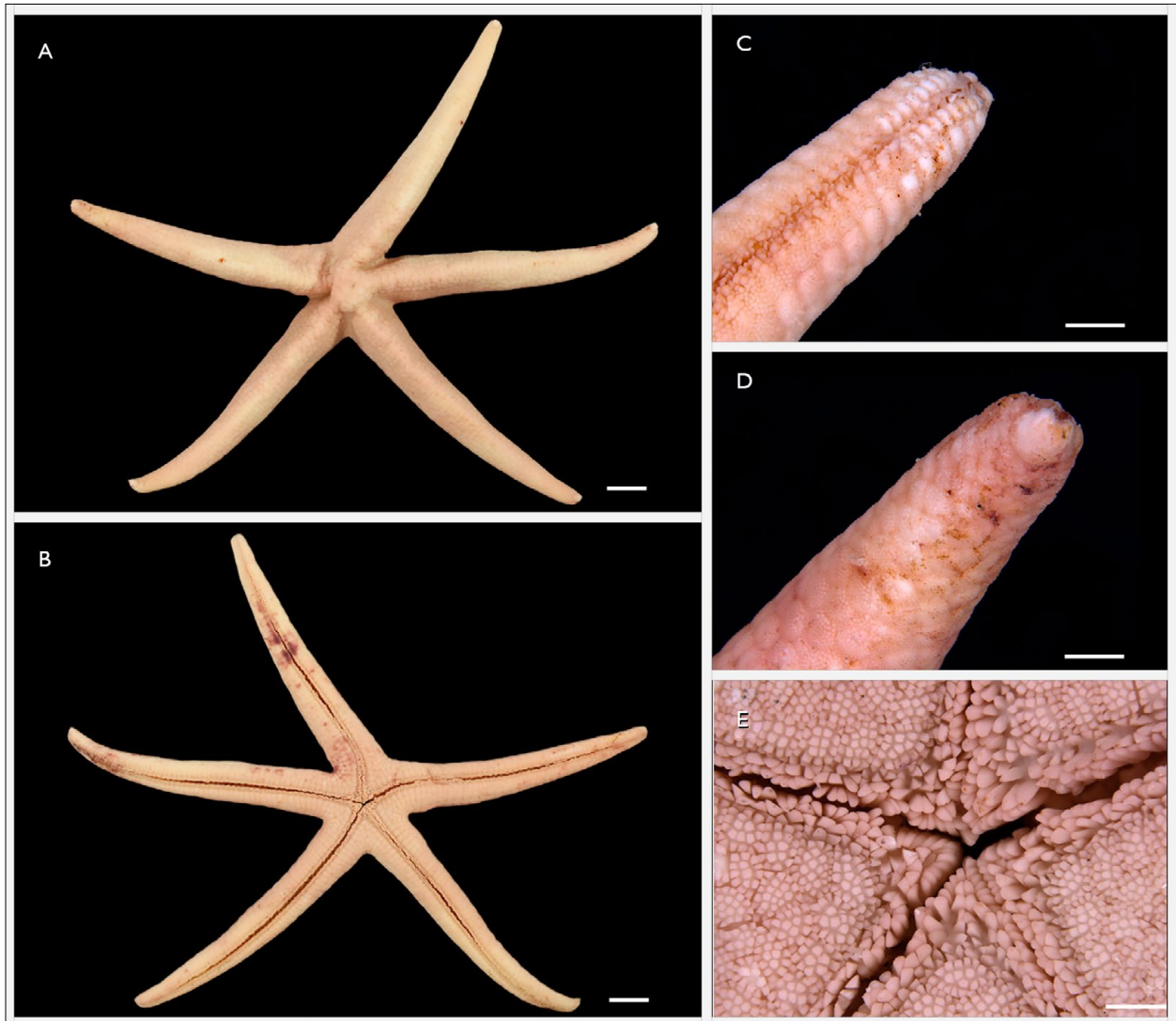


Figure 10. Asteroidea, *Narcissia trigonaria* (MPEG 0048). Abactinal general view (A); actinal general view (B); in detail the mouth (E); actinal view of the arm (C); abactinal view of the arm (D). Scale bars: 10 mm (A, B); 2 mm (C-E). Source: Authors (2025).

CEPNOR-ICMBio, collected as bycatch from a red snapper (*Lutjanus* spp.) fishery, 80 meters, biogenic substrates (rhodoliths), 2 ind., MPEG 0048.

Distribution: Eastern Atlantic Ocean, from Gabon to South Africa (São Tomé and Príncipe). Western Atlantic Ocean, from North Carolina (USA) to the Gulf of Mexico, and Brazil (Amapá, Pará, from Bahia to São Paulo).

Order Spinulosida Perrier, 1884

Family Echinasteridae Verrill, 1867

Genus *Echinaster* Müller
& Troschel, 1840

Echinaster (Othilia) guyanensis A.M Clark, 1987
(Figure 11)

Original designation: *Echinaster (Othilia) guyanensis* A.M. Clark, 1987.

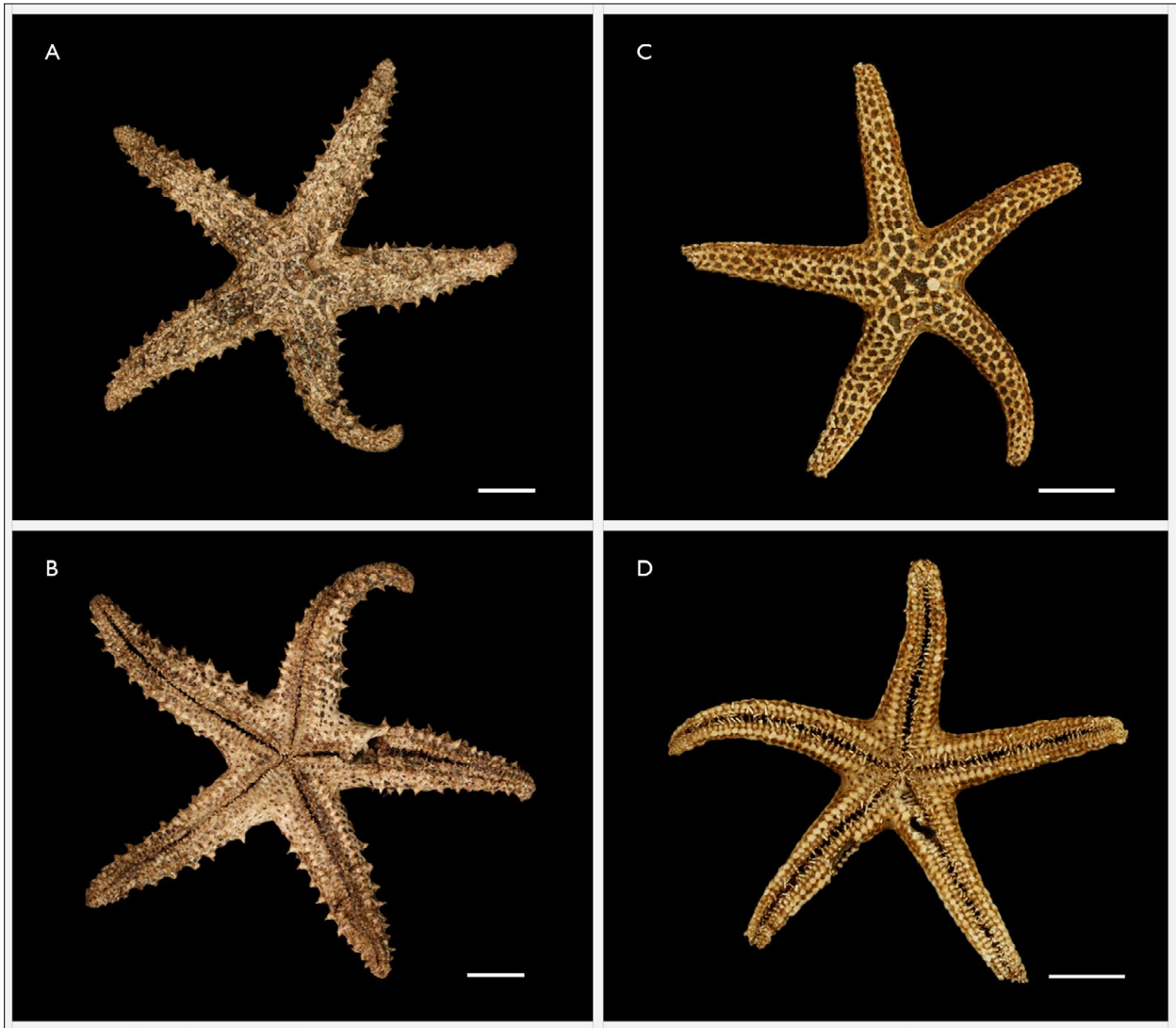


Figure 11. Asteroidea, *Echinaster (Othilia) guyanensis* (A, B: MPEG 0006; C, D: MPEG 0046). Abactinal general view (A, C); actinal general view (B, D). Scale bars: 10 mm. Source: Authors (2025).

Material examined: Amazon continental shelf (Pará), 01° 25,800' N, 47° 51,000' W, 04.III.2017, collected as bycatch during pink shrimp (*P. subtilis*), muddy bottom, 1 ind., MPEG 00006; Continental shelf (Amapá), 04° 54,894' N, 50° 40,887' W, 06.XI.2022, CEPNOR-ICMBio, collected as bycatch from a red snapper (*Lutjanus* spp.) fishery, 80 meters, biogenic substrates (rhodoliths), 1 ind., MPEG 0046.

Distribution: Western Atlantic Ocean, from Central America to Brazil (Amapá, Pará, from Espírito Santos to Rio de Janeiro), Uruguay, and Argentina.

Remark: This is the first record of *Echinaster guyanensis* on the Amazonian coast.

Echinaster (Othilia) spinulosus Verrill, 1869
(Figure 12)

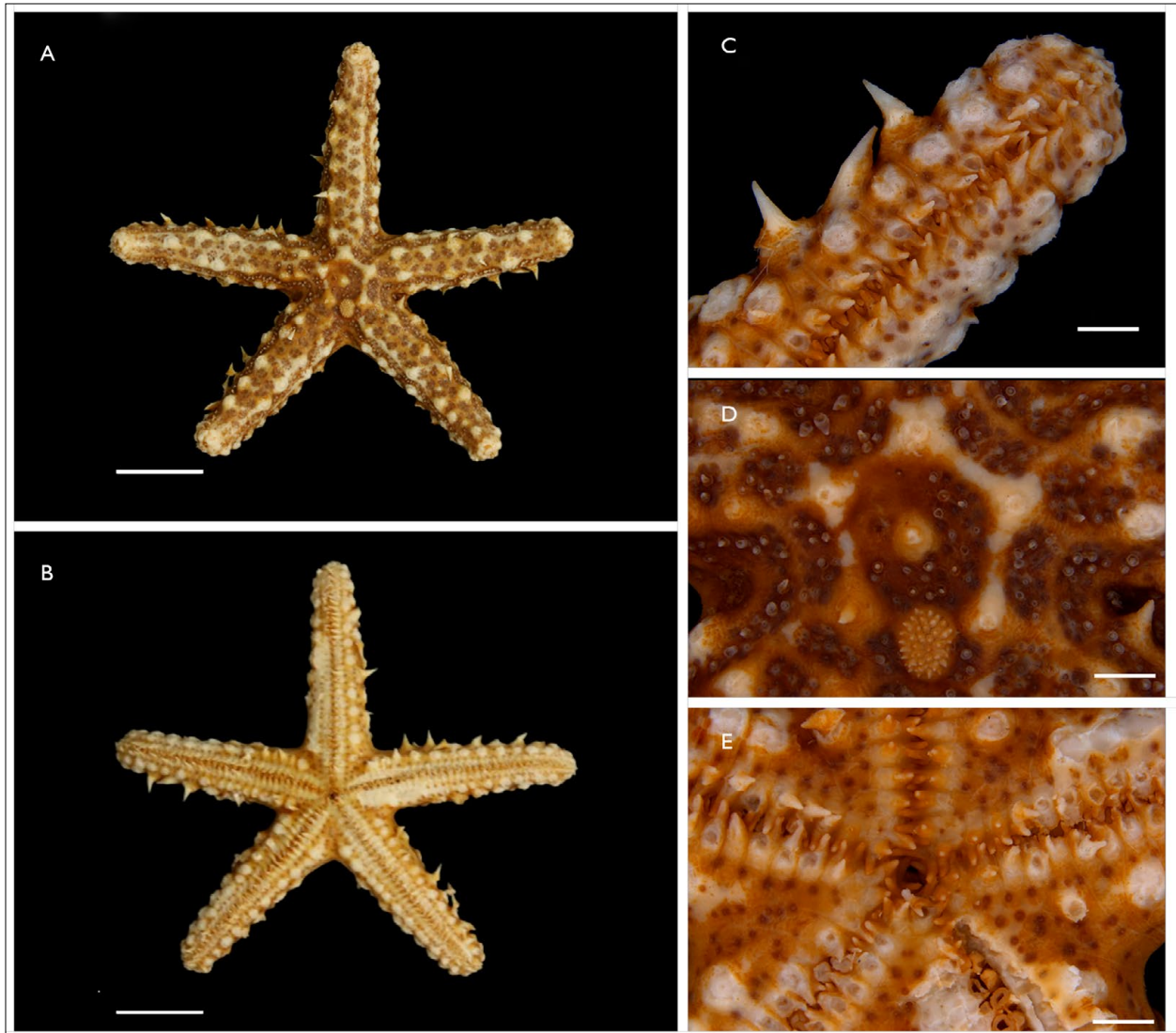


Figure 12. Asteroidea, *Echinaster (Othilia) spinulosus* (MPEG 0042). Abactinal general view (A); actinal general view (B); abactinal view of the arm (C); detailed view of the abactinal surface of the disk (D); detail of the mouth (E). Scale bars: 10 mm (A, B); 2 mm (C-E). Source: Authors (2025).

Original designation: *Echinaster (Othilia) spinulosus* Verrill, 1869.

Material examined: Continental shelf (Amapá), 04° 54,894' N, 50° 40,887' W, 06.XI.2022, CEPNOR-ICMBio, collected as bycatch from a red snapper (*Lutjanus* spp.) fishery, at 80 meters, biogenic substrates (rhodoliths), 1 ind., MPEG 0042.

Distribution: Western Atlantic Ocean, the Caribbean Sea and Gulf of Mexico. Brazil (Amapá, Rio de Janeiro).

Remark: This is the first record of *Echinaster (Othilia) spinulosus* on the Amazonian coast.

Class Ophiuroidea Gray, 1840

Order Euryalida Lamarck, 1816

Family Gorgonocephalidae Ljungman, 1867

Genus *Asteroporpa* Örsted & Lütken, 1856

Asteroporpa (Asteroporpa) annulata Örsted & Lütken, 1856
(Figure 13)

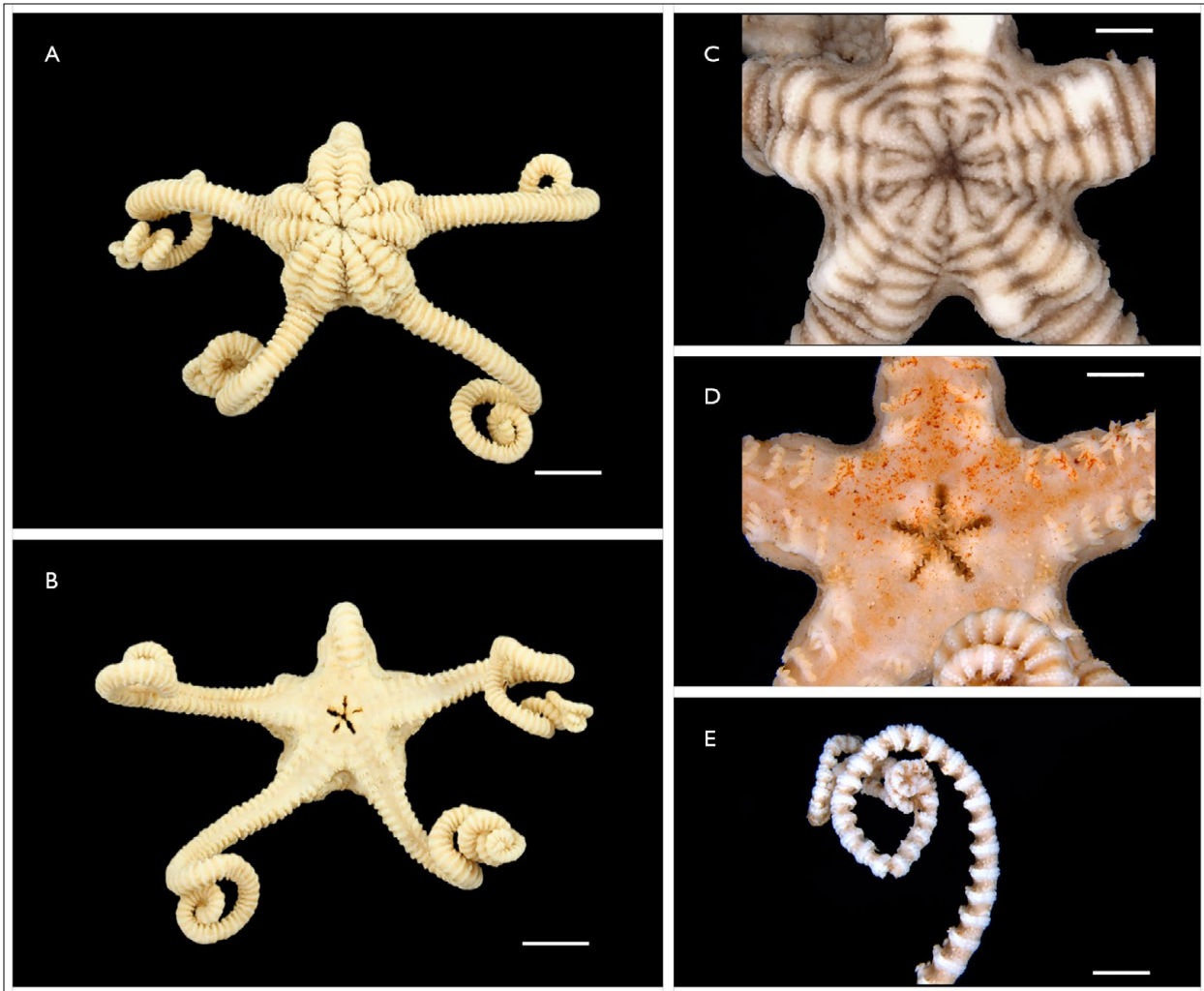


Figure 13. Ophiuroidea, *Asteroporpa (Asteroporpa) annulata* (MPEG 0044). Dorsal general view (A); ventral general view (B); detailed view of the dorsal surface of the disk (C); detail of the mouth (D); lateral view of the arm (E). Scale bars: 10 mm (A, B); 2 mm (C-E). Source: Authors (2025).

Original designation: *Asteroporpa annulata* Örsted & Lütken in Lütken, 1856.

Material examined: Amazon continental shelf (Amapá), 04° 52,668' N, 50° 46,916' W, XI.2022, CEPNOR-ICMBio, collected as bycatch from a red snapper (*Lutjanus* spp.) fishery, 122 meters, biogenic substrates (rhodoliths), 4 ind., MPEG 0044.

Distribution: North Carolina (USA), Bermuda, Bahamas, Gulf of Mexico, Caribbean Sea (Mexican Caribbean, Cuba, Puerto Rico, Panama, Colombia), and Brazil (Amapá, Pará, Rio Grande do Norte).

Asteroporpa sp.
(Figure 14)

Material examined: Amazon continental shelf (Amapá), 04° 52,668' N, 50° 46,916' W, XI.2022, CEPNOR-ICMBio, collected as bycatch from a red snapper (*Lutjanus* spp.) fishery, 122 meters, biogenic substrates (rhodoliths), 1 ind., MPEG 0043.

Genus *Astrophyton* Fleming, 1828

Astrophyton muricatum (Lamarck, 1816)
(Figure 15)

Original designation: *Euryale muricatum* Lamarck, 1816.

Material examined: Amazon continental shelf (Amapá), 04° 52,668' N, 50° 46,916' W, XI.2022,

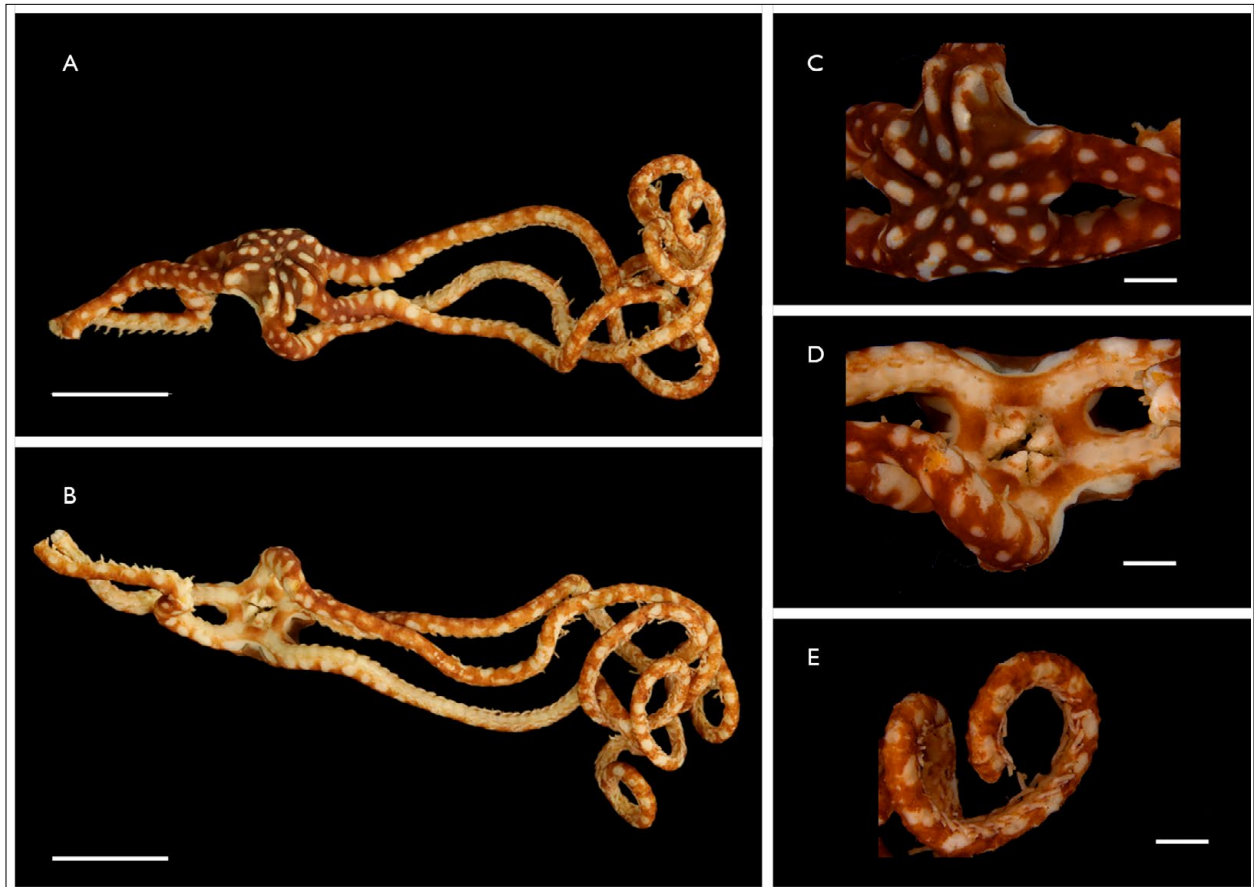


Figure 14. Ophiuroidea, *Asteroporpa* sp. (MPEG 0043). Dorsal general view (A); ventral view (B); detailed view of the dorsal surface of the disk (C); detail of the mouth (D); lateral view of the arm (E). Scale bars: 10 mm (A, B); 2 mm (C-E). Source: Authors (2025).

CEPNOR-ICMBio, collected as bycatch from a red snapper (*Lutjanus* spp.) fishery, 122 meters, biogenic substrates (rhodoliths), 2 ind., MPEG 0045 and MPEG 0053.

Distribution: Red Sea, Egypt. Pacific Ocean, Crescent City (USA). Eastern Atlantic Ocean, France (Roscoff). Western Atlantic Ocean, from North Carolina (USA) to the

Gulf of Mexico, and Brazil (Amapá, Pará, Espírito Santo).

Gorgonocephalidae sp.

(Figure 16)

Material examined: Amazon continental shelf (Amapá),

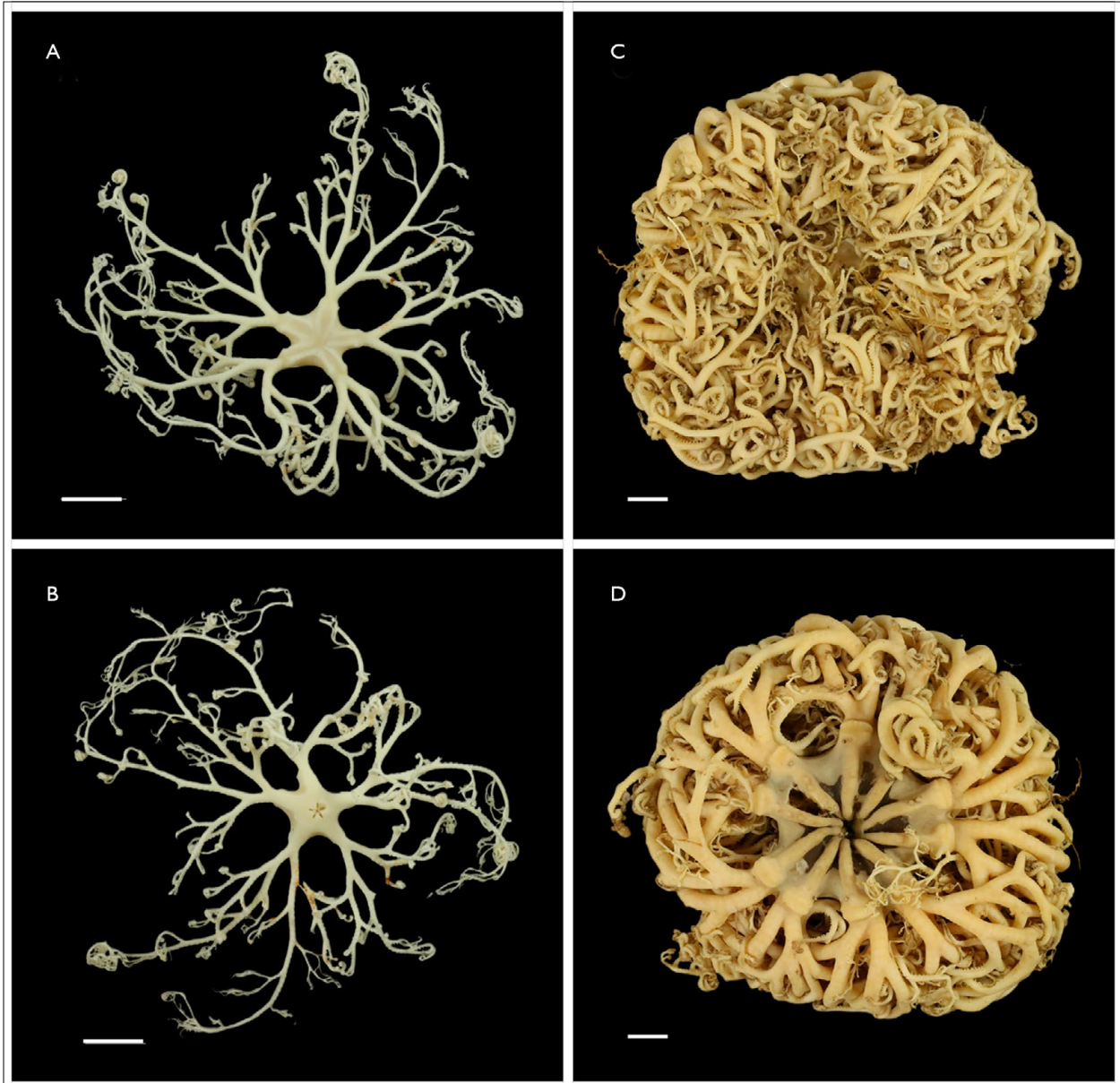


Figure 15. Ophiuroidea, *Astrophyton muricatum* (A, B: MPEG 0045; C, D: MPEG 0053). Dorsal general view (A, C); ventral view (B, D). Scale bars: 10 mm. Source: Authors (2025).

03° 52,833' N, 49° 29,600' W, 25.VIII.2016, Muniz-Mairink, collected as bycatch during pink shrimp (*P. subtilis*), muddy bottom, 1 ind., MPEG 0007.

Remark: The specimen is quite damaged with only the disc remaining.

Family Ophiomyxidae Ljungman, 1867
Genus *Ophiomyxa* Müller & Troschel, 1840

Ophiomyxa sp.
(Figure 17)

Material examined: Amazon continental shelf (Amapá), 04° 52,668' N, 50° 46,916' W, XI.2022, CEPNOR-ICMBio, collected as bycatch from a red snapper (*Lutjanus* spp.) fishery, 122 meters, biogenic substrates (rhodoliths), 1 ind., MPEG 0062.

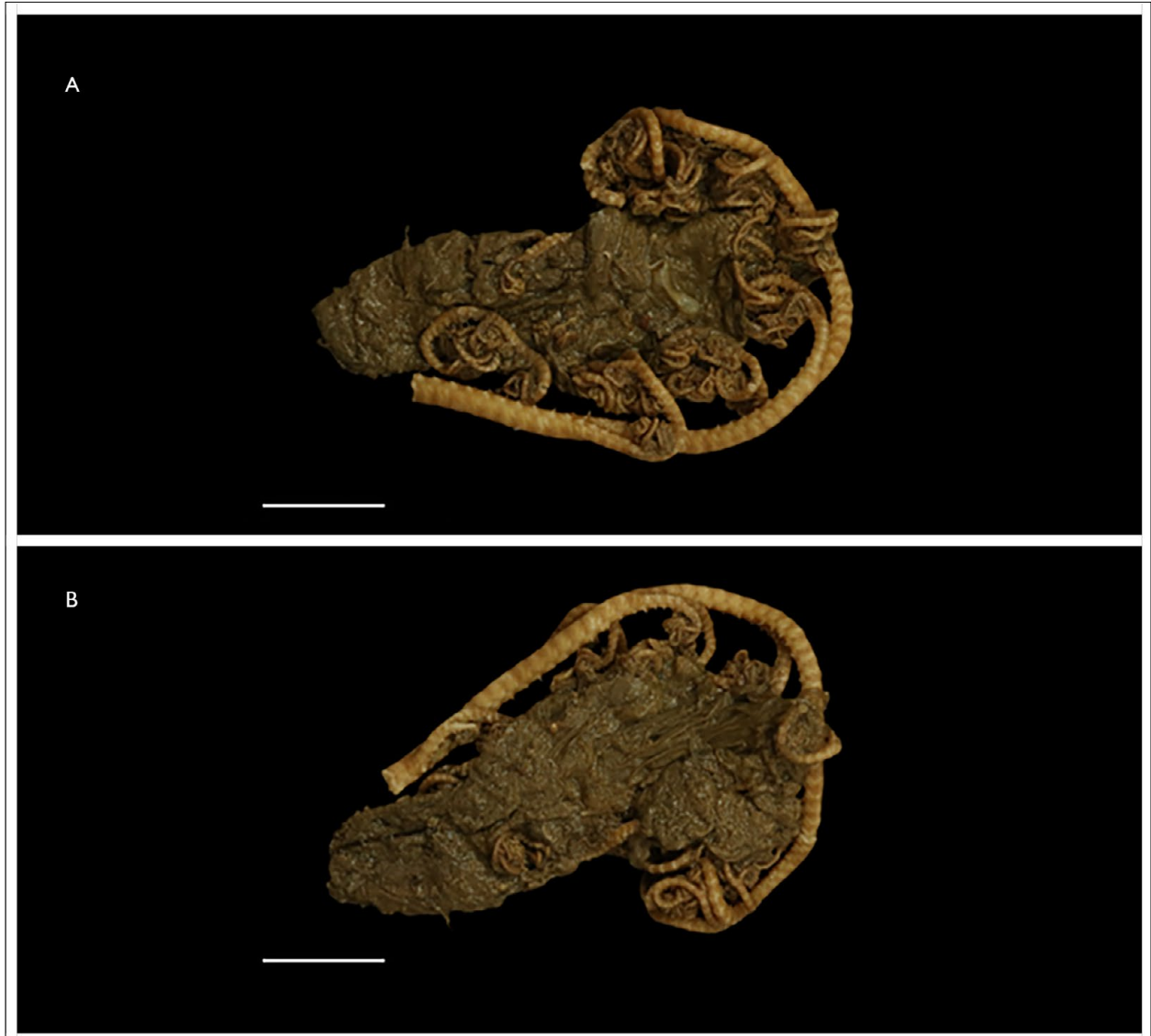


Figure 16. Ophiuroidea, Gorgonocephalidae sp. (MPEG 0007). Dorsal general view (A); ventral general view (B). Scale bars: 10 mm. Source: Authors (2025).

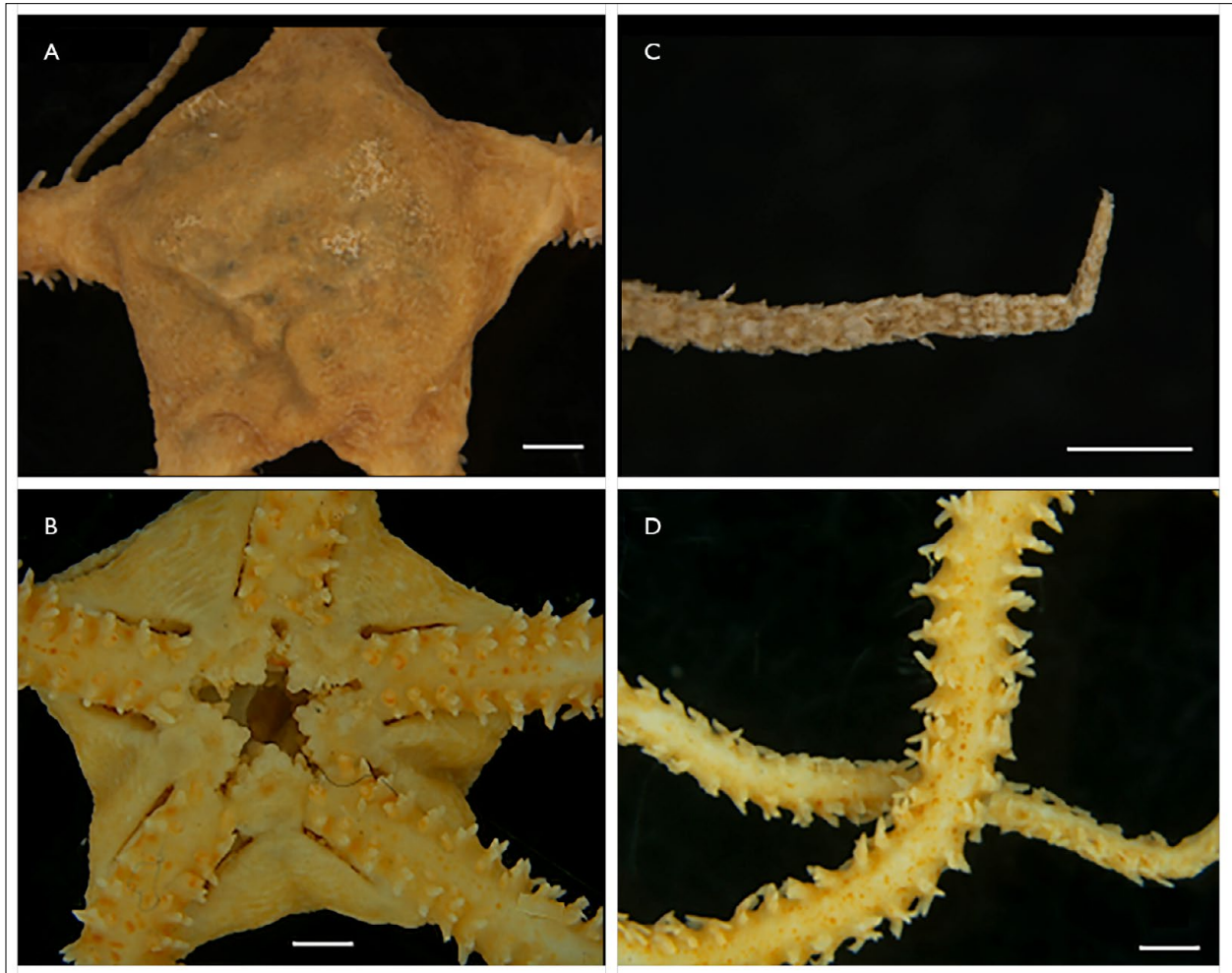


Figure 17. Ophiuroidea, *Ophiomyxa* sp. (MPEG 0062). Dorsal view of the disk (A); ventral view of the disk (B); lateral view of the arm (C); ventral of the arm (D). Scale bars: 1 mm. Source: Authors (2025).

Order Amphilepidida O'Hara, Hugall,
Thuy, Stöhr & Martynov, 2017
Family Amphiuridae Ljungman, 1867
Genus *Amphiodia* Verrill, 1899

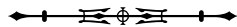
Amphiodia planispina
(von Martens, 1867)
(Figure 18)

Original designation: *Amphiura planispina* von Martens,
1867.

Material examined: Continental shelf (Pará), 01°
02,932' N, 46° 41,139' W, XI.2008, PIATAM-Oceano
Project (#206), NHOc Amorim do Valle, at 63 meters,
sandy bottom, 1 ind., MPEG 0027.

Distribution: Western Atlantic Ocean, Florida, the
islands off southern Florida, the Antilles, Panama, Brazil
(Pará, Maranhão, Ceará, Rio Grande do Norte, Paraíba,
Rio de Janeiro, São Paulo, Rio Grande do Sul) and off Mar
del Plata, Argentina.

Remark: This is the first record of *Amphiodia*
planispina on the Amazonian coast.



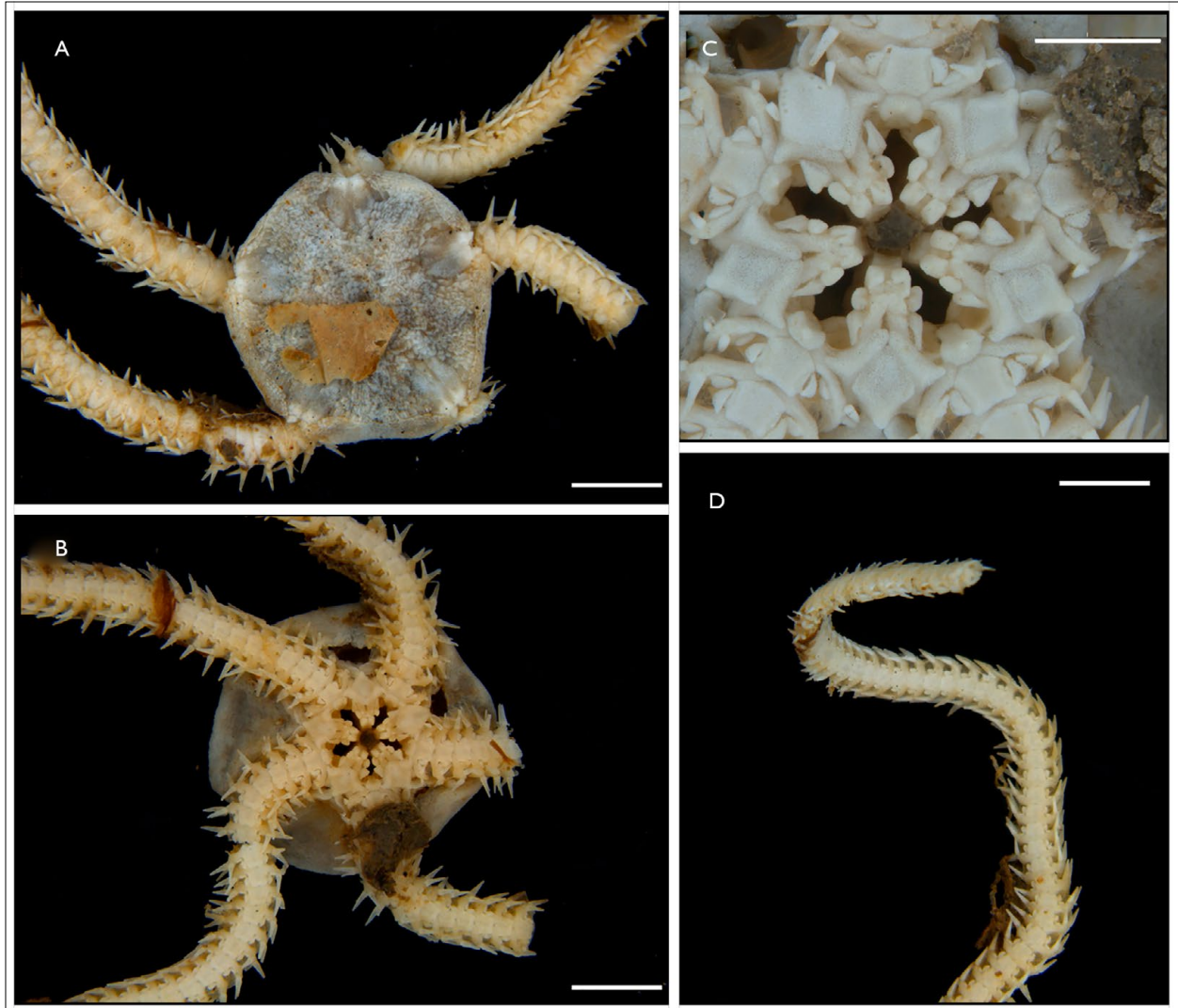


Figure 18. Ophiuroidea, *Amphiodia planispina* (MPEG 0027). Dorsal view of the disk (A); ventral view of the disk (B); in detail the mouth and jaws (C); ventral view of the arm (D). Scale bars: 2 mm. Source: Authors (2025).

Genus *Ophiocnida* Lyman, 1865
Ophiocnida scabriuscula (Lütken, 1859)
(Figure 19)

Original designation: *Amphiura scabriuscula* Lütken, 1859.

Material examined: Continental shelf (Pará), 0° 21,242' S, 46° 53,949' W, XI.2008, PIATAM-Oceanographic Project (#310), NHOc Amorim do Valle, 27 meters, 1 ind., MPEG 0003.

Remark: The specimens are quite damaged with only the disc remaining.

Distribution: Western Atlantic Ocean, Bermuda, Florida (USA), the islands off southern Florida, the Antilles, Mexican Caribbean, Panama, Colombia, Venezuela, and Brazil (Pará, Maranhão, Paraíba, Pernambuco, Alagoas, Bahia, Rio de Janeiro, São Paulo, Paraná).

Remark: This is the first record of *Ophiocnida scabriuscula* on the Amazonian coast.

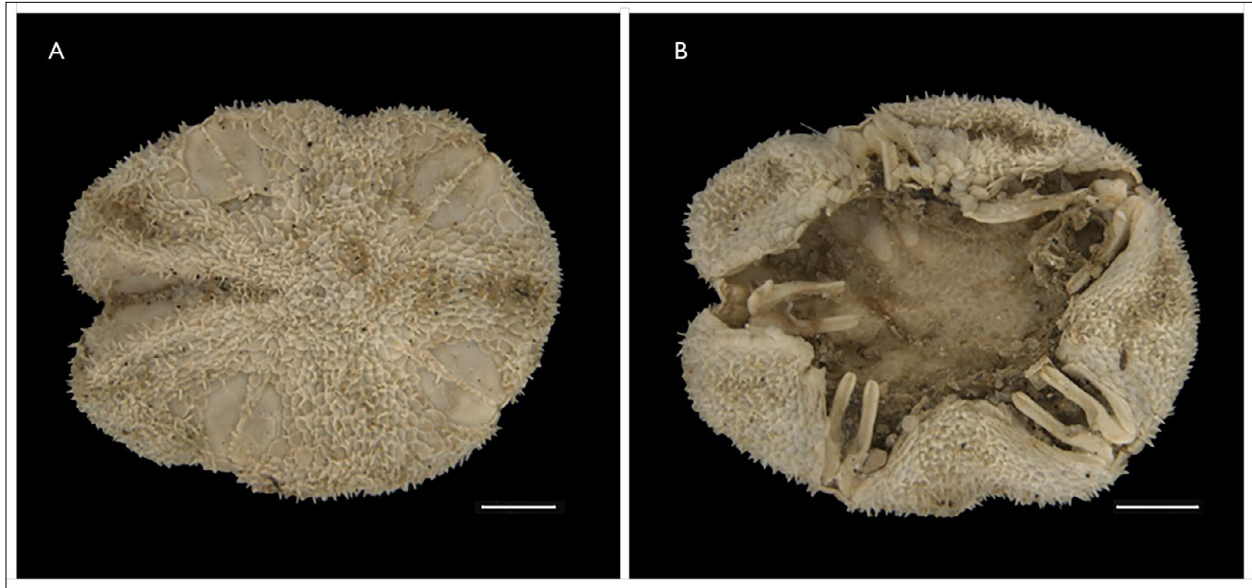


Figure 19. Ophiuroidea, *Ophiocnida scabriuscula* (MPEG 0003). Dorsal view of the disk (A); ventral view of the disk (B). Scale bars: 1 mm. Source: Authors (2025).

Genus *Ophiostigma* Lütken, 1856

Ophiostigma isocanthum (Say, 1825)
(Figure 20)

Original designation: *Ophiura isocantha* Say, 1825.

Material examined: Continental shelf (Maranhão), 0° 08,871' S, 44° 29,454' W, XI.2008, PIATAM-Oceano Project (#103), NHOc Amorim do Valle, 50 meters, 1 ind., MPEG 0002.

Distribution: Western Atlantic Ocean, Bermudas, USA, North Carolina to Florida and the island off southern Florida, Texas offshore reefs, Bahamas, Antilles, islands off Caribbean, Colombia, Venezuela, and Brazil (Maranhão, Ceará, Paraíba, Pernambuco, Alagoas, Bahia, and Rio de Janeiro).

Remark: The specimens are quite damaged with only the disc remaining. This is the first record of *Ophiostigma isocanthum* on the Amazonian coast.

Family Ophiactidae Matsumoto, 1915
Genus *Ophiactis* Lütken, 1856

Ophiactis lymani Ljungman, 1872
(Figure 21)

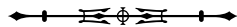
Original designation: *Ophiactis lymani* Ljungman, 1872.

Material examined: Amazon continental shelf (Amapá), 04° 05,900' N, 49° 16,909' W, 02.IX.2016, collected as bycatch during pink shrimp (*P. subtilis*), muddy bottom, 20 ind., MPEG 0014; Algodual Island, Maracanã (Pará), 0° 34,663' S, 47° 35,270' W, associated with Sabellariidae reefs from sandy beach intertidal zone, 1 ind., MPEG 0037.

Distribution: Indian Ocean, Madagascar and Mozambique; Eastern Atlantic Ocean, southern part of the African continent. Western Atlantic Ocean, Trinidad and Tobago, Caribbean Sea, and Brazil (Amapá, Pará, Paraíba, Pernambuco, Alagoas, and Bahia).

Remark: This is the first record of *Ophiactis lymani* on the Amazonian coast.

Ophiactis savignyi (Müller & Troschel, 1842)
(Figure 22)



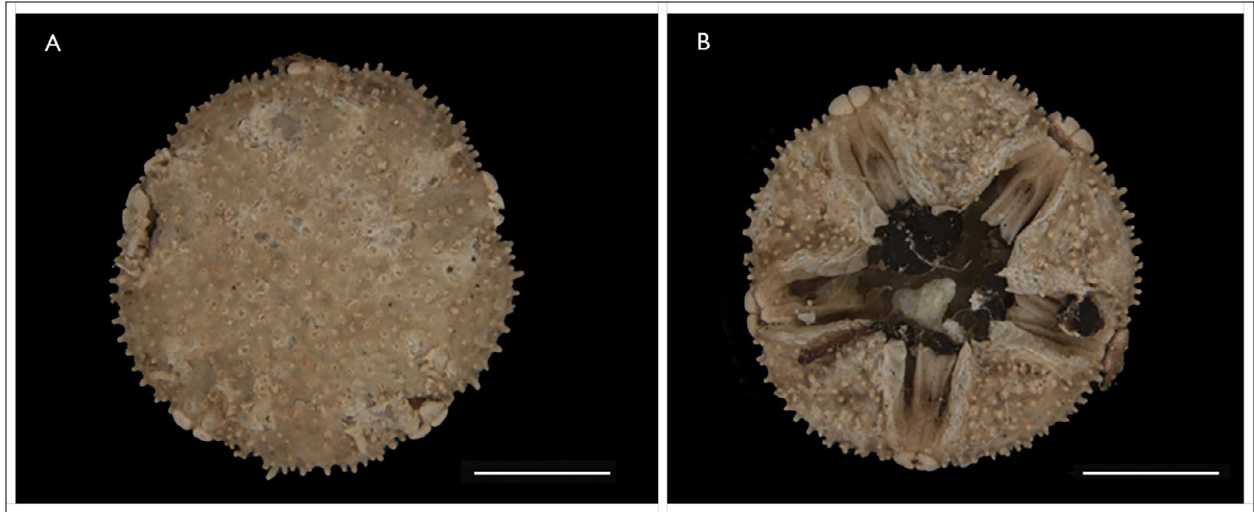


Figure 20. Ophiuroidea, *Ophiostigma isocanthum* (MPEG 0002). Dorsal view of the disk (A); ventral view of the disk (B). Scale bars: 1 mm. Source: Authors (2025).

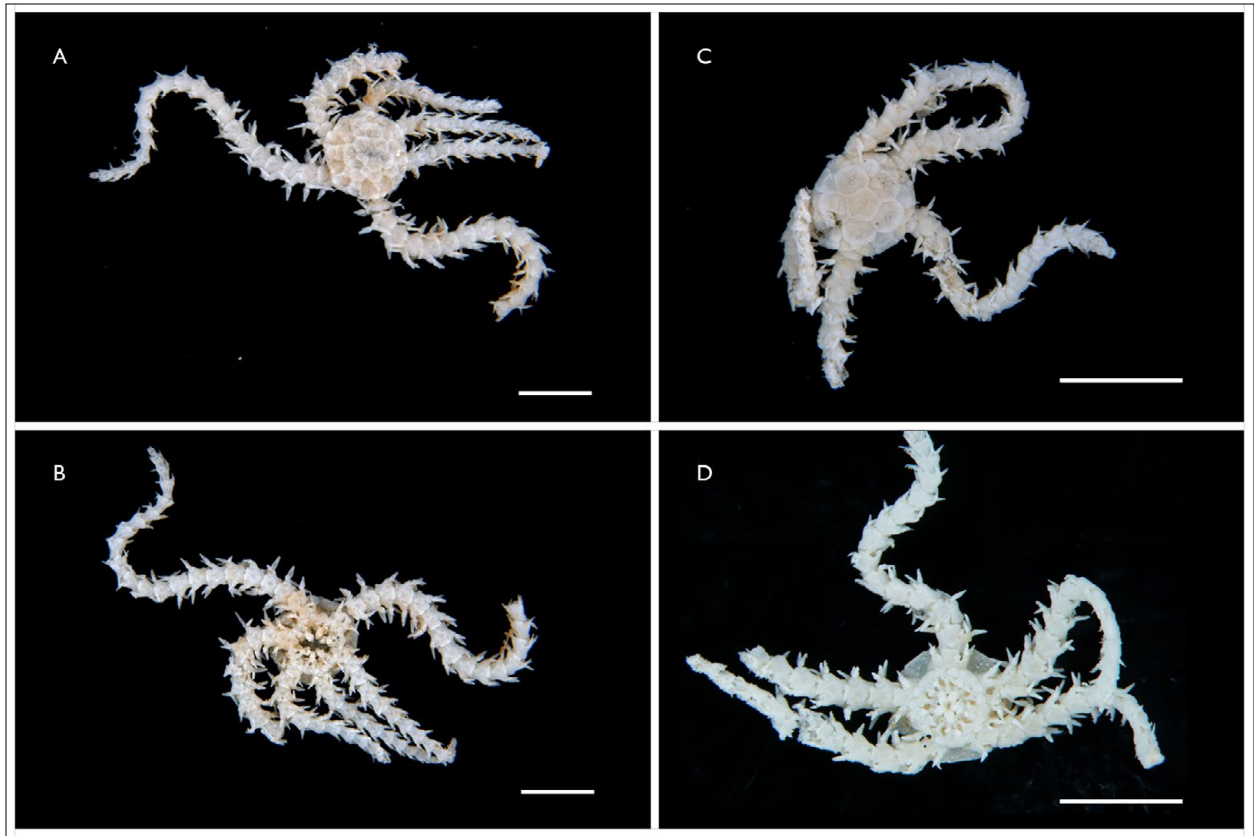


Figure 21. Ophiuroidea, *Ophiactis lymani* (A, B: MPEG 0014; C, D: MPEG 0037). Dorsal general view (A, C); ventral general view (B, D). Scale bars: 2 mm. Source: Authors (2026).

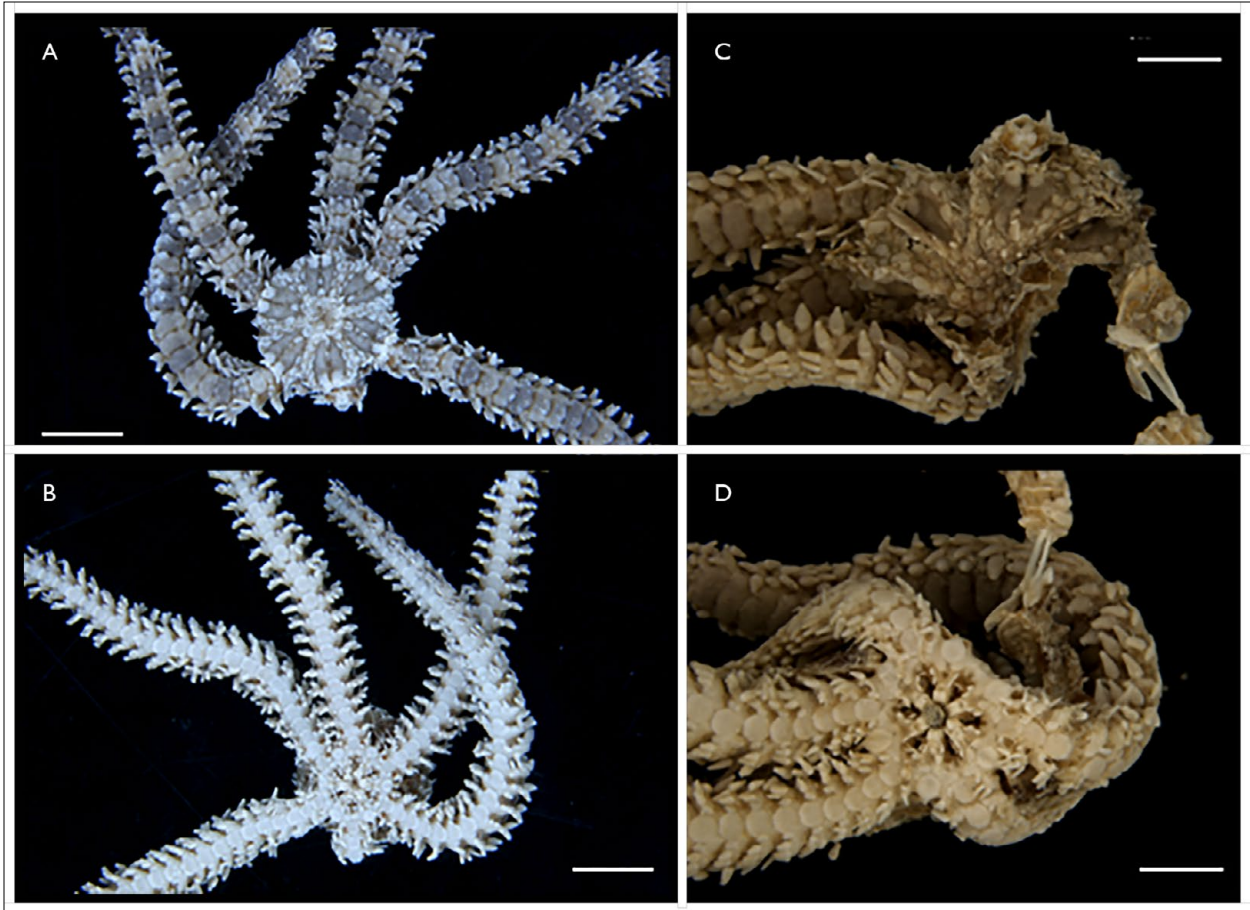


Figure 22. Ophiuroidea, *Ophiactis savignyi* (A, B: MPEG 0040; C, D: MPEG 0063). Dorsal view of the disk (A, C); ventral view of the disk (B, D). Scale bars: 2 mm (A, B), 1 mm (C, D). Source: Authors (2025).

Original designation: *Ophiopsis savignyi* Müller & Troschel, 1842.

Material examined: Continental shelf (Maranhão), 01° 40,687' S, 43° 54,572' W, XI.2008, PIATAM-Oceano Project (#305), NHOc Amorim do Valle, 31 meters, 9 ind., MPEG 0040; Amazon continental shelf (Amapá), 04° 52,668' N, 50° 46,916' W, XI.2022, CEPNOR-ICMBio, collected as bycatch from a red snapper (*Lutjanus* spp.) fishery, 122 meters, biogenic substrates (rhodoliths), 1 ind., MPEG 0063.

Distribution: Western Indo-Pacific, Eastern Pacific, Western Atlantic. South Carolina, Bermuda, Mexican Caribbean, Honduras, and Brazil (Amapá, Pará, Maranhão

Ceará, Paraíba, Pernambuco, Alagoas, Bahia, Abrolhos off southern Bahia, Rio de Janeiro, São Paulo).

Remark: This is the first record of *Ophiactis savignyi* on the Amazonian coast.

Ophiactis sp.
(Figure 23)

Material examined: Continental shelf (Pará), near 0° 47,786' N, 46° 14,378' W, XI.2008, PIATAM-Oceano Project (#101), NHOc Amorim do Valle, 63 meters, 1 ind., MPEG 0034; Continental shelf (Pará), X.2008, PIATAM-Oceano Project (#204), NHOc Amorim do Valle, 1 ind., MPEG 0061.

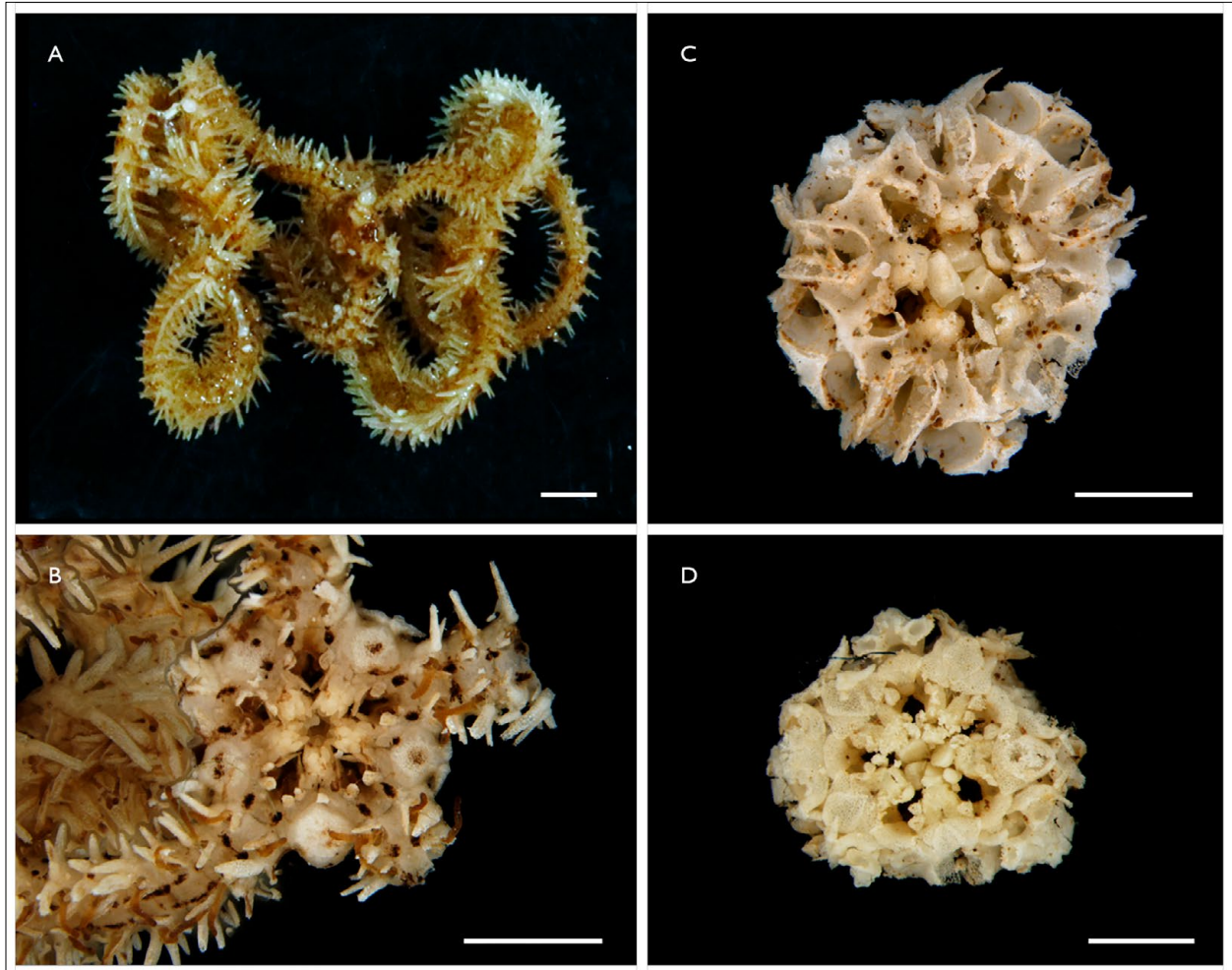


Figure 23. Ophiuroidea, *Ophiactis* sp. (A, B: MPEG 0034; C, D: MPEG 0061). Dorsal general view (A); ventral view of the disk (B, D); dorsal view of the disk (C). Scale bars: 2 mm (A, B); 500 μ m (C, D). Source: Authors (2025).

Family Ophiotrichidae Ljungman, 1867
Genus *Ophiotrix* Müller & Troschel, 1840

Ophiotrix tommasii Santana,
Manso, Almeida & Alves, 2020
(Figure 24)

Original designation: *Ophiotrix tommasii* Santana, Manso, Almeida & Alves, 2020.

Material examined: Camará River Beach (Vista Alegre), Marapanim (Pará), 04.XI.1980, Brigida, M.S. and Rosemiro,

5. ind., MPEG 0016; Camará River Beach (Vista Alegre), Marapanim (Pará), X.1981, Brigida, M.S., 28 ind., MPEG 0017; Amazon continental shelf (Pará), 01° 24,450' N, 47° 56,111' W, 27.II.2017, collected as bycatch during pink shrimp (*P. subtilis*), muddy bottom, 1 ind., MPEG 0021; Fortaleza Island, São João de Pirabas (Pará), 1956, Cunha, 31 ind., MPEG 0026; Continental shelf (Maranhão), 02° 06,369' S, 43° 22,306' W, 14.XI.2008, PIATAM-Oceano Project (#304), NHOc Amorim do Valle, 31 meters, 1 ind., MPEG 0032.

Distribution: Western Atlantic, Brazil (Pará, Maranhão, Piauí, Ceará, Rio Grande do Norte, Paraíba, Pernambuco,

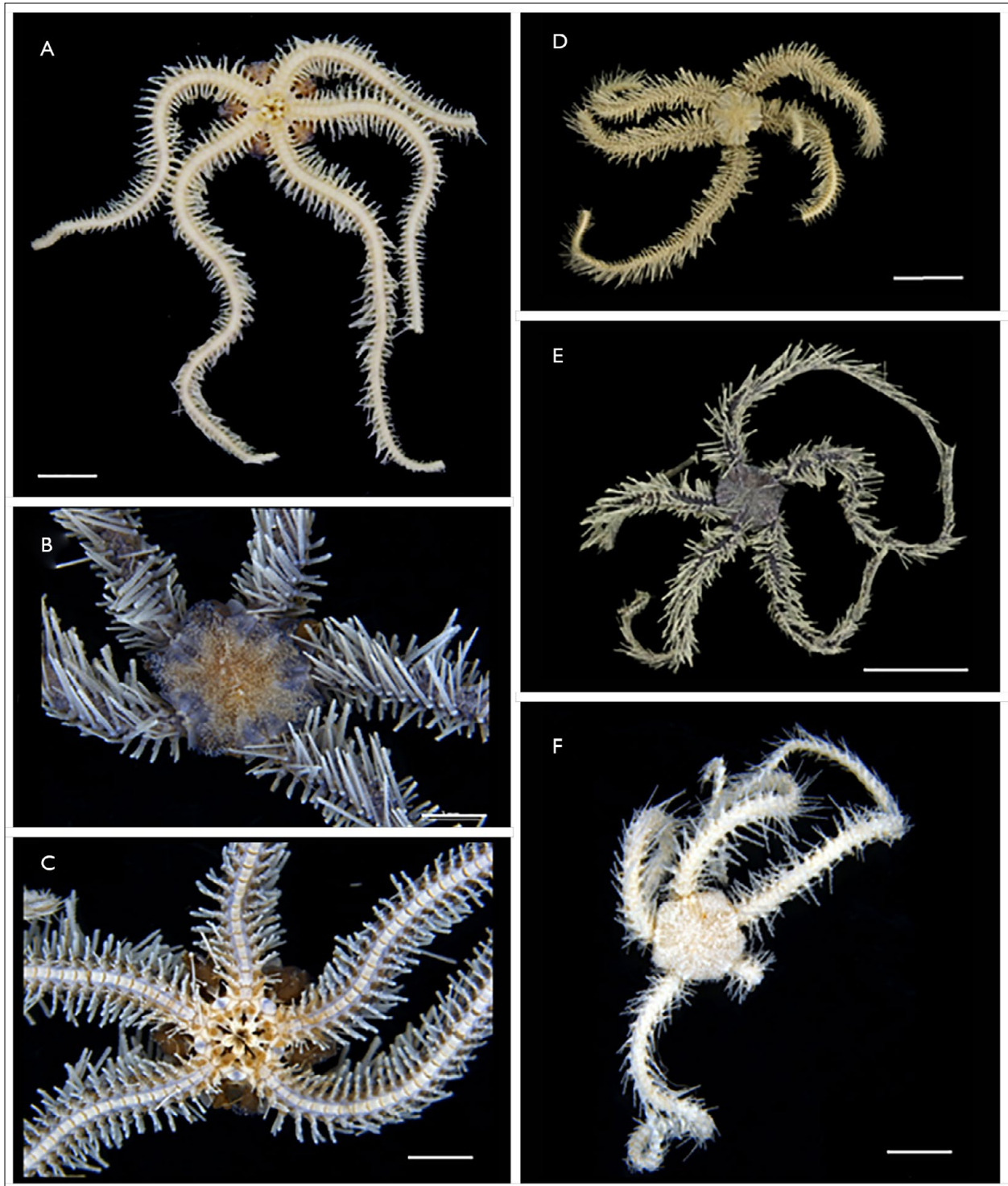


Figure 24. Ophiuroidea, *Ophiothrix tommasii* (A: MPEG 0016; B, C: MPEG 0017; D: MPEG 0021; E: MPEG 0026; F: MPEG 0032). Ventral general view (A); dorsal view of the disc (B); ventral view of the disc (C); dorsal general view (D-F). Scale bars: 2 mm. Source: Authors (2025).

Alagoas, Bahia, Espírito Santo, Rio de Janeiro, São Paulo, Paraná and Santa Catarina).

Remark: This is the first record of *Ophiothrix tommasii* on the Amazonian coast.

Order Ophiacanthida O'Hara, Hugall,
Thuy, Stöhr & Martynov, 2017

Family Ophiodermatidae Ljungman, 1867
Genus *Ophioderma* Müller &
Troschel, 1840

Ophioderma cinereum
Müller & Troschel, 1842
(Figure 25)

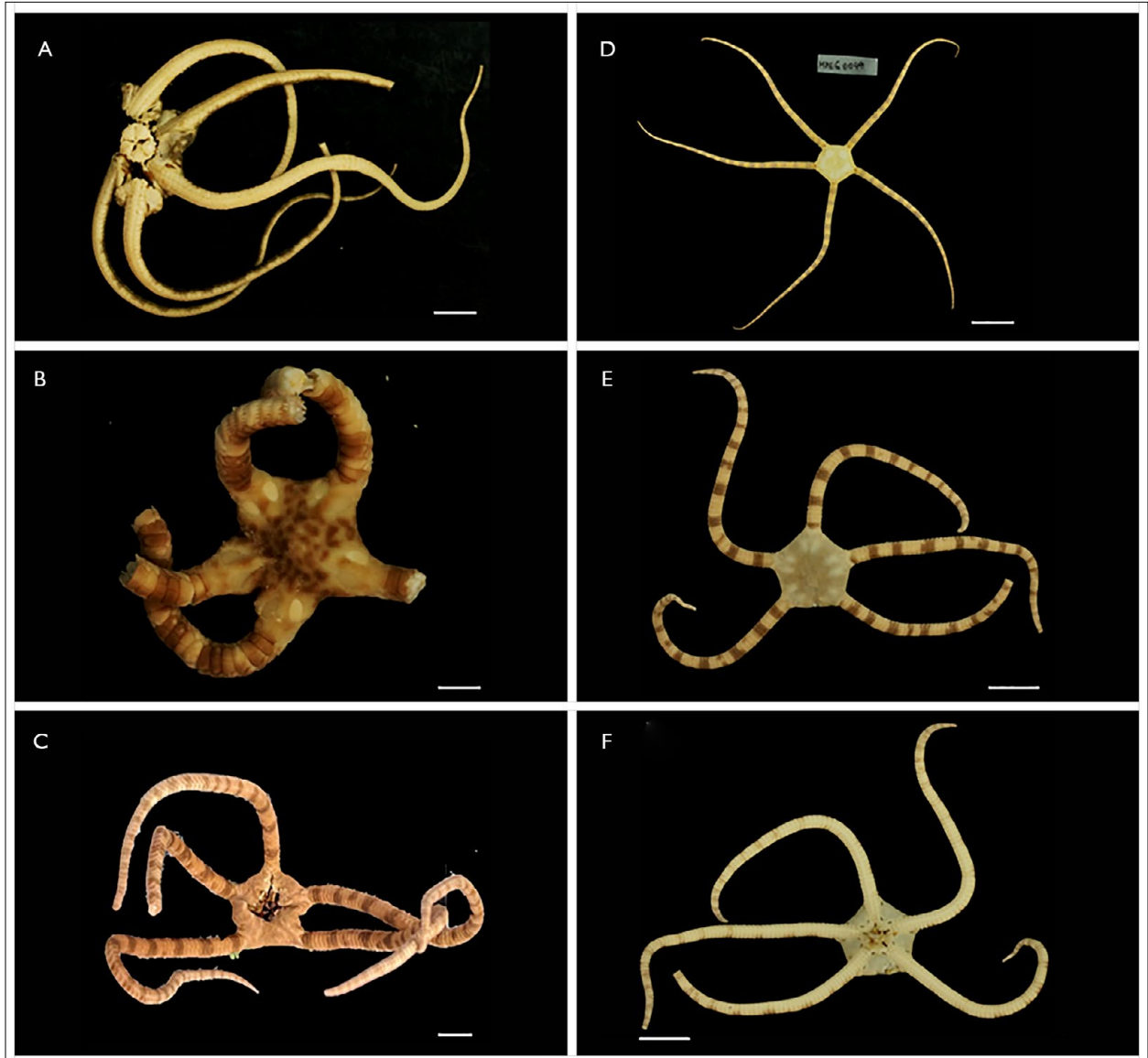


Figure 25. Ophiuroidea, *Ophioderma cinereum* (A: MPEG 0011; B: MPEG 0031; C: MPEG 0047; D: MPEG 0049; EF: MPEG 0050). Ventral general view (A, F); dorsal general view (B-E). Scale bars: 10 mm. Source: Authors (2025).

Original designation: *Ophioderma cinereum* Müller & Troschel, 1842.

Material examined: Amazon continental shelf (Pará), 01° 24,450' N, 47° 56,111' W, 27.II.2017, Muniz-Mairink, collected as bycatch during pink shrimp (*P. subtilis*), muddy bottom, 1 ind., MPEG 0011; Continental shelf (Maranhão), 00° 21,013' S, 44° 09,848' W, 26.X.2008, PIATAM-Oceano Project (#104), NHOc Amorim do Valle, 55 meters, 3 ind., MPEG 0031; Amazon continental shelf (Amapá), 04° 52,668' N, 50° 46,916' W, XI.2022, CEPNOR-ICMBio, collected as bycatch from a red snapper (*Lutjanus* spp.) fishery, 122 meters, biogenic substrates (rhodoliths), 5 ind., MPEG 0047, MPEG 0049, MPEG 0050.

Distribution: Florida (USA), Caribe Sea, Bahamas, Bermudas, and Brazil (Amapá, Pará, Maranhão, Alagoas, Bahia and Paraíba).

Remark: This is the first record of *Ophioderma cinereum* on the Amazonian coast.

Class Echinoidea Schumacher, 1817
Order Cidaroida Claus, 1880
Family Cidaridae Gray, 1825
Genus *Eucidaris* Pomel, 1883

Eucidaris tribuloides (Lamarck, 1816)
(Figure 26)

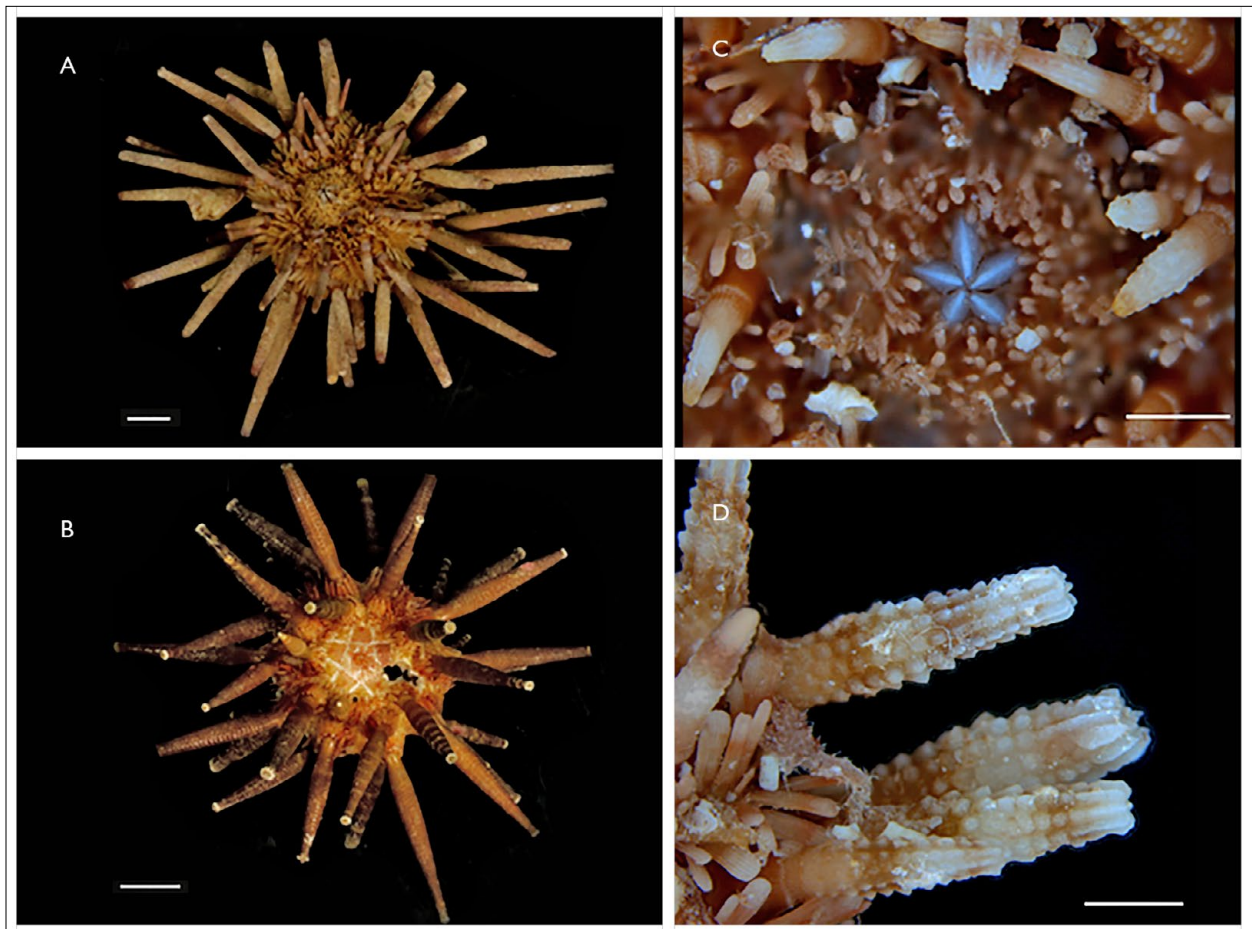


Figure 26. Echinoidea, *Eucidaris tribuloides* (A: MPEG 0005; B-D: MPEG 0030). Oral general view (A); aboral general view (B); detail of the peristome (C); details of the spines (D). Scale bars: 10 mm (A, B); 1 mm (C, D). Source: Authors (2025).

Original designation: *Cidarites tribuloides* Lamarck, 1816.

Material examined: Amazon continental shelf (Amapá), 03° 31,424' N, 50° 12,288' W, 28.VII.2015, Romão, J., collected as bycatch during pink shrimp (*P. subtilis*), muddy bottom, 1 ind., MPEG 0005; Continental shelf (Maranhão), 00° 21,013' S, 44° 09,848' W, 26.X.2008, PIATAM-Oceano Project (#104), NHOc Amorim do Valle, 55 meters, 1 ind., MPEG 0030; Amazon continental shelf (Amapá), 04° 52,668' N, 50° 46,916' W, XI.2022, CEPNOR-ICMBio, collected as bycatch from a red snapper

(*Lutjanus* spp.) fishery, 122 meters, biogenic substrates (rhodoliths), 1 ind., MPEG 0056.

Distribution: Western Atlantic Ocean, USA (North Carolina and Florida), Caribbean Sea, and Brazil (from the North Coast to the South).

Order Camarodonta Jackson, 1912

Family Toxopneustidae Troschel, 1872

Genus *Lytechinus* Agassiz, 1863

Lytechinus variegatus (Lamarck, 1816)

(Figure 27)

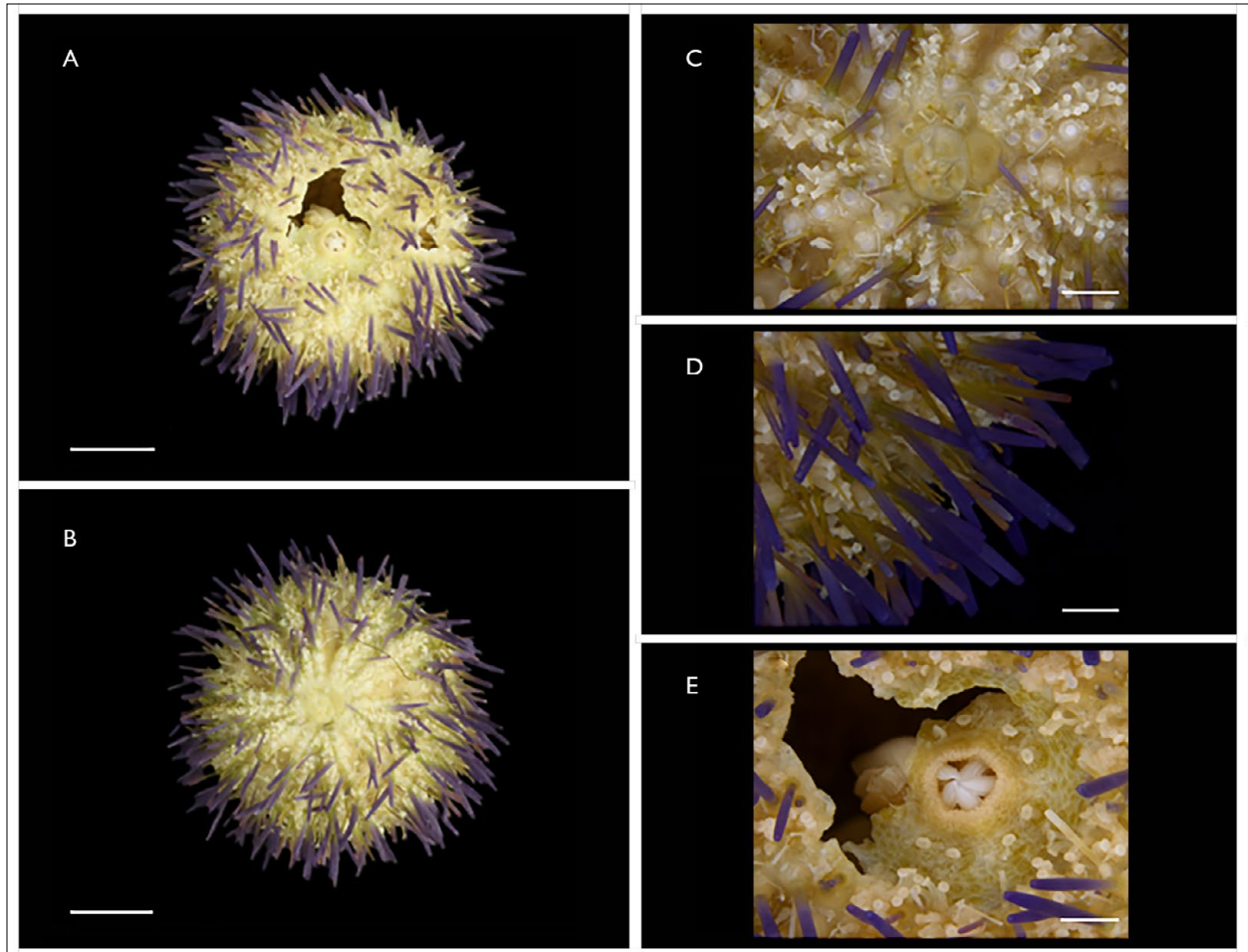


Figure 27. Echinoidea, *Lytechinus variegatus* (MPEG 0041). Oral general view (A); aboral view (B); view of the periproctal plates (C); details of the spines (D); and detail of the peristome (E). Scale bars: 10 mm (A, B); 2 mm (C-E). Source: Authors (2025).

Original designation: *Echinus variegatus* Lamarck, 1816.

Material examined: Amazon continental shelf (Amapá), 04° 52,668' N, 50° 46,916' W, XI.2022, CEPNOR-ICMBio, collected as bycatch from a red snapper (*Lutjanus* spp.) fishery, 122 meters, biogenic substrates (rhodoliths), 1 ind., MPEG 0041.

Distribution: Western Atlantic Ocean, occurring from North Carolina (USA) and the Gulf of Mexico, throughout the Caribbean, to Brazil (Amapá, Bahia, Southeast and South).

Remark: This is the first record of *Lytechinus variegatus* on the Amazonian coast.

Order Echinolampadacea Mongiardino Koch et al., 2018

Family Mellitidae Stefanini, 1912

Genus *Encope* Agassiz, 1840

Encope michelini Agassiz, 1841

(Figure 28)

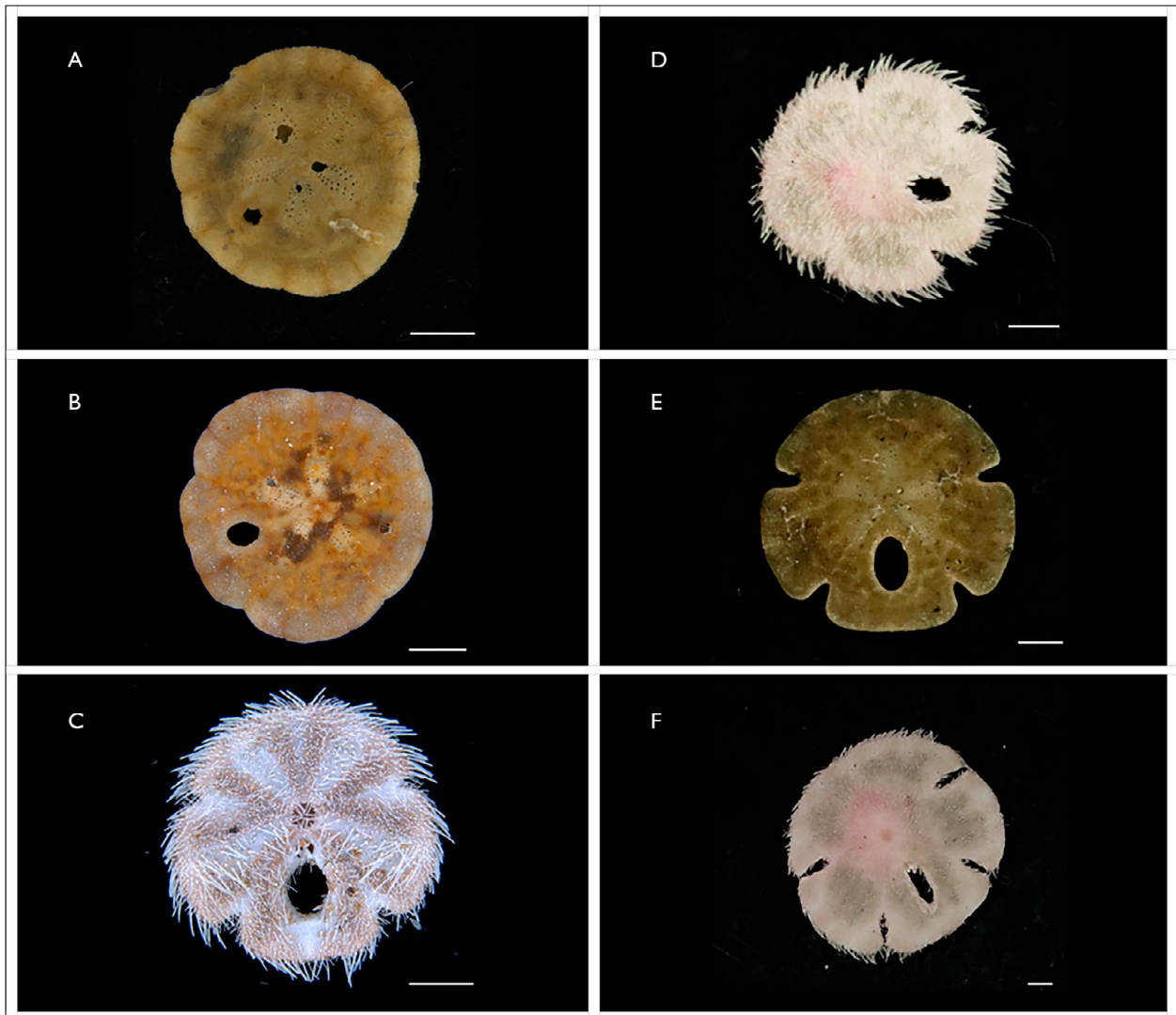


Figure 28. Echinoidea, *Encope michelini* (A: MPEG 0001; B: MPEG 0023; C: MPEG 0024; D: MPEG 0028; E: MPEG 0033; F: MPEG 0036). Aboral view (A-F). Scale bars: 2 mm. Source: Authors (2025).

Original designation: *Encope michelini* Agassiz, 1841.

Material examined: Continental shelf (Pará), 01° 02.932' N, 46° 41.139' W, XI.2008, PIATAM-Oceano Project (#206), NHOc Amorim do Valle, 63 meters, 3 ind., MPEG 0001; Continental shelf (Pará), XI.2008, PIATAM-Oceano Project (#204), NHOc Amorim do Valle, 112 ind., MPEG 0023; Continental shelf (Pará), near 0° 47,786' N, 46° 14.378' W, XI.2008, PIATAM-Oceano Project (#101), NHOc Amorim do Valle, 63 meters, 5 ind., MPEG 0033; Caburé Beach, Barreirinhas (Maranhão), 02° 34,116' S, 42° 41,105' W, IV.2014,

Carvalho, V. and Alves, I., 4 ind., MPEG 0024, MPEG 0028, MPEG 0036.

Distribution: Western Atlantic Ocean, Southeastern United States, Gulf of Mexico, Caribbean Sea, and Brazil (Pará, Maranhão, Rio de Janeiro).

Remark: This is the first record of *Encope michelini* on the Amazonian coast.

Genus *Mellita* Agassiz, 1841

Mellita quinquesperforata (Leske, 1778)
(Figure 29)

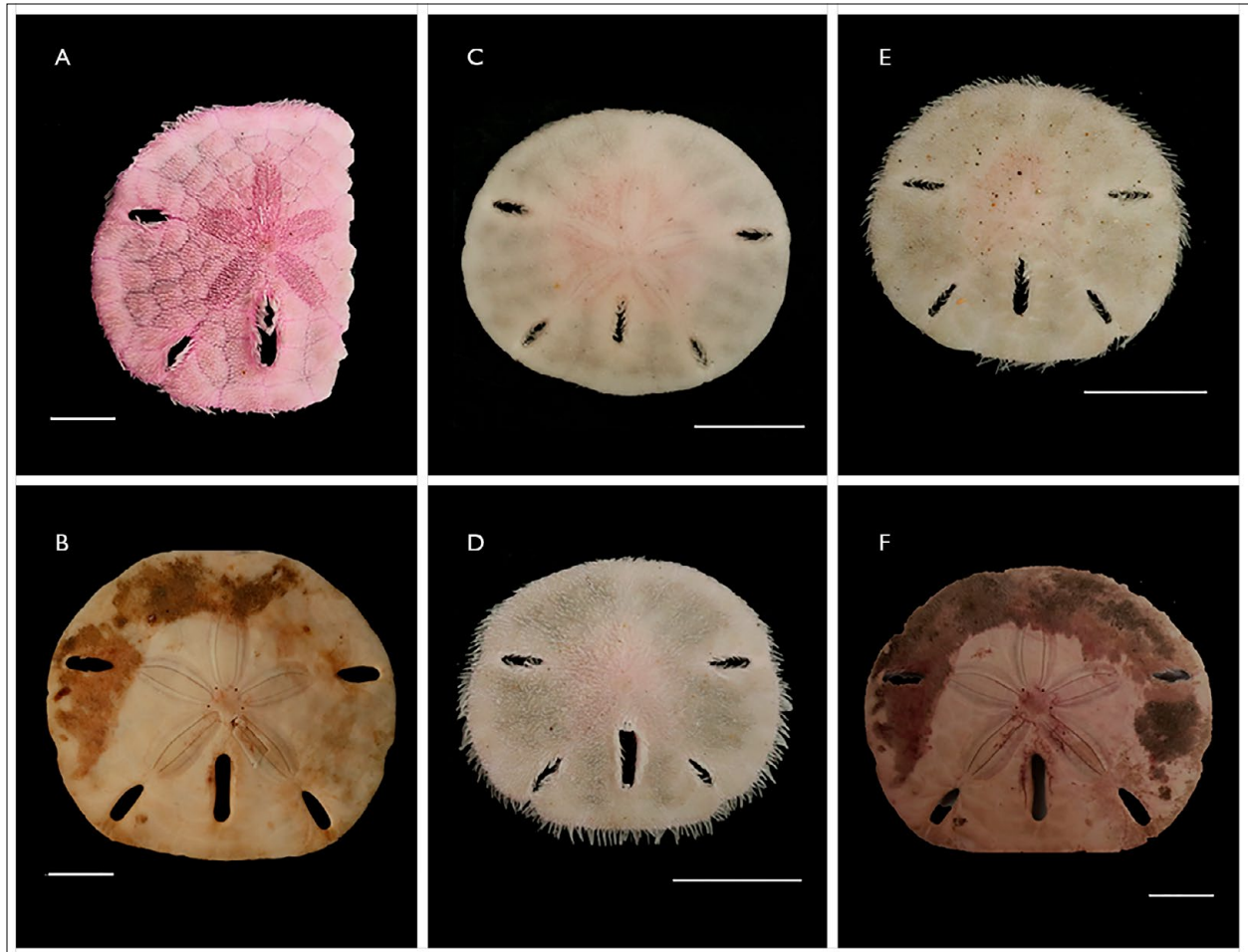


Figure 29. Echinoidea, *Mellita quinquesperforata* (A: MPEG 0015; B: MPEG 0022; C: MPEG 0029; D: MPEG 0035; E: MPEG 0058; F: MPEG 0064). Aboral view (A-F). Scar bar: 10 mm. Source: Authors (2025).



Original designation: *Echinodiscus quinquiesperforata* Leske, 1778.

Material examined: Caburé Beach, Barreirinhas (Maranhão), 02° 34,116' S, 42° 41,105' W, IV.2014, Carvalho, V. and Alves, I., 3 ind., MPEG 0015, MPEG 0035, MPEG 0058; Ajuruteua Beach, Bragança (Pará), 0° 49,548' S, 46° 36,357' W, III.2004, LOB-UFPA, 1 ind., MPEG 0022; Ajuruteua Beach, Bragança (Pará), 0° 49,548' S, 46° 36,357' W, XII.2003, LOB-UFPA, 1 ind., MPEG 0029; Princesa Beach, Algodual Island, Maracanã (Pará), III.2013, LOB-UFPA, MPEG 0064.

Distribution: Western Atlantic Ocean, Mexico, Cuba, Dominican Republic, Puerto Rico, Honduras, Nicaragua,

Costa Rica, Panama, Colombia, Brazil (from the North to the South) and Uruguay.

Order Spatangoida Agassiz, 1840

Family Brissidae Gray, 1855

Genus *Meoma* Gray, 1851

Meoma ventricosa (Lamarck, 1816)

(Figure 30)

Original designation: *Spatangus ventricosus* Lamarck, 1816.

Material examined: Amazon continental shelf (Amapá), 04° 52,668' N, 50° 46,916' W, XI.2022, CEPNOR-ICMBio, collected as bycatch from a red snapper (*Lutjanus* spp.) fishery, 122 meters, biogenic substrates (rhodoliths), 1 ind., MPEG 0055.

Distribution: Western Atlantic Ocean, Florida, Bahamas, Mexico, Panama, Colombia and Brazil (Amapá, Rio de Janeiro).

Remark: This is the first record of *Meoma ventricosa* on the Amazonian coast.

Class Holothuroidea De Blainville, 1834

Order Dendrochirotida Grube, 1840

Family Cucumariidae Ludwig, 1894

Genus *Thyonella* Verrill, 1872

Thyonella pervicax (Théel, 1886)

(Figure 31)

Original designation: *Thyone pervicax* Théel, 1886.

Material examined: Amazon River Estuary, adjacent to Marajó Island (Pará), 0° 45.02' N, 48° 3.46' W, 15.III.1997, Barthem, R., 2 ind., MPEG 0018, MPEG 0019; Amazon continental shelf (Amapá), 04° 52,668' N, 50° 46,916' W, XI.2022, CEPNOR-ICMBio, collected as bycatch from a red snapper (*Lutjanus* spp.) fishery, 122 meters, biogenic substrates (rhodoliths), 2 ind., MPEG 0057.

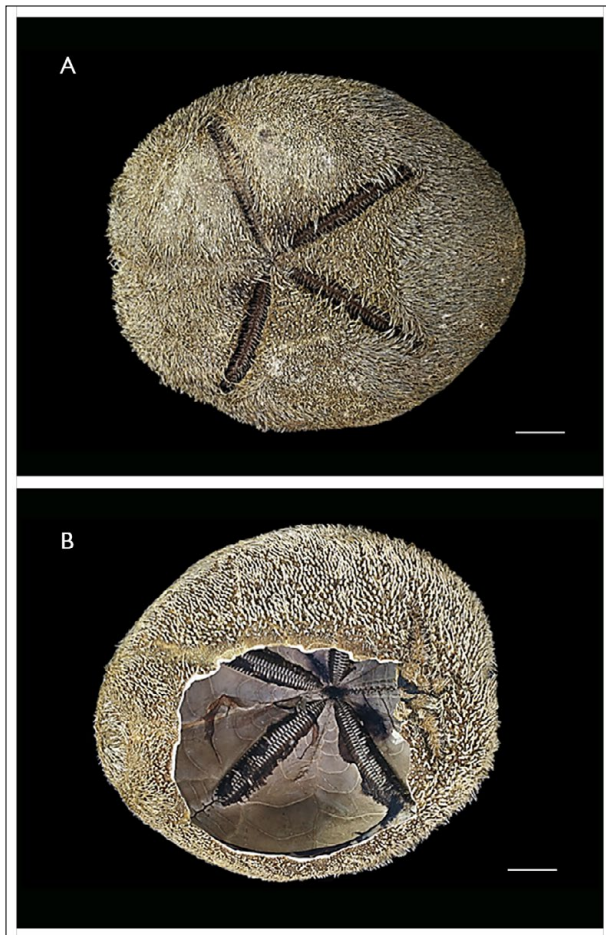


Figure 30. Echinoidea, *Meoma ventricosa* (MPEG 0055). Aboral view (A); oral view (B); Scar bar: 10 mm. Source: Authors (2025).

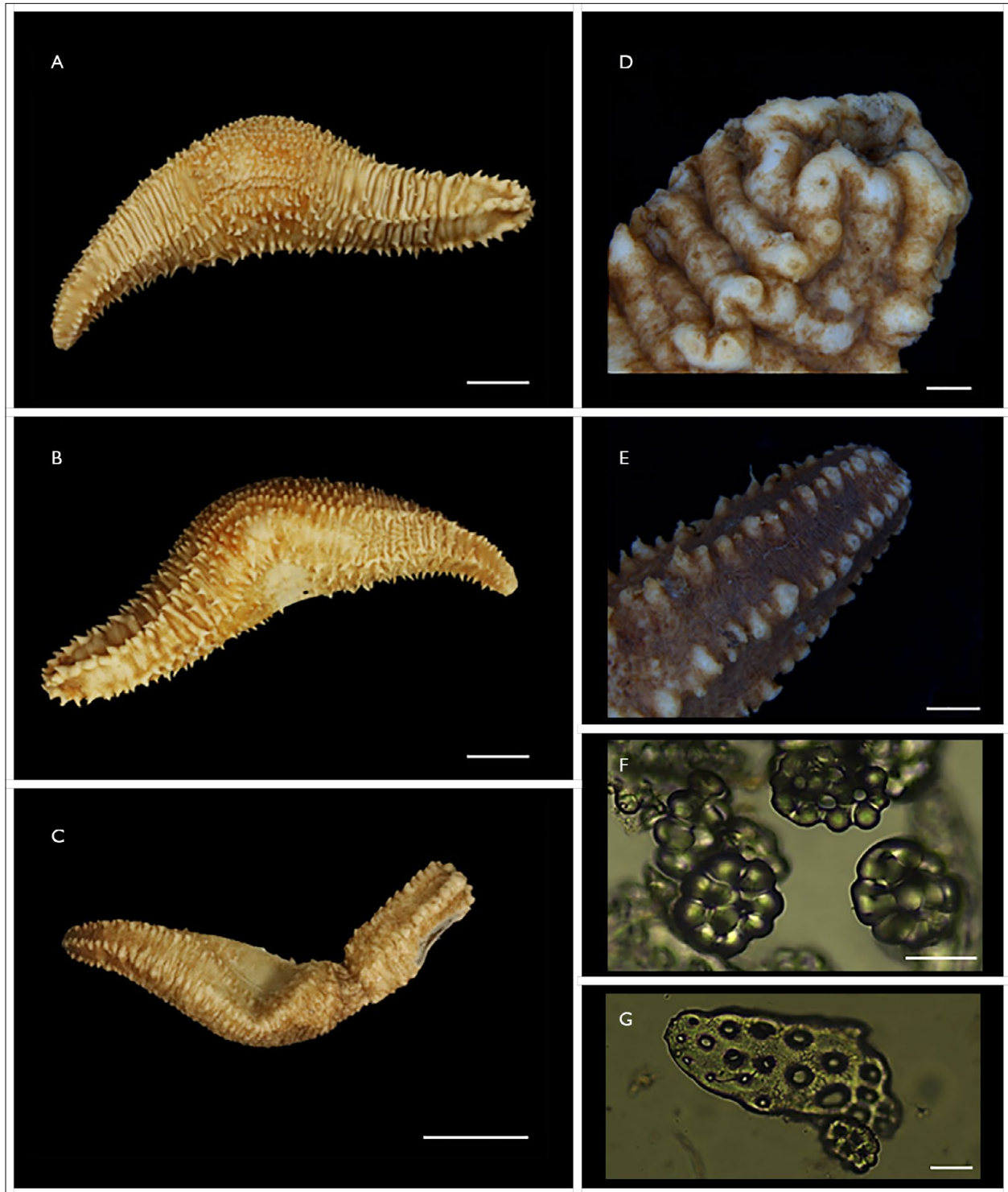


Figure 31. Holothuroidea, *Thyonella pervicax* (A, F, G: MPEG 0018; B, D, E: MPEG 0019; C: MPEG 0057). Lateral general view (A-C); ossicles of the body wall (F, G); oral extremity (D); anal extremity (E). Scar bar: 10 mm (A-C); 2 mm (D, E); 50 μ m (F, G). Source: Authors (2025).



Distribution: Western Atlantic Ocean, USA (Massachusetts, Texas, and Florida), Mexico Gulf of Mexico, Brazil (Pará, Amapá, Bahia, Espírito Santos, São Paulo).

Remark: This is the first record of *Thyonella pervicax* on the Amazonian coast.

Family Phyllophoridae Östergren, 1907
Genus *Stolus* Selenka, 1867

Stolus pseudofusus (Deichmann, 1930)
(Figure 32)

Original designation: *Thyone pseudofusus* Deichmann, 1930.
Material examined: Continental shelf (Maranhão), 01° 40,687' S, 43° 54,572' W, XI.2008, PIATAM-Oceano Project (#305), NHOc Amorim do Valle, 31 meters, 1 ind., MPEG 0039.

Distribution: Western Atlantic Ocean, Florida (USA), Mexico, from Sea Caribe to the coast of Brazil (Pará, Paraíba, Abrolhos Archipelago, Bahia).

Remark: This is the first record of *Stolus pseudofusus* on the Amazonian coast.

Order Apodida Brandt, 1835
Family Synaptidae Burmeister, 1837
Genus *Protankyra* Östergren, 1898

Protankyra sp.
(Figure 33)

Material examined: Amazon continental shelf (Amapá), 01° 17,180' N, 47° 51,500' W, 22.II.2017, Muniz, M., collected as bycatch during pink shrimp (*P. subtilis*), muddy bottom, 1 ind., MPEG 0020.

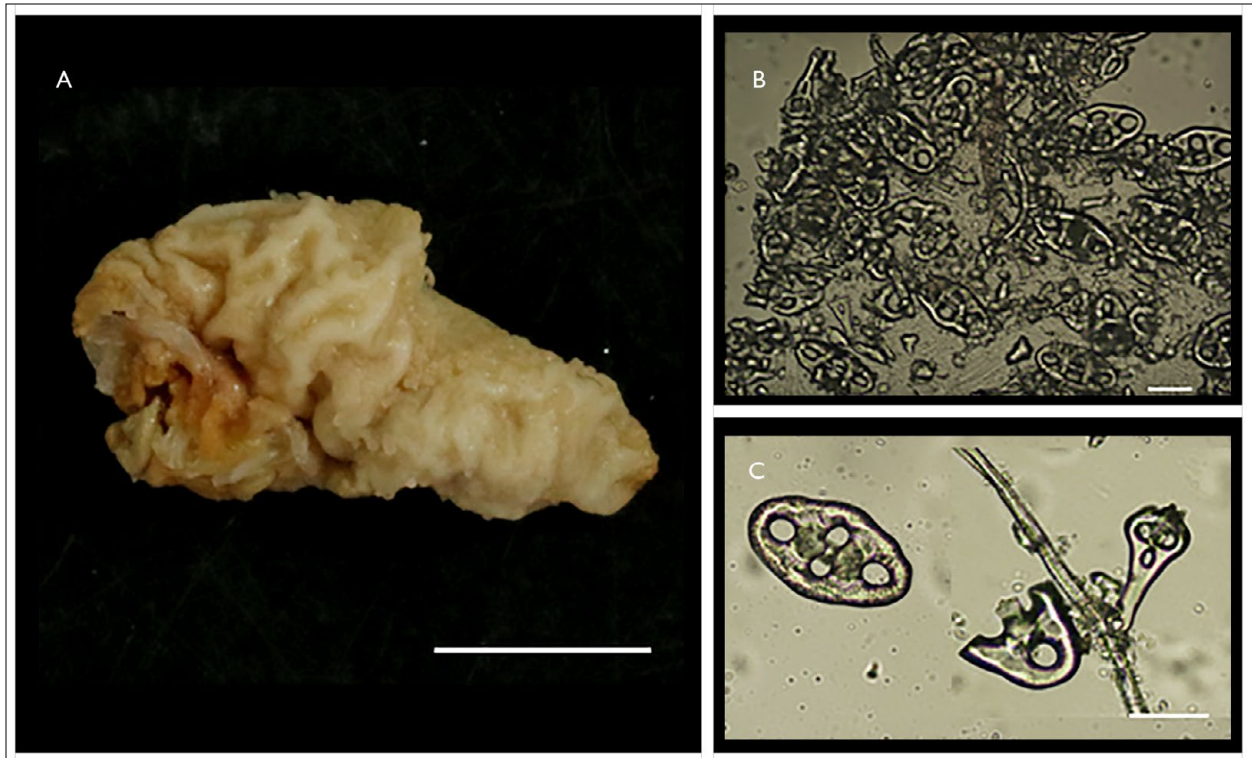


Figure 32. Holothuroidea, *Stolus pseudofusus* (MPEG 0039). Lateral general view (A); ossicles of the body wall (B, C). Scale bar: 5 mm (A); 50 μ m (B, C). Source: Authors (2025).



Figure 33. Holothuroidea, *Protankyra* sp. (MPEG 0020). General view (A); ossicles of the body wall (B, C). Scar bar: 2 mm (A); 100 μ m (B, C). Source: Authors (2025).

DISCUSSION

The MPEG is a pioneering institution for scientific studies of the Amazon's natural systems, as well as for the dissemination of knowledge and the organization and maintenance of world-class collections related to the region's biodiversity. The MPEG houses several unique biological collections, including those related to Amazonian marine environments. In fact, the Echinodermata collection of the MPEG (MPEG.ECH) is the only one dedicated to the phylum in northern Brazil. This collection is relatively recent, started in 2016, although its oldest record dates back to 1956, referring to ophiuroids (*Ophiothrix tommasii* Santana, Manso, Almeida & Alves, 2020) sampling from estuarine areas in the northeastern of Pará State.

In recent years, the collections of the MPEG have received valuable material from the outer continental shelf, especially from bycatch of pink shrimp (*Penaeus (Farfantepenaeus) subtilis* Pérez Farfante, 1967) and red snapper (*Lutjanus* spp.) fisheries. This material helps fill

gaps in the sampling of Amazonian marine invertebrates, as it covers a wide area and various bottom types in the coastal zone. For example, bottom trawling for capturing pink shrimps occurs on soft substrates (muddy, sandy, or gravel), while the fishery of red snappers predominantly occurs on consolidated substrates of the Great Amazon Reef System (GARS) (Marceniuk et al., 2025). Despite recent efforts to characterize biodiversity in this macrohabitat in the world, the macrobenthic fauna remains unstudied, despite being key to the functioning of this reef system. This lack of basic biological knowledge, and specific conservation and management plans, pave the way for the unregulated fisheries, as well as the expansion of mining, oil and gas exploration (Francini-Filho et al., 2018; Banha et al., 2022; Oliveira Silva et al., 2025).

The MPEG collection comprises 32 deposited echinoderm species, a number similar to that of the didactic collection of PUC-Campinas, which includes 23 species (Alitto et al., 2025), and to the type-species collection of the Museum of Zoology of the University of São Paulo (MZUSP),

with 22 deposited type species (Martins et al., 2022). More diverse collections are found in the Northeast region, such as those of the Federal University of Alagoas, with 50 catalogued species (Miranda et al., 2012), the Federal University of Ceará, which records 59 species (Barroso et al., 2022), the Federal University of Sergipe, with 121 species (Oliveira et al., 2011), and the Paulo Young Invertebrate Collection (CIPY/UFPB), which holds 128 species (J. Prata, personal communication, 2025); and in the Southeast region, such as the collection of the National Museum/UFRJ, which has 86 deposited species according to SiBBr data (MN/UFRJ, n.d.). Although numerically smaller, the MPEG is the first collection in the Northern region and has significant value for taxonomic, biogeographic, genetic, and evolutionary studies, contributing to the understanding of Western Atlantic echinoderms.

In Brazil, some studies are noteworthy, such as the pioneering research “A list of the Brazilian echinoderms” by Richard Rathbun, which reported 64 species from the Asterozoa (13 species), Crinozoa (four species), Echinozoa (11 species), Holothurozoa (four species), and Ophiurozoa classes (32 species), catalogued across all Brazilian coast (Rathbun, 1879). Subsequently, Luiz Roberto Tommasi published many studies on the Brazilian coast, including new species and new occurrences (e.g. Tommasi, 1971), as well as on other Atlantic coastal areas (Tommasi, 1972), significantly contributing for taxonomic characterization.

Based on the literature review of extant Brazilian echinoderm species by Ventura et al. (2013) there are a total of 347 species, including 77 of Asterozoa, 16 of Crinozoa, 52 of Echinozoa, 49 of Holothurozoa, and 153 of Ophiurozoa, occurring mainly in the Northeast, Southeast and South regions of Brazil (Ventura et al., 2013). In addition, other studies have been conducted, such as from the northeastern Brazil (Martins et al., 2012; Martins & Souto, 2018; Gondim et al., 2018; Prata et al., 2014, 2017, 2020; Silva et al., 2025), southeastern Brazil (Alitto et al., 2018, 2019; Chagas et al., 2020), and southern

Brazil (Bueno et al., 2018; Slivak et al., 2022), increasing the number of species recorded from the Brazilian coast.

In the Northern region of Brazil, research in echinoderms was mainly targeted at the Pirabas Miocene Formation along the equatorial margin (Ventura et al., 2013), highlighting the Crinozoa, Ophiurozoa (Távora et al., 2015) and Echinozoa classes (Bencomo et al., 2021; Ventura et al., 2013). This geological feature was influenced by the former Amazon delta and natural littoral drainages during the late Miocene, which is distinguished by a shallow-marine carbonate platform with great diversity in micro- and macrofossil remnants (Aguilera et al., 2020). In addition, crinoids were recorded for the Ererê Devonian-Formation of the Amazon basin (Scheffler et al., 2014).

Nonetheless, until this study, no taxonomic studies have been performed on the Amazon shelf, representing a significant gap in echinoderm knowledge, remarkably for holothurians (Prata & Christoffersen, 2024). Despite this, some record insights were catalogued, such as the sand dollar *Encope emarginata* (Leske, 1778), and the sea urchin *Eucidaris tribuloides* (Lamarck, 1816) from the Amapá continental shelf (Tommasi, 1972), as well as the sea cucumber species *Molpadia oolitica* (Pourtales, 1851) and echinoid *Cidaris rugosa* (Clark, 1907) from the Guianas region – French Guiana and Suriname continental shelves, respectively (Tommasi, 1972). In addition, the occurrence of the Pacific-exotic-brittle-star *Ophiothela mirabilis* (Verrill, 1867) in association with the octocoral *Leptogorgia miniata* (Milne Edwards & Haime, 1857) was registered for Amazonian reefs – GARS (Moura et al., 2016). Recently, Oliveira Silva et al. (2025) catalogued 35 echinoderm species/morphospecies for the GARS region, collected by incidental fishing on the Amazon shelf, including two species of Crinozoa, 19 species of the Asterozoa, seven species of the Ophiurozoa, five of the Echinozoa, and two of the Holothurozoa.

If we compile previous records (Moura et al., 2016; Oliveira Silva et al., 2025; Tommasi, 1972) with the present study, we recognize 45 species (specific epithet) and 41 genera of echinoderms from the Brazilian Amazon coast.



Notably, 15 species are recorded exclusively in the Echinodermata collection of the MPEG, thus representing their first official (based on taxonomic study) occurrence on the Amazon coast – Echinoidea: *Astropecten brasiliensis* Müller & Troschel, 1842, *Echinaster (Othilia) guyanensis* Clark, 1987, *Echinaster (Othilia) spinulosus* Verrill, 1869, *Encope michelini* Agassiz, 1841, *Lytechinus variegatus* (Lamarck, 1816), and *Meoma ventricosa* (Lamarck, 1816); Ophiuroidea: *Amphiodia planispina* (von Martens, 1867), *Ophiactis lymani* Ljungman, 1872, *Ophiactis savignyi* (Müller & Troschel, 1842), *Ophiocnida scabruscula* (Lütken, 1859), *Ophioderma cinereum* Müller & Troschel, 1842, *Ophiostigma isocanthum* (Say, 1825) and *Ophiothrix tommasii* Santana, Manso, Almeida & Alves, 2020; Holothuroidea: *Stolus pseudofusus* (Deichmann, 1930) and *Thyonella pervicax* (Théel, 1886).

Another important point is that the species recorded by Oliveira Silva et al. (2025) have no specimens vouchered in any collection in the Amazon region, i.e. *Comactinea echinopectera* (Müller, 1840), *Tropiometra carinata* (Lamarck, 1816), *Asterina* sp., *Astropecten alligator* Perrier, 1881, *Astropecten marginatus* Gray, 1840, *Astropecten* sp., *Chaetaster nodosus* Perrier, 1875, *Acanthaster* sp., *Echinaster* sp., *Goniaster tessellatus* (Lamarck, 1816), *Henricia antillarum* Perrier, 1881, *Henricia* sp., *Linckia guildingi* Gray, 1840, *Linckia nodosa* Perrier, 1875, *Luidia alternata* (Say, 1825), *Luidia clathrata* (Say, 1825), *Luidia ludwigi scotti* Bell, 1917, *Luidia senegalensis* (Lamarck, 1816), *Mithrodia clavigera* (Lamarck, 1816), *Narcissia trigonaria* Sladen, 1889, *Tethyaster vestitus* (Say, 1825), *Astrophyton muricatum* (Lamarck, 1816), *Hemieuryale pustulata* von Martens, 1867, *Ophioderma januarii* Lütken, 1856, *Ophiomastix wendtii* (Müller & Troschel, 1842), *Ophiothrix* sp., *O. mirabilis* (Verrill, 1867), *Asteroporpa (Asteroporpa) annulata* Örsted & Lütken, 1856, *Astropyga magnifica* Clark, 1934, *Coelopleurus floridanus* Agassiz, 1872, *E. tribuloides* (Lamarck, 1816), *Salenocidaris* sp., *Stylocidaris affinis* (Philippi, 1845), *Isostichopus badionotus* (Selenka, 1867) and *Ocnus* sp. Therefore, we emphasise that better-preserved-specimens collected in the Amazon region should be

primarily deposited at the MPEG, representing the main Brazilian Amazon scientific collection. Additionally, duplicate specimens may be deposited in local collections, serving as support for the preservation of Amazonian biodiversity.

The present study reveals a diverse echinoderm fauna and expands the knowledge of these animals in the Northern Brazilian region, filling a gap in our understanding of an ecologically and economically important area, the Amazon. In addition, the findings highlight the importance role of zoological collections in biodiversity studies, underscoring the importance of the MPEG as a definitive repository for specimens collected from studies in the Amazonian region.

CONCLUSION

This is the first catalogue of Echinodermata species from the MPEG, representing a novel contribution to the Eastern Amazon context, in which specimens were identified at the lowest possible taxonomic level and were mainly collected from the Great Amazon Reef System. Taxonomic characterization of Amazonian invertebrates is revealing to be promising for further studies on this notable biome, a global biodiversity heritage site.

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AUTHOR'S CONTRIBUTION

D. A. Costa contributed with conceptualization, data curation, formal analysis, methodology, project administration; supervision; validation, writing (original draft, review and editing); K. Rocha contributed with methodology and writing (original draft, review and editing); N. C. M. Guimarães contributed with methodology and writing (original draft, review and editing); Paulo A. B. Beltrão contributed with methodology and writing (original draft); D. B. Pires contributed with methodology and writing (original draft); J. Prata contributed with data curation, methodology, validation and writing (original draft, review and editing); C. R. M. dos Santos contributed with data curation, validation and writing (review and editing); R. A. das Chagas contributed with methodology and writing (review and editing); W. C. R. dos Santos contributed with methodology and writing (review and editing); F. de A. Alves-Júnior contributed with writing (original draft, review and editing); and D. Aviz contributed with formal analysis, methodology, supervision and writing (original draft, review and editing).



**Nova espécie de *Perissocytheridea* (Crustacea, Ostracoda, Cytheridae)
da zona entremarés de uma ilha costeira da Amazônia oriental**
**New species of *Perissocytheridea* (Crustacea, Ostracoda, Cytheridae)
from the intertidal zone of a coastal island in Eastern Amazonia**

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Resumo: Este estudo investigou a ocorrência de ostracodes na zona entremarés da ilha de Algodual, no nordeste do estado do Pará, Brasil. Esses ambientes são pouco estudados, especialmente em relação à taxonomia desses pequenos crustáceos. As amostras foram obtidas em três praias (Caixa D'Água, Princesinha e Princesa), durante a maré vazante, em diferentes períodos climáticos do ano (seco e chuvoso). Além da coleta de ostracodes, foram aferidos o pH, a salinidade e a temperatura da água. Os resultados indicaram baixa diversidade de ostracodes, com predomínio do gênero *Perissocytheridea*, com uma espécie nova descrita. A salinidade foi o parâmetro ambiental que mais variou entre os períodos (entre 0 e 30 ppm), sendo *Perissocytheridea materterrae* sp. nov. registrada entre 0 e 20 ppm. Esse resultado reforça a preferência do gênero por ambientes salobros e seu potencial uso como um bioindicador ecológico. Os registros de ostracodes foram restritos à praia da Caixa D'Água, a qual, devido à sua topografia suave e à menor energia hidrodinâmica, proporcionou um refúgio adequado para esses organismos.

Palavras-chave: Litoral. Crustáceos. Costa norte do Brasil. Atlântico Sul.

Abstract: This study investigated the ostracods in the intertidal zone on Algodual Island, on the northeast of Pará state, Brazil. These environments are poorly studied, especially regarding the taxonomy of these small crustaceans. Samples were collected in three beaches (Caixa D'Água, Princesinha, and Princesa) during low tide, in different seasons of the year (dry and rainy). In addition to sampling ostracods, the pH, salinity, and water temperature were measured. The results indicated low ostracods diversity, with the genus *Perissocytheridea* predominating, and a new species described. Salinity was the environmental parameter that varied most between periods (0 to 30 ppm), with *Perissocytheridea materterrae* sp. nov. recorded between 0 and 20 ppm. This result reinforces the genus's preference for brackish environments and its potential use as an ecological bioindicator. The ostracod records were restricted to Caixa D'Água Beach, which, due to its smooth topography and lower hydrodynamic energy, provided a suitable refuge for these organisms.

Keywords: Coastal region. Crustaceans. North Coast of Brazil. South Atlantic.

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INTRODUÇÃO

Ostracodes são pequenos crustáceos de carapaça bivalve, com comprimento entre aproximadamente 0,5 mm e 4 mm. Cada valva é composta por uma lamela externa e outra interna cuja borda calcificada é chamada duplicatura. A morfologia desses organismos varia consideravelmente, podendo ser mais ou menos complexa, sendo fundamental para a identificação de famílias e gêneros (Armstrong & Brasier, 2005). Entre as características internas, a charneira localizada dorsalmente, que serve para unir as valvas, é um dos principais caracteres taxonômicos, além dos padrões das impressões musculares adutoras, que, em combinação com as estruturas externas, servem como características diagnósticas para a identificação taxonômica (Horne et al., 2002).

O corpo dos ostracodes é compacto, com até oito pares de apêndices articulados e especializados, incluindo o apêndice copulatório nos machos, bem desenvolvido na fase adulta. Na região anterior à cabeça e ao tórax, estão fusionados para formar um cefalotórax; devido a isso, é difícil homologar os segmentos e apêndices com outros crustáceos (Smith, 2025). Nos Podocopida Sars, 1866, de forma geral, a maior parte do corpo fica alojada nesta região, onde constam as antênulas, as antenas, as mandíbulas e as maxilas (Smith, 2025). Na região posterior, ficam alojados três pares de apêndices torácicos e uma furca, geralmente considerada homóloga ao telson em outros artrópodes (Armstrong & Braiser, 2005). Os apêndices de ambas as regiões apresentam articulações chamadas podômeros; entre estas, o protopodito corresponde à base do apêndice, sendo formado pela coxa e pela base, das quais se originam dois ramos: o interno, denominado endopodito, e o externo, chamado exopodito (Fransozo & Negreiros-Fransozo, 2017; Smith, 2025). As funções dos apêndices cefálicos e torácicos dependem do hábito de vida, sendo os da região cefálica normalmente utilizados para a locomoção, a filtração e a alimentação, e também como órgãos sensoriais, enquanto os da região posterior para a locomoção e a limpeza da carapaça (Horne et al., 2002).

O carbonato de cálcio da carapaça dos ostracodes é obtido da água, não reabsorvido, tornando-se útil em estudos geoquímicos e paleoambientais (Bergue, 2006). São organismos essencialmente aquáticos, podendo ocorrer nos mais diversos ambientes marinhos (como fundos oceânicos, ambientes litorâneos e lagunas) e não marinhos (como lagos, corpos d'água temporários e águas intersticiais) (Rosário et al., 2007). Alguns *taxa* são adaptados à vida semiterrestre, podendo ser encontrados em serrapilheira úmida (Horne et al., 2005) e em tanques de bromélias, como *Elpidium bromeliarum* Müller, 1880 (Pinto & Purper, 1970).

Apesar da importância, da grande riqueza e da diversidade biológica, os ambientes costeiros no Brasil carecem de estudos sobre os ostracodes atuais (Pinto et al., 1978; Würdjig et al., 1990; Coimbra et al., 2007; Morais & Coimbra, 2014), principalmente na região Norte, onde existem poucos registros da classe (Ataide et al., 2014; Baia & Venekey, 2019). O litoral norte brasileiro é muito rico em ecossistemas, como manguezais, estuários, praias, ilhas e lagunas, os quais servem de áreas de refúgio e de reprodução para diversas espécies, incluindo ostracodes. O conhecimento dessa biodiversidade é de fundamental importância para o direcionamento das políticas públicas, garantindo a efetividade de áreas de conservação, como é o caso da ilha de Algodoal/Maiandeuá, que é uma Área de Proteção Ambiental (APA), ou seja, uma unidade de conservação de uso sustentável da natureza (Pará, 1990).

Dessa forma, este estudo descreve uma nova espécie de *Perissocytheridea* ocorrente na zona entremarés da ilha de Algodoal (Pará, Brasil, Amazônia oriental), além de analisar a diversidade local e a influência das variáveis ambientais sobre a assembleia de Ostracoda.

METODOLOGIA

ÁREA DE ESTUDO

A área de estudo compreende a ilha de Algodoal, a qual faz parte da Área de Proteção Ambiental (APA) Algodoal/Maiandeuá (47° 32' 05" e 47° 34' 12" W; 0° 34' 45" e



0° 37' 30" S), município de Maracanã, localizada a uma distância de cerca de 170 km da capital, Belém (Pará, Brasil). A ilha é delimitada ao norte pelo oceano Atlântico, ao sul pelo furo de Mocoóca, que a separa do continente, a leste pela baía de Maracanã e a oeste pela baía de Marapanim (Mascarenhas, 2006) (Figura 1).

O clima da ilha de Algodal é caracterizado como tropical úmido, com temperaturas anuais em torno de 26 °C (Mascarenhas, 2006). Na região, existem dois períodos climáticos bem definidos: um período seco, que vai de julho a meados de dezembro, e outro mais chuvoso, de dezembro a junho, com índice pluviométrico na faixa de 2.300 a 2.800 mm anuais (Moraes et al., 2005).

A área de estudo é influenciada por ventos alísios, com altas velocidades durante o período seco

(Guerreiro et al., 2020). As ondas que se aproximam da costa apresentam a mesma direção dos ventos alísios que controlam o regime de ondas no Nordeste brasileiro (Bittencourt et al., 2005). No período chuvoso, as ondas têm altura maior do que 1 m e, durante a preamar, no período seco, a altura de ondas é menor, na faixa de 0,7 m. A amplitude das marés varia de 4 a 6 m (macromaré), com um ciclo semidiurno (Ataide et al., 2014).

As principais praias da ilha de Algodal são Caixa D'Água, Princesinha e Princesa. A Caixa D'Água é morfologicamente classificada como uma praia intermediária de terraço de maré baixa (Rosa Filho et al., 2011), possuindo uma zona entremarés de aproximadamente 200 m de extensão, com sedimentos superficiais dominados por areia muito fina (Rosa Filho et al., 2011). Essa praia apresenta uma

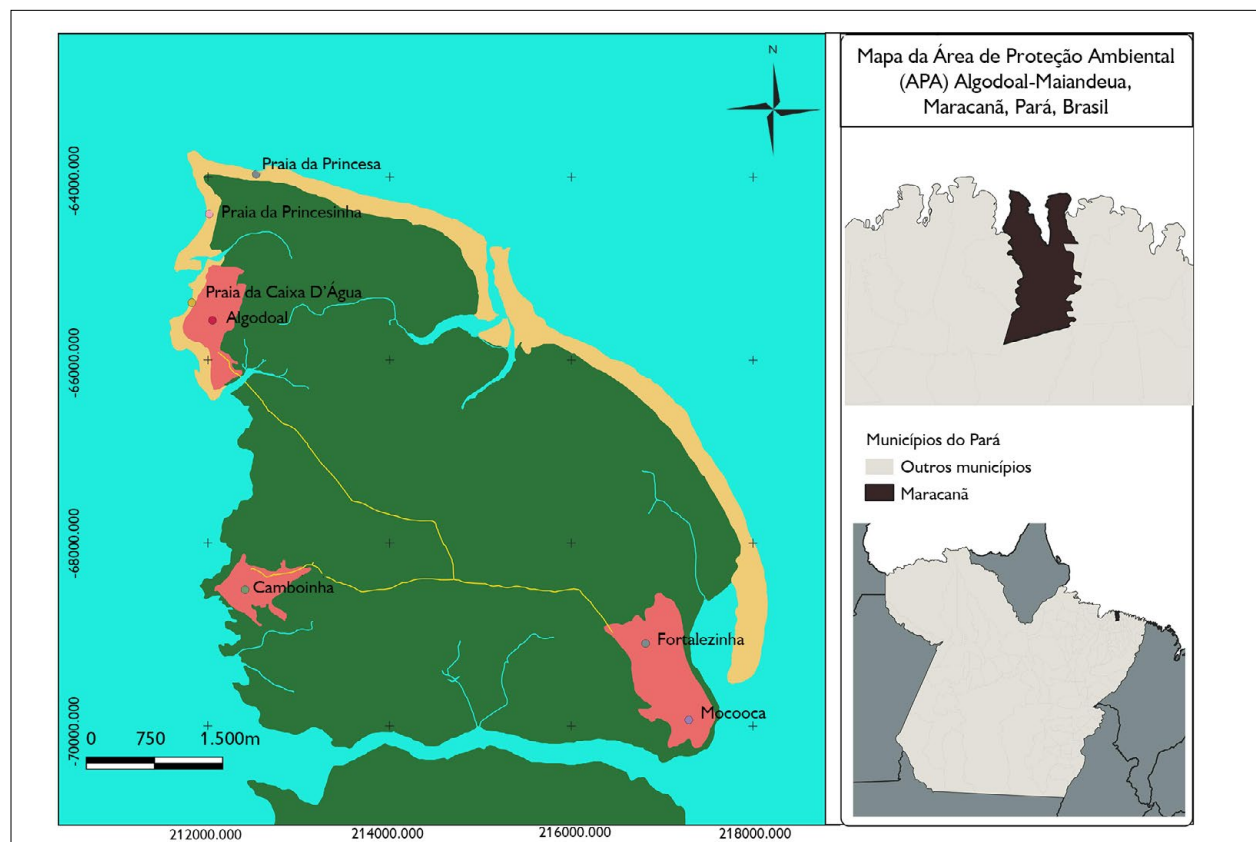


Figura 1. Mapa da ilha de Algodal/Maiandeua, Maracanã, Pará, Brasil. Fonte: Autores (2025).

Figure 1. Map of Algodal/Maiandeua Island, Maracanã, Pará, Brazil. Source: Authors (2025).

alta diversidade de ambientes, representada por uma planície estuarina, que compreende o funil estuarino, o canal de maré e a planície de inundação (Filgueira, 2019). As poças de maré que se formam durante a baixa-mar e durante a preamar religam-se ao mar e tornam-se sujeitas à ação das ondas e da turbulência (Horn & Gibson, 1988). Entretanto, essas feições não são permanentes, tendo em vista a grande variação da morfologia de costa e as constantes ações das marés de quadratura e sizígias (Horn & Gibson, 1988).

A praia da Princesinha, por sua vez, é uma praia com característica reflectiva, com declividade mais acentuada, ausência de bancos submersos e da zona de surfe (Sousa, 2010). Nesta praia, são observadas ondas de menor altura e sedimentos de granulometria média a grossa (Sousa, 2010). A praia da Princesa apresenta ondas mais enérgicas e mais rápidas, uma longa zona de surfe, com grande estoque de sedimentos de granulometria fina (Sousa, 2010).

AMOSTRAGEM QUALITATIVA

As coletas foram realizadas durante a maré vazante, nos meses de julho e outubro de 2023 (período seco) e em abril de 2024 (período chuvoso) (Tabela 1), em três praias distintas da ilha de Algodual (praias da Caixa D'Água, Princesa e Princesinha) (Figura 4A-4H). As coletas ocorreram em três tipos de ambientes: poças de maré, canal de maré e área infralitoral. Nas poças de maré e nas margens dos canais de maré, as amostras de água superficial foram coletadas acima dos primeiros 5 cm de profundidade com uma seringa de 60 ml e uma bomba de sucção manual, e o sedimento de fundo foi coletado através do método de arrasto com vasilhames plásticos de 300 ml. Para as áreas de infralitoral e canais de maré, foram realizadas coletas de sedimento de fundo através de um tubo cilíndrico de PVC de 30 cm de comprimento por 10 cm de diâmetro. As amostras, após coletadas, foram acondicionadas em sacos plásticos e fixadas em álcool 70%. Os parâmetros de pH, salinidade e temperatura da água dos pontos de coleta foram aferidos com uma sonda multiparamétrica Hanna® e um refratômetro (Figura 2A).

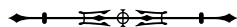
Após as coletas, as amostras foram peneiradas a úmido em peneiras de malhas 500, 250, 180 e 125 μm , e posteriormente acondicionadas em potes com álcool 70%. A triagem foi realizada em meio líquido com auxílio de pincéis (nº 000). Alguns ostracodes foram acondicionados em tubo Eppendorf e fixados em álcool 70% para preservação das partes moles. Posteriormente, para alguns espécimes, as carapaças foram fotografadas em microscópio eletrônico de varredura e suas partes orgânicas foram dissecadas sob estereomicroscópio. Os apêndices foram dissecados com agulha histológica, organizados em lâmina de vidro e fixados com fixador à base de glicerina. Posteriormente, a lâmina foi tamponada com lamínula e selada com esmalte transparente (Namiotko et al., 2011). As partes orgânicas foram fotomicrografadas em microscópio biológico por fluorescência e em microscópio eletrônico de varredura. O material-tipo está depositado na Coleção de Microfósseis do Museu Paraense Emílio Goeldi, sob os números MPEG-1098-M a MPEG-1109-M (onde MPEG = Museu Paraense Emílio Goeldi e M = microfósseis).

A classificação taxonômica supragenérica segue Liebau (2025) e a descrição dos apêndices segue Smith (2025) (PR = protopodito; En = endopodito; Ex = exopodito; Cx = coxa; G = garra; RC = ramo caudal; RA = região anterior; RP = região posterior).

RESULTADOS

DESCRIÇÃO TAXONÔMICA

Classe Ostracoda Latreille, 1806
Subclasse Podocopa Sars, 1866
Ordem Podocopida Sars, 1866
Subordem Cytherocopina Grundel, 1967
Superfamília Cytheroidea Baird, 1850
Família Cytheridae Sars, 1925
Subfamília Perissocytherideinae Bold, 1963
Gênero *Perissocytheridea* Stephenson, 1938



Espécie-tipo *Perissocytheridea matsoni*
(Stephenson, 1935)

Perissocytheridea materterrae sp. nov.

<http://zoobank.org/urn:lsid:zoobank.org:act:A1E9F81A-C4C0-4E4D-9159-B5B5790EBCBF>
(Figuras 3 a 6)

Holótipo: MPEG-1098-M: fêmea, carapaça, adulta. Algodual, praia da Caixa D'Água (0° 35' 35.563" S, 47° 35' 22.352" W), 7 de julho de 2023. Valva direita, comprimento: 0,50 mm; altura: 0,26 mm; valva esquerda, comprimento: 0,51 mm; altura: 0,27 mm.

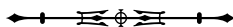
Parátipos: MPEG-1099-M: macho, carapaça, adulto, valva direita, comprimento de 0,53 mm e altura de 0,27 mm; valva esquerda, comprimento de 0,54 mm e altura de 0,28 mm; MPEG-1100-M: fêmea adulta, valva direita, comprimento de 0,51 mm e altura de 0,26 mm; valva esquerda, comprimento de 0,53 mm e altura de 0,27 mm; MPEG-1101-M: macho adulto, comprimento de 0,56 mm, altura de 0,28 mm e largura de 0,27 mm; MPEG-1102-M: carapaça, juvenil, A-1, valva direita, comprimento de 0,50 mm e altura de 0,29 mm; MPEG-1103-M: carapaça, juvenil, A-3, valva direita, comprimento de 0,42 mm e altura de 0,22 mm; MPEG-1104-M: carapaça, macho, valva direita, comprimento de 0,56 mm e altura de 0,30 mm; valva esquerda, comprimento de 0,58 mm e altura de 0,29 mm. Material suplementar: MPEG-1105-M: carapaça, macho, adulto, valva direita, comprimento de 0,58 mm e altura de 0,30 mm; MPEG-1106-M: 1 carapaça, juvenil, A-1, comprimento de 0,53 mm e altura de 0,25 mm; MPEG-1107-M: 1 carapaça, juvenil, comprimento de 0,47 mm e altura de 0,28 mm; MPEG-1108-M: 1 carapaça juvenil, comprimento de 0,49 mm e altura de 0,28 mm; MPEG-1109-M: valva direita, juvenil; comprimento de 0,50 mm e altura de 0,28 mm.

Origem do nome: do Latim, *materterrae*, em alusão ao nome da ilha de Algodual/Maiandeuá –, que originalmente na língua Tupi significa 'mãe da terra'.

Localidade-tipo: Amazônia brasileira: praia da Caixa D'Água, ilha de Algodual, Pará, Brasil (0.5932118823844159, -47.58954213832689).

Diagnose: carapaça muito pequena, subquadrada a subretangular, com contorno lateral alongado. Carapaça bulbosa na região posterodorsal. Valva esquerda maior do que a direita. Altura máxima na região anteromediana. Superfície ornamentada com reticulações, mais pontilhadas na região anterior; retículos arredondados, mais fortemente marcados na região mediana-central; duas ou três costelas longitudinais sinuosas estendendo-se da região central para a região posteromediana. Costelas ventral e marginal, e sulco anterodorsomediano bem evidente. Apêndices: a antênula é unirreme, formada por cinco podômeros com cerdas e garras relativamente curtas de funções motoras e sensoriais. A antena é birreme, formada por três podômeros, com cerdas relativamente mais longas do que as antênulas, além de garras curtas usadas para cavar. A mandíbula é composta por protopodito, exopodito e endopodito, além de um palpo mandibular com três podômeros e dentes na base. O palpo maxilar tem três podômeros e a placa branquial apresenta setas plumosas. Os três primeiros pares de patas estão ligados ao tórax. O primeiro par, localizado entre a cabeça e o tórax, tem três podômeros, com uma unha curva, relativamente menor do que a dos demais apêndices torácicos. O segundo e o terceiro pares possuem quatro podômeros com unhas de diferentes tamanhos. Dimorfismo sexual pouco aparente.

Carapaça: carapaça muito pequena, subquadrada a subretangular, com contorno lateral alongado. Altura máxima na região anteromediana. Margem anterior levemente arredondada e levemente truncada na região anterodorsal. Margem posterior estreita, ligeiramente truncada e levemente voltada para baixo, com processo caudal evidente. Margem dorsal sinuosa e ventral convexa. Superfície fortemente reticulada a pontuada para as margens. Retículos arredondados,



mais fortemente marcados na região mediana-central. Costela submarginal bem marcada se estendendo por toda a margem livre. Duas a três costelas longitudinais sinuosas estendendo-se da região central para a região posteromediana. Costela ventral evidente, terminando com uma protuberância formando um leve processo alar. Sulco anterodorsomediano bem marcado. Região posterodorsal fortemente inflada nos adultos. Vista interna: características internas típicas do gênero. Porocanais normais crivados de onde se projeta uma longa cerda sensorial em forma helicoidal. Em vista dorsal, a carapaça é subalongada e maior na porção posteromediana. Dimorfismo sexual discreto, com machos levemente mais alongados do que as fêmeas. Vista interna: charneira típica do gênero com cinco a seis pequenos dentes terminais e uma barra fracamente crenulada na valva direita. Valva esquerda com os elementos correspondentes.

Apêndices cefálicos: a região cefálica é constituída por um par de antênulas, antenas, mandíbulas e maxilas; a região torácica é levemente fusionada e constitui-se de três pares de apêndices bem desenvolvidos e demais elementos, conforme descrito abaixo (Figuras 4 e 5). Antênula (Figuras 4A e 5A) unirreme formada por cinco podômeros, com cerdas e garras relativamente curtas e espessas, de funções motoras e sensoriais. Uma cerda mais fina e longa no segundo podômero, e nos demais podômeros cinco cerdas mais curtas e espessas. A antena (Figuras 4A e 5B) é birreme, como os demais apêndices, e formada por três podômeros (En1, En2 e En3) com cerdas mais longas do que as antênulas, com uma garra estriada, forte e curta na extremidade. A mandíbula (Figuras 4B e 4F, 5C e 5E) é composta por protopodito, exopodito e endopodito; coxa longa seguida de um endopodito e dentes fortes e curtos na base. O palpo mandibular é formado pela base, seguida por dois endopoditos (En1 e En2), sendo o primeiro dividido em dois (En1a e En1b), com oito a nove longas cerdas nas extremidades e um exopodito fino e longo.

A maxila (Figura 5F) é formada pelo protopodito com base curta e larga, de onde se conectam três curtos endopoditos (En1, En2 e En3), com cerdas curtas nas extremidades; o exopodito (Ex) está representado por uma larga placa branquial com longas setas plumosas.

Apêndices torácicos: os três primeiros pares de apêndices torácicos estão ligados ao tórax por uma forte estrutura (endoesqueleto e músculos) (Figuras 4H e 6D). O primeiro par (Figura 6A), localizado entre a cabeça e o tórax, apresenta um protopodito (coxa) forte e espesso, de onde se conectam três consideravelmente longos endopoditos (En1, En2 e En3), sendo o terceiro muito curto (En3), fusionado a uma garra, semelhante a uma unha, relativamente longa na extremidade, embora menor do que a dos demais apêndices torácicos que auxilia na locomoção, na copulação e na mastigação. Nos juvenis, este apêndice é menos desenvolvido e modificado, apresentando uma seta caudal com tufo na extremidade (Figura 4G). O segundo (Figura 6B) e o terceiro (Figuras 6C e 6E) par de patas possuem três podômeros, sendo o segundo dividido (En2a e En2b) e mais longo, enquanto o terceiro é igualmente longo, ambos com unhas de tamanhos distintos. O terceiro par tem o primeiro e o segundo endopodito mais alongado do que os demais apêndices, assim como a unha da extremidade bem mais fina e mais longa. A extremidade posterior do corpo apresenta um ramo caudal curto de formato triangular, bem desenvolvido (Figura 6G), de onde partem músculos fortes (pareados) e um endoesqueleto por onde se articulam os apêndices torácicos (Figuras 4D e 4E). Os machos apresentam um órgão pareado em forma de pincel (*brush shaped*), de cerdas curtas e abertas (Figura 6E), conectado ao segundo apêndice torácico, que provavelmente serve para a limpeza. O aparato reprodutivo é complexo (Figura 4I) e pareado, formado por um lobo largo (hemipênis) que serve como receptáculo seminal, pelo órgão de Zenker e um aparato fino e longo na região posteroventral utilizado para a cópula.



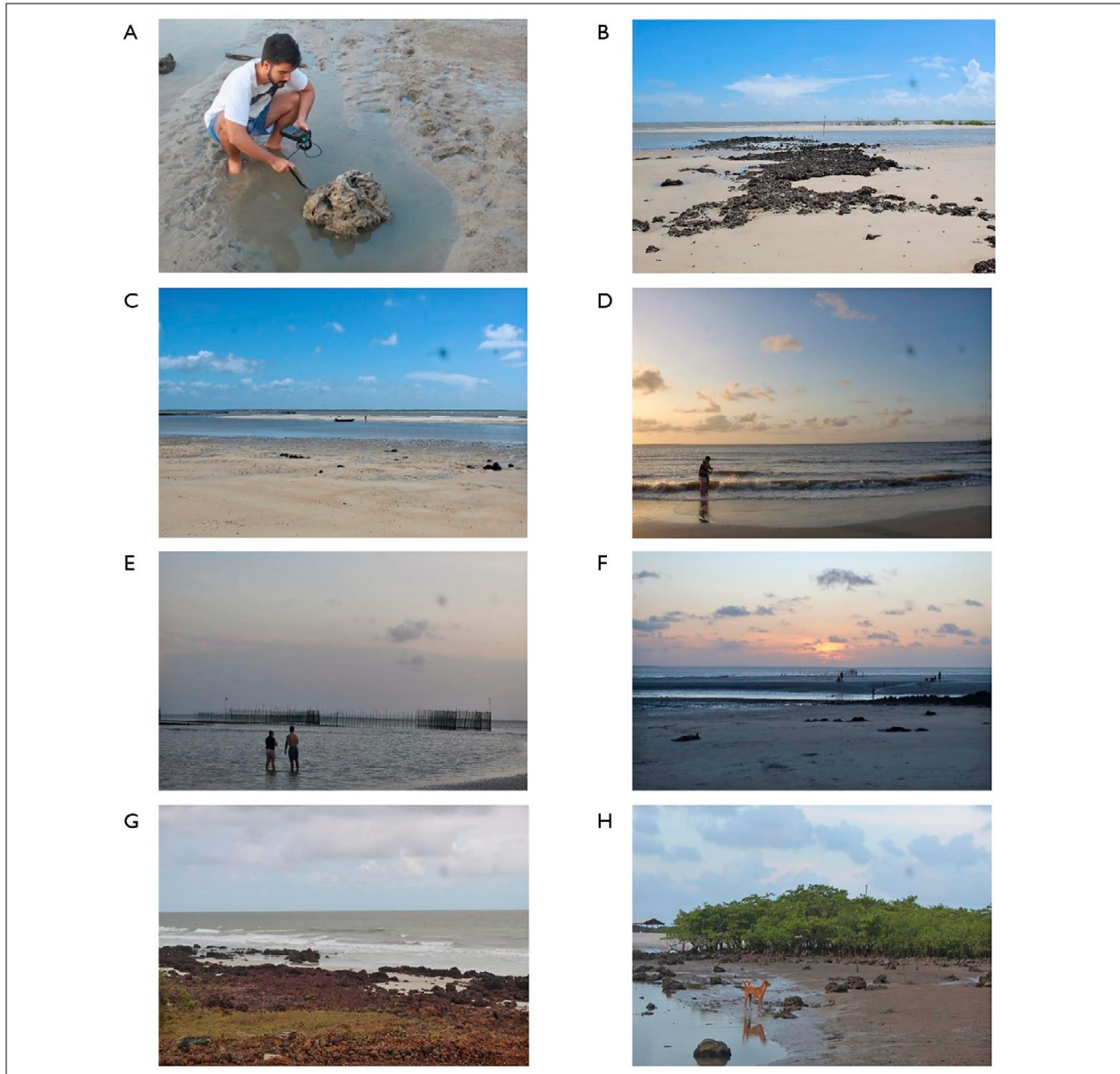


Figura 2. A) Poças de maré durante a baixa-mar, na praia da Caixa D'Água, e sonda utilizada para as medições dos atributos físicos da água em cada ponto de coleta; B) canal de maré (Furo de Algodual) e poças de maré que se formam entre as rochas lateríticas durante a baixa-mar na praia da Caixa D'Água; C) canal de maré (Furo de Algodual), praia da Caixa D'Água; D) litoral na baixa-mar, praia da Caixa D'Água; E) área do canal (Furo de Algodual), na maré vazante, praia da Caixa D'Água; F) canal de maré (Furo de Algodual), durante a baixa-mar, e exposição das rochas lateríticas formando ilhas barreiras, praia da Caixa D'Água; G) zona litorânea durante a baixa-mar, expondo as rochas lateríticas, praia da Princesa; H) área de mangue do Furo de Algodual (canal de maré), na baixa-mar, praia da Caixa D'Água. Fonte: Autores (2025).

Figure 2. A) Tide pools during low tide, Caixa D'Água Beach and probe used for measuring the physical attributes of the water at each collection point; B) tidal channel (Algodual Channel) and tide pools that form between the lateritic rocks during low tide at Caixa D'Água Beach; C) tidal channel (Algodual Channel), Caixa D'Água Beach; D) coastline at low tide, Caixa D'Água Beach; E) channel area (Algodual Channel) at low tide, Caixa D'Água Beach; F) tidal channel (Algodual Channel) during low tide, and exposure of lateritic rocks forming barrier islands, Caixa D'Água Beach; G) coastal zone during low tide, exposing the lateritic rocks, Princesa Beach; H) mangrove area of the Algodual Channel (Tidal channel) at low tide, Caixa D'Água Beach. Source: Authors (2025).

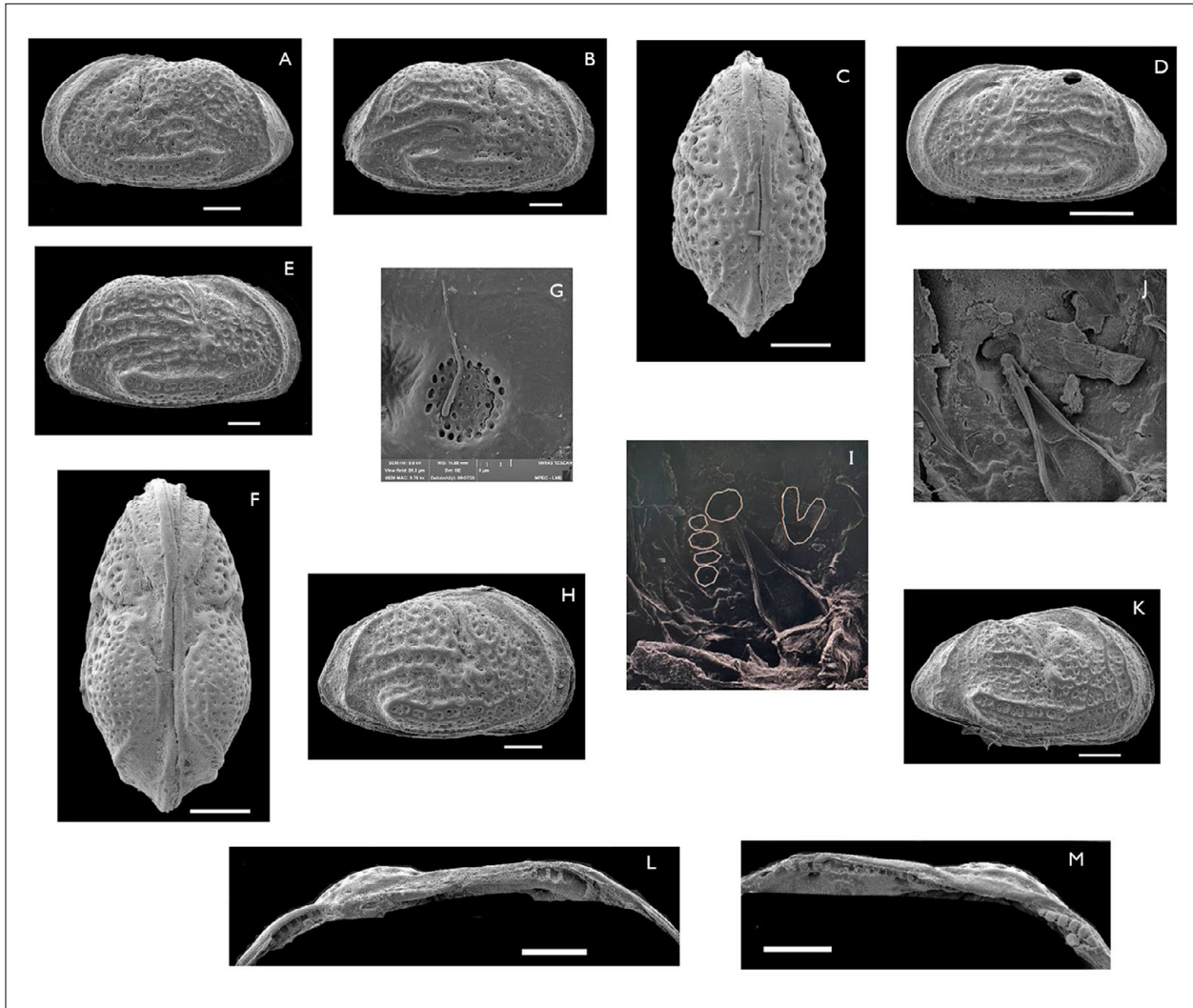


Figura 3. *Perissocytheridea materterrae* sp. nov.: A) holótipo: MPEG-1098-M, vista lateral externa, valva esquerda, fêmea; B) holótipo, MPEG-1098-M, vista lateral externa, valva direita, fêmea; C) holótipo, MPEG-1098-M, carapaça, vista dorsal, fêmea; D) parátipo 1: MPEG-1099-M, vista lateral externa, valva esquerda, macho; E) parátipo 1: MPEG-1099-M, vista lateral externa, valva direita, macho; F) parátipo 3, MPEG-1101-M, vista dorsal, macho; G) parátipo 5, MPEG-1103-M, detalhe do porocanal normal em forma de crivo com a cerda sensorial; H) parátipo 3, MPEG-1101-M, vista lateral, valva direita, juvenil A-1; I) parátipo 2, MPEG-1100-M, valva esquerda, vista interna, detalhe das impressões musculares; J) parátipo 2, MPEG-1100-M, valva esquerda, vista interna, detalhe da impressão mandibular; K) parátipo 4, MPEG-1102-M, vista lateral da valva direita, juvenil A-3; L e M) parátipo 2, MPEG-1100-M, detalhe da charneira (L = valva esquerda, vista interna; M = valva direita, vista interna). Fotomicrografias por microscopia eletrônica de varredura. Escalas: A-C, E, G-H, K-M = 100 micrômetros; D = 200 micrômetros; F = 5 micrômetros; I-J = 20 micrômetros. Fonte: Autores (2025).

Figure 3. *Perissocytheridea materterrae* sp. nov.: A) holotype: MPEG-1098-M, external lateral view, left valve, female; B) holotype, MPEG-1098-M, external lateral view, right valve, female; C) holotype, MPEG-1098-M, carapace dorsal view, female; D) paratype 1: MPEG-1099-M, external lateral view, left valve, male; E) paratype 1: MPEG-1099-M, external lateral view, right valve, male; F) paratype 3, MPEG-1101-M, dorsal view, male; G) paratype 5, MPEG-1103-M, detail of the normal sieve-shaped porocanal with the sensory seta; H) paratype 3, MPEG-1101-M, lateral view of the right valve, juvenile A-1; I) paratype 2, MPEG-1100-M, left valve, internal view, detail of muscle impressions; J) paratype 2, MPEG-1100-M, left valve, internal view, detail of the mandibular impression; K) paratype 4, MPEG-1102-M, lateral view of the right valve, juvenile A-3; L and M) paratype 2, MPEG-1100-M (detail of the hinge: L = left valve, internal view; M = right valve, internal view). Scanning electron microscopy photographs. Scales: A-C, E, G-H, K-M = 100 micrometers; D = 200 micrometers; F = 5 micrometers; I-J = 20 micrometers. Source: Authors (2025).

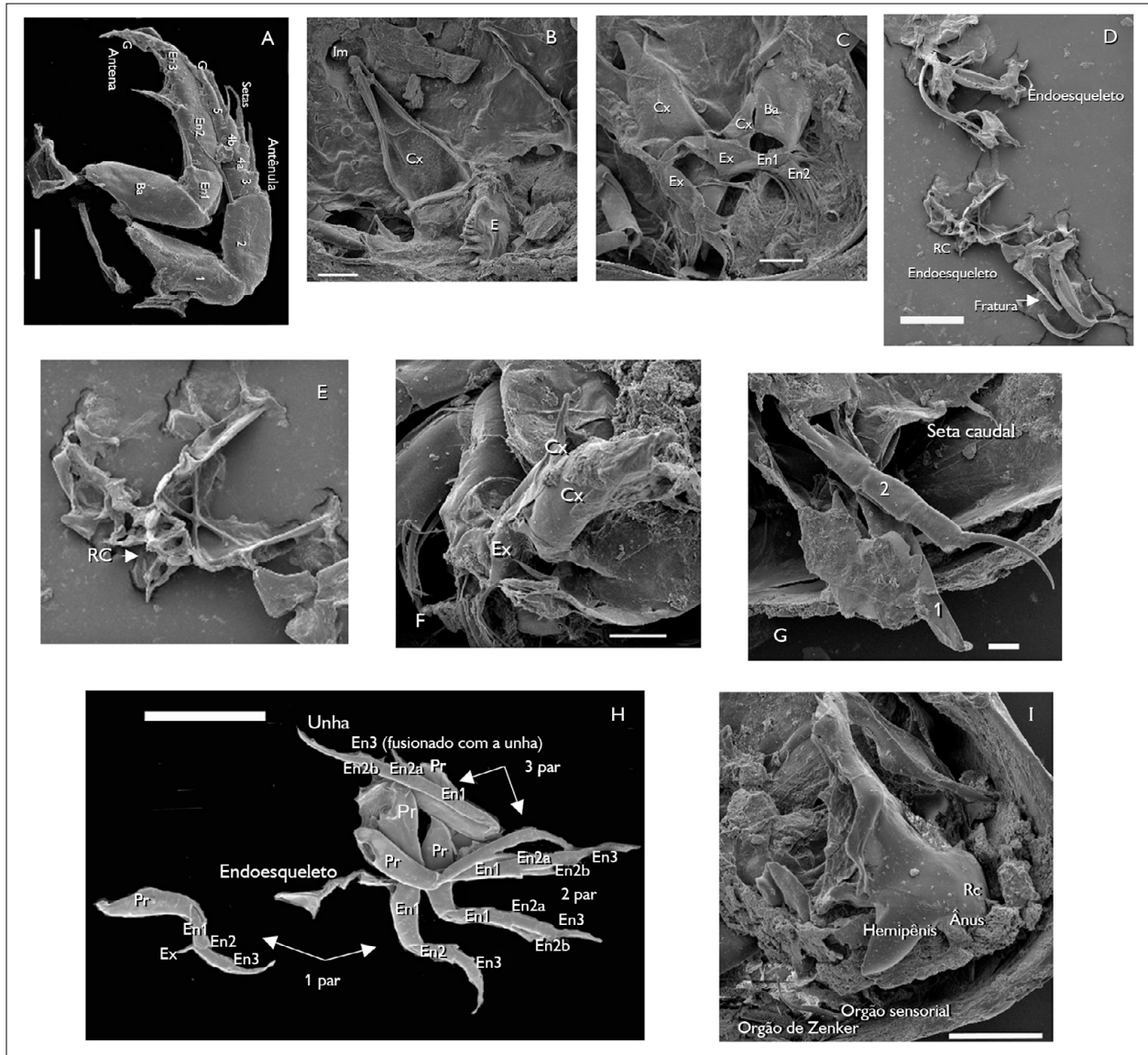


Figura 4. *Perissocytheridea materterrae* sp. nov.: A) parátipo 7, MPEG-1105-M, juvenil, A-1, detalhe do primeiro e segundo apêndice cefálico (antênula e antena); B) parátipo 2, MPEG-1100-M, detalhe do palpo mandibular; C, F, G e I) parátipo 6, MPEG-1104-M; C) detalhes da maxila, fêmea, adulta; D) detalhe do endoesqueleto (articulações dos apêndices) da região torácica; E) detalhe do ramo caudal e parte do endoesqueleto; F) parátipo 6, MPEG-1104-M, detalhe do palpo mandibular; G) parátipo 6, MPEG-1104-M, detalhe do primeiro apêndice modificado e segundo apêndice torácico, juvenil; H) detalhe dos três pares de apêndices torácicos e parte do endoesqueleto; I) parátipo 6, MPEG-1104-M, detalhe do aparelho reprodutor masculino e ramo caudal. Fotografias por microscopia eletrônica de varredura. Escalas: A e I = 50 micrômetros; B, C, F-G = 20 micrômetros; H = 100 micrômetros; D-F = 200 micrômetros. Fonte: Autores (2025).

Figure 4. *Perissocytheridea materterrae* sp. nov.: A) paratype 7, MPEG-1105-M, juvenile, A-1, detail of the first and second cephalic appendages (antennule and antenna); B) paratype 2, MPEG-1100-M, detail of the mandibular palp; C, F, G and I) paratype 6, MPEG-1104-M; C) details of the maxilla, adult female; D) detail of the endoskeleton (appendage joints) of the thoracic region; E) detail of the caudal branch and part of the endoskeleton; F) paratype 6, MPEG-1104-M, detail of the mandibular palp; G) paratype 6, MPEG-1104-M, detail of the first modified appendage and second thoracic appendage, juvenile; H) detail of the three pairs of thoracic appendages and part of the endoskeleton; I) paratype 6, MPEG-1104-M, detail of the male reproductive system and caudal branch. Scanning electron microscopy photographs. Scales: A and I = 50 micrometers; B, C, F-G = 20 micrometers; H = 100 micrometers; D-F = 200 micrometers. Source: Authors (2025).

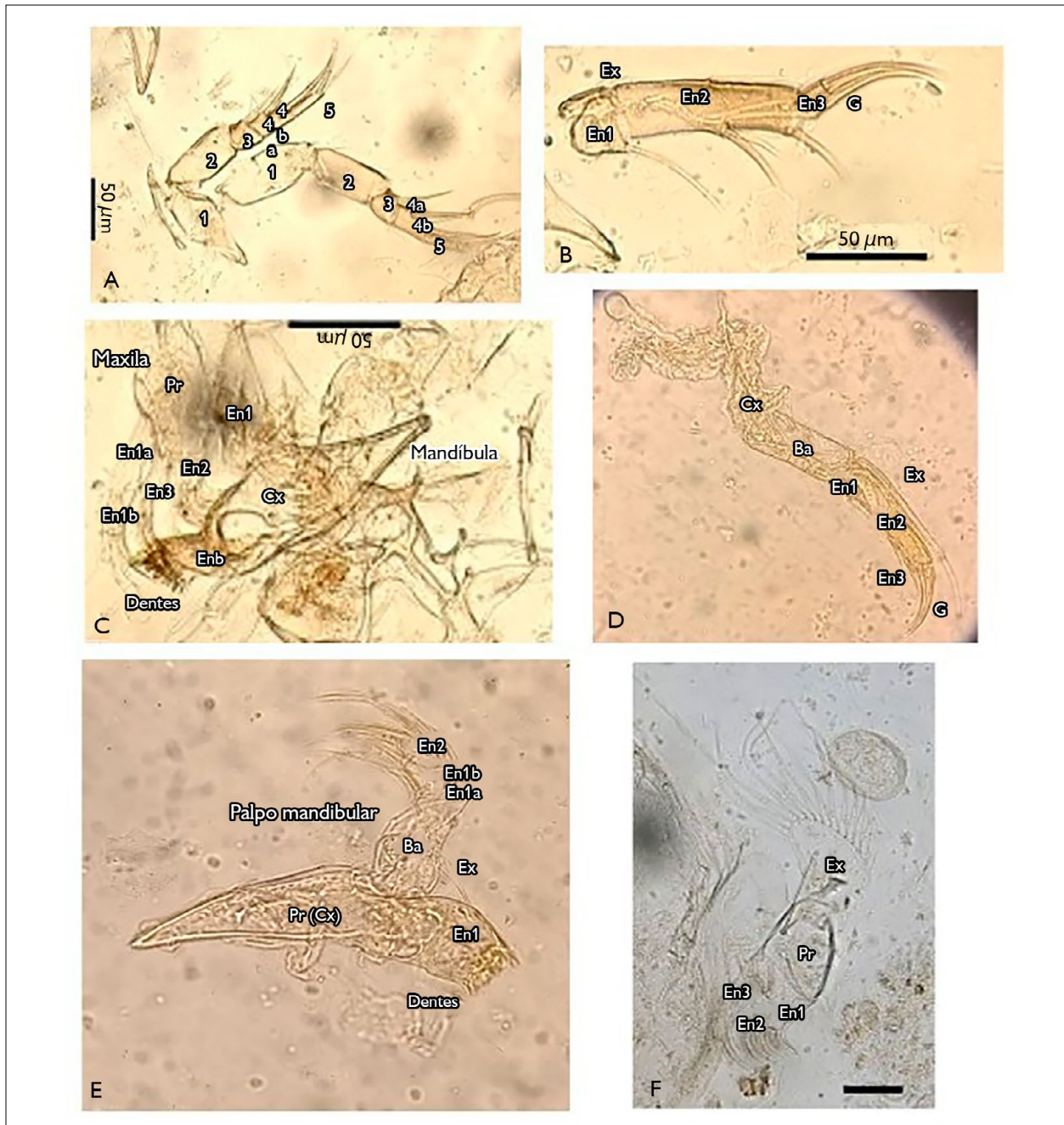


Figura 5. *Perissocytheridea materterrae* sp. nov.: A) MPEG-1106-M, parátipo 8, antênulas; B e D) MPEG-1107-M, parátipo 9, antena; C e E) parátipo 9, mandíbula; F) MPEG-1108-M, parátipo 10, maxila. Legendas: 1 a 5 = detalhe dos apêndices; En = endopodito; Ex = exopodito; Cx = coxa; Pr = protopodito; Ba = base; G = garra. Fotografias feitas por microscópio biológico por fluorescência. Escalas = 50 micrômetros. Fonte: Autores (2025).

Figure 5. *Perissocytheridea materterrae* sp. nov.: A) MPEG-1106-M, paratype 8, antennules; B and D) MPEG-1107-M, paratype 9, antenna; C and E) paratype 9, mandible; F) MPEG-1108-M, paratype 10, maxilla. Legend: 1–5 = appendages details; En = endopod; Ex = exopod; Cx = coxa; Pr = protopod; Ba = basis; G = claw. Photographs taken by biological fluorescence microscope. Scales = 50 micrometers. Source: Authors (2025).

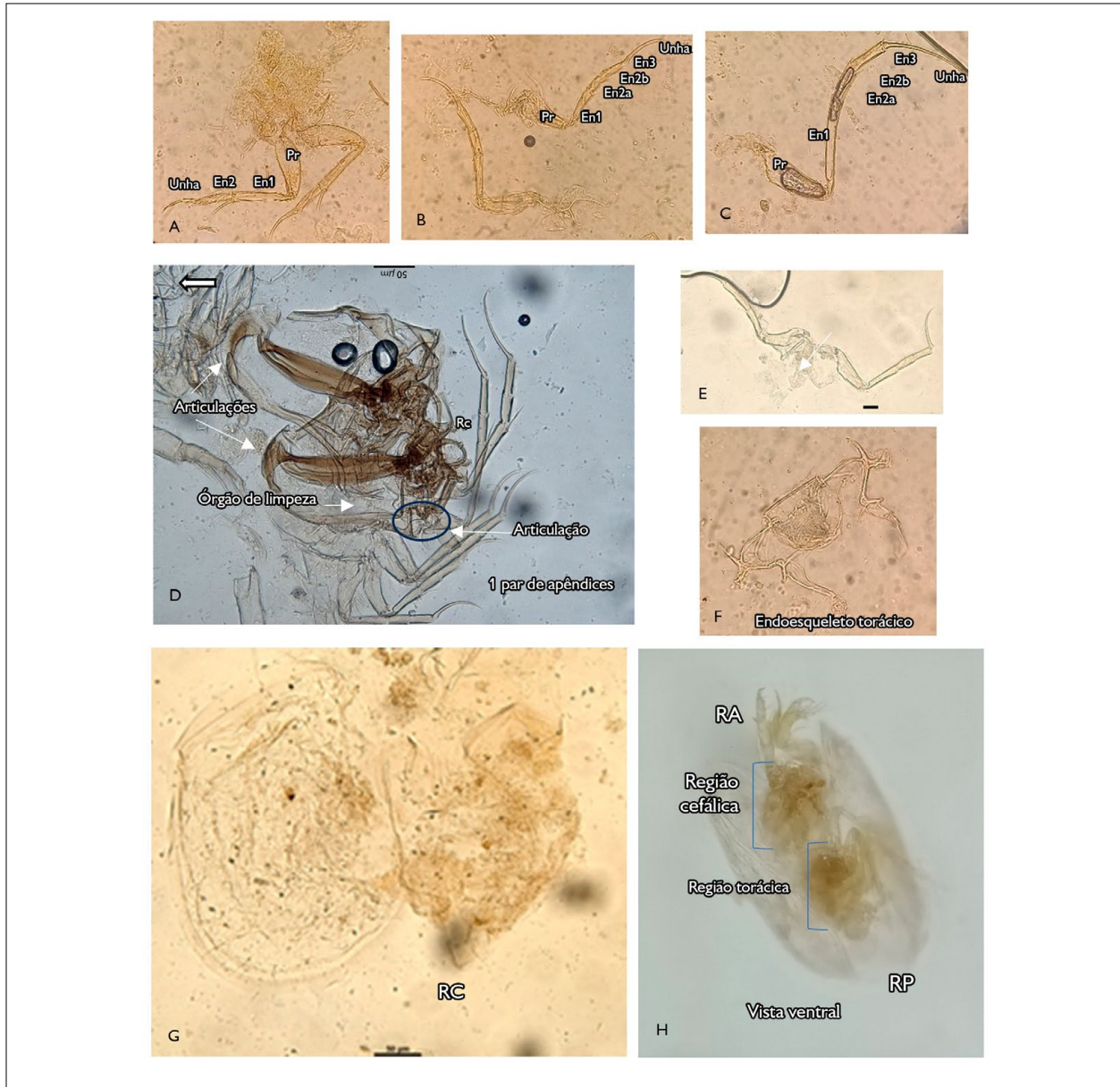


Figura 6. *Perissocytheridea materterrae* sp. nov.: A) MPEG-1109-M, parátipo 11, primeiro par de apêndices torácicos; B) parátipo 9, segundo par de apêndices torácicos; C) parátipo 9, terceiro apêndice torácico; D) parátipo 10, detalhe do endoesqueleto da região torácica; E) parátipo 9, detalhe do segundo apêndice torácico e o órgão de limpeza (*brush shaped organ*); F) parátipo 9, endoesqueleto do ramo caudal; G) detalhe do ramo caudal; H) carapaça aberta em vista ventral com as partes moles expostas. Legendas: En = endopodito; Pr = protopodito; RC = ramo caudal; RA = região anterior; RP = região posterior. Fotografias feitas por microscópio biológico por fluorescência. Escalas = 50 micrômetros. Fonte: Autores (2025).

Figure 6. *Perissocytheridea materterrae* sp. nov.: A) MPEG-1109-M, paratype 11, first pair of thoracic appendages; B) Paratype 9, second pair of thoracic appendages; C) paratype 9, third thoracic appendage; D) paratype 10, detail of the endoskeleton of the thoracic region; E) paratype 9, detail of the second thoracic appendage and the brush-shaped organ; F) paratype 9, endoskeleton of the caudal branch; G) detail of the caudal branch; H) carapace open in ventral view with soft parts exposed. Legend: En = endopod; Pr = protopod; RC = caudal ramus; RA = anterior region; RP = posterior region. Photographs taken by fluorescence microscope. Scales = 50 micrometers. Source: Authors (2025).

DISCUSSÃO

INFERÊNCIAS TAXONÔMICAS

A nova espécie, *Perissocytheridea materterrae* sp. nov., apresenta características diagnósticas do gênero *Perissocytheridea* Stephenson, 1938 e assemelha-se à espécie *Perissocytheridea kroemmelbeini* Pinto & Omellas, 1970. Entretanto, difere desta espécie por apresentar uma ornamentação mais evidente e mais marcada na região posterodorsal, com duas ou três costelas longitudinais bem marcadas e sinuosas, estendendo-se da região central para a região posteromediana, e uma costela ventral evidente. Ademais, as inflações bulbosas dorsolaterais são menos desenvolvidas, e a margem anterior fortemente arredondada; em *P. materterrae* sp. nov., a costela submarginal é bem marcada, ausente em *P. kroemmelbeini*, se estendendo por toda a margem livre. Os porocanais são crivados, como em *Perissocytheridea kroemmelbeini*, e os apêndices do tórax também são muito semelhantes, com fortes garras na extremidade, diferindo fortemente apenas no número de setas da maxila. Contudo, *Perissocytheridea materterrae* sp. nov. apresenta um menor número de podômeros nesses apêndices. O apêndice copulatório dos machos das duas espécies tem uma base forte, que serve como receptáculo de sêmen, e apêndices longos e finos para a cópula (Pinto & Omellas, 1970), conforme constatado no presente estudo.

Perissocytheridea materterrae sp. nov. também se assemelha a *Perissocytheridea pirabensis* Nogueira & Ramos, 2016, descrita para o Mioceno da Formação Pirabas, nordeste do estado do Pará, ao apresentar margem ventral convexa e margem anterior arredondada, diferindo desta pelo processo caudal evidente, mais curto em *Perissocytheridea pirabensis*. Ambas apresentam a superfície fortemente reticulada, com os machos das espécies mais longos do que as fêmeas. *Perissocytheridea materterrae* sp. nov. ainda é semelhante a *Perissocytheridea largulateralis* Nogueira & Ramos, 2016, também descrita para o Mioceno da Formação Pirabas, pela presença de duas costelas longitudinais e uma terceira mais evidente, que forma o processo alar. Entretanto, *P. materterrae*

sp. nov. difere dessa espécie por ter carapaça mais convexa na região ventral e apresentar um processo caudal mais evidente. Poucos são os registros de espécies modernas de *Perissocytheridea* descritas para a região Neotropical, sendo a maioria delas fósseis, como as encontradas no Golfo do México (Benson & Coleman, 1963) e no Caribe (Swain, 1955), as quais possuem carapaça mais lisa, com exceção das espécies *P. cribrosa* (Klie, 1933) e *P. rugata* (Swain, 1955) que possuem suas carapaças com mais retículos e com rugosidades. Ademais, a literatura científica carece de informações da descrição de apêndices para uma comparação anatômica mais profunda com a espécie aqui descrita.

INFERÊNCIAS ECOLÓGICAS

Os ostracodes apresentaram baixa diversidade na área de estudo, com presença apenas do gênero *Perissocytheridea*, representado pela nova espécie aqui descrita: *Perissocytheridea materterrae* sp. nov. Esse gênero tem preferência por fácies de águas salobras, representadas por diferentes sistemas, como os lagunares, os estuarinos, os de baías e os lacustres (Pinto & Omellas, 1970; Coimbra et al., 1999, 2007; Nogueira & Ramos, 2016; Berndt et al., 2026).

Dentre os vinte e cinco pontos amostrados na ilha de Algodual, apenas oito (Tabelas 1 e 2) continham ostracodes. Os espécimes foram restritos à praia da Caixa D'Água, mais abundantes no período seco, nas poças de maré e no canal de maré, totalizando 52 indivíduos. Os parâmetros mensurados (salinidade, pH e temperatura) não tiveram grandes variações entre os pontos (poças de maré, canais de maré e infralitoral) e os períodos de coleta, com exceção da salinidade, com mínima de 0 ppm, no período chuvoso, e máxima de 30 ppm, no período seco (Tabela 2). A espécie *P. materterrae* sp. nov. foi encontrada em pontos com salinidades entre 0 e 20 ppm, pH entre 7,9 e 8,0, e temperatura entre 28,5 e 33,6 °C. Os resultados indicam a preferência de *P. materterrae* sp. nov. por ambientes estuarinos mais estáveis, protegidos da ação das ondas, como as poças e os canais de maré, mas com grande variação de salinidade, pH básico e elevadas temperaturas.

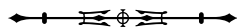


Tabela 1. Dados de localização dos pontos (Pt.) e datas de coleta de ostracodes em ambientes de entremarés da ilha de Algodoal/Maiandeuá, Maracanã, Pará, Brasil.

Table 1. Location data of the sampling points (Pt.) and dates of ostracods in intertidal environments of Algodoal/Maiandeuá Island, Maracanã, Pará, Brazil.

Ponto	Local de coleta	Coordenadas	Data	Horário	Ambiente	Ostracodes
Pt. 1	Praia da Caixa D'Água	-0.5932118823844159, -47.58954213832689	07/07/2023	12:30-14:00	Canal de maré	<i>Perissocytheridea materterrae</i> sp. nov.
Pt. 2	Praia da Caixa D'Água	-0.5932118823844159, -47.58954213832689	07/07/2023	12:30-14:01	Poças de maré	<i>Perissocytheridea materterrae</i> sp. nov.
Pt. 3	Praia da Caixa D'Água	-0.5932118823844159, -47.58954213832689	07/07/2023	12:30-14:02	Poças de maré, rochas lateríticas	<i>Perissocytheridea materterrae</i> sp. nov.
Pt. 4	Praia da Caixa D'Água	-0.5932118823844159, -47.58954213832689	08/07/2023	8:30-10:00	Canal de maré	Ausente
Pt. 7	Praia da Caixa D'Água	-0.5932118823844159, -47.58954213832689	20/10/2023	16:38-18:00	Canal de maré	Ausente
Pt. 8	Praia da Caixa D'Água	-0.5932118823844159, -47.58954213832689	20/10/2023	16:38-18:01	Infralitoral	Ausente
Pt. 9	Praia da Caixa D'Água	-0.5932118823844159, -47.58954213832689	20/10/2023	16:38-18:02	Canal de maré	Ausente
Pt. 10	Praia da Caixa D'Água	-0.5932118823844159, -47.58954213832689	21/10/2023	07:30:00- 9:00	Poças de maré, rochas lateríticas	<i>Perissocytheridea materterrae</i> sp. nov.
Pt. 11	Praia da Caixa D'Água	0.5932118823844159, -47.58954213832689	21/10/2023	07:30:00- 9:01	Canal de maré	Ausente
Pt. 13	Praia da Princesinha	-0.5814876048243837, -47.58696918182099	21/10/2023	10:00-12:02	Infralitoral	Ausente
Pt. 14	Praia da Caixa D'Água	-0.5932118823844159, -47.58954213832689	21/10/2023	17:48-19:00	Manguezal	Ausente
Pt. 16	Praia da Caixa D'Água	-0.5932118823844159, -47.58954213832689	19/04/2024	17:30	Poças de maré, rochas lateríticas	Ausente
Pt. 17	Praia da Caixa D'Água	-0.5932118823844159, -47.58954213832689	19/04/2024	17:32	Infralitoral	<i>Perissocytheridea materterrae</i> sp. nov.
Pt. 18	Praia da Caixa D'Água	-0.5932118823844159, -47.58954213832689	20/04/2024	09:02	Poças de maré, rochas lateríticas	<i>Perissocytheridea materterrae</i> sp. nov.
Pt. 19	Praia da Caixa D'Água	-0.5932118823844159, -47.58954213832689	20/04/2024	09:30	Canal de maré	<i>Perissocytheridea materterrae</i> sp. nov.
Pt. 20	Praia da Caixa D'Água	-0.5932118823844159, -47.58954213832689	20/04/2024	09:50	Infralitoral	<i>Perissocytheridea materterrae</i> sp. nov.
Pt. 21	Praia da Princesa	-0.5785303079235351, -47.58162710848417	20/04/2024	11:11	Poças de maré, rochas lateríticas	Ausente
Pt. 22	Praia da Princesa	-0.5785303079235351, -47.58162710848417	20/04/2024	11:34	Poças de maré, rochas lateríticas	Ausente



Tabela 2. Número total de espécimes de *Perissocytheridea materterrae* sp. nov. coletados na praia da Caixa D'Água (ilha de Algodual/Maiandeuá, Maracanã, Pará, Brasil) durante o período seco (2023) e o chuvoso (2024).

Table 2. Total number of specimens of *Perissocytheridea materterrae* sp. nov. collected at Caixa D'Água Beach (Algodual/Maiandeuá Island, Maracanã, Pará, Brazil) during the dry (2023) and rainy (2024) seasons.

Pontos	Praias	Data	Ambiente	Nº de indivíduos
Pt.1	Praia da Caixa D'Água	07/07/2023	Canal de maré	23
Pt. 2	Praia da Caixa D'Água	07/07/2023	Poças de maré	27
Pt. 3	Praia da Caixa D'Água	07/07/2023	Poças de maré, rochas lateríticas	1
Pt. 4	Praia da Caixa D'Água	08/07/2023	Canal de maré	0
Pt. 7	Praia da Caixa D'Água	20/10/2023	Canal de maré	0
Pt. 8	Praia da Caixa D'Água	20/10/2023	Infralitoral	0
Pt. 9	Praia da Caixa D'Água	20/10/2023	Canal de maré	0
Pt. 10	Praia da Caixa D'Água	21/10/2023	Poças de maré, rochas lateríticas	1
Pt. 11	Praia da Caixa D'Água	21/10/2023	Canal de maré	0
Pt. 13	Praia da Princesinha	21/10/2023	Infralitoral	0
Pt. 14	Praia da Caixa D'Água	21/10/2023	Manguezal	0
Pt. 16	Praia da Caixa D'Água	19/04/2024	Poças de maré, rochas lateríticas	0
Pt. 17	Praia da Caixa D'Água	19/04/2024	Infralitoral	2
Pt. 18	Praia da Caixa D'Água	20/04/2024	Poças de maré, rochas lateríticas	2
Pt. 19	Praia da Caixa D'Água	20/04/2024	Canal de maré	1
Pt. 20	Praia da Caixa D'Água	20/04/2024	Infralitoral	1
Pt. 21	Praia da Caixa D'Água	20/04/2024	Poças de maré, rochas lateríticas	0
Pt. 22	Praia da Princesa	20/04/2024	Poças de maré, rochas lateríticas	0
			Total	58

CONCLUSÃO

O estudo traz um dos poucos registros de espécimes atuais de *Perissocytheridea* para a região Neotropical. As amostragens de ostracodes em ambientes entremarés da ilha de Algodual (costa amazônica do Brasil) permitiram a descrição de uma nova espécie: *Perissocytheridea materterrae* sp. nov. A espécie foi restrita às poças e aos canais de maré da praia da Caixa D'Água, atestando a preferência do gênero por ambientes salobros de baixa energia. A salinidade variou de forma expressiva (entre 0 e 20 ppm) nos locais de ocorrência de *P. materterrae* sp. nov. A ocorrência de uma única espécie revela a baixa diversidade de ostracodes na área estudada e a tolerância de *P. materterrae* sp. nov. à intensa ação das macromarés

e às variações ambientais sazonais, bem como sua importância como bioindicador.

A presença de ostracodes em áreas menos expostas do entremarés de zonas litorâneas reforça que esses habitats proporcionam um refúgio adequado para a fauna bentônica. A análise de ostracodes fornece dados importantes para compreender a dinâmica do litoral equatorial brasileiro e das áreas tropicais.

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Coleção didática de invertebrados marinhos como recurso para compreensão da biodiversidade e ensino em ciências do mar na Amazônia

Educational collection of marine invertebrates as a resource for understanding biodiversity and teaching marine sciences on the Amazon

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Resumo: As coleções didáticas são elos fundamentais entre o conhecimento teórico e a prática científica, sendo ferramentas importantes na educação formal e na educação ambiental, sensibilizando a sociedade para a conservação dos ecossistemas e a salvaguarda da biodiversidade. O objetivo desse estudo foi caracterizar a Coleção de Invertebrados Marinhos da Universidade Federal do Pará (CZIM-UFPA), detalhando sua estrutura e diversidade taxonômica, e o seu uso como ferramenta didática no ensino fundamental, médio e superior. A coleção é composta por 256 tombamentos, os quais abrigam 1.562 indivíduos. São registrados oito filos, 61 famílias, 74 gêneros e 67 espécies de invertebrados marinhos. O filo Mollusca é o mais representativo (54% dos indivíduos e 36 espécies), seguido pelo subfilo Crustacea (33,6 % dos exemplares e 23 espécies). A coleção destaca-se pela representatividade de espécies típicas de ambientes costeiros, incluindo praias arenosas, manguezais e afloramentos rochosos. A notável diversidade taxonômica do acervo amplia seu uso como uma valiosa fonte de dados para a pesquisa sobre a biodiversidade marinha regional. Com mais de duas décadas de existência, a CZIM consolidou-se como um importante recurso didático, oferecendo suporte ao ensino de zoologia e contribuindo para projetos de extensão universitária e ações de popularização das ciências do mar na Amazônia.

Palavras-chave: Biodiversidade marinha. Coleções zoológicas. Ensino de zoologia. Projeto de extensão.

Abstract: Didactic collections are fundamental links between theoretical knowledge and scientific practice, being important tools in formal education and environmental education, sensitizing society to the conservation of ecosystems and the safeguarding of biodiversity. The objective of this study was to characterize the Marine Invertebrate Collection of the Federal University of Pará (CZIM-UFPA), detailing its structure and taxonomic diversity, and its use as a didactic tool in elementary, secondary and higher education. The collection consists of 256 listings, which house 1,562 individuals. Eight phyla, 61 families, 74 genera and 67 species of marine invertebrates are recorded. The phylum Mollusca is the most representative (54% of the individuals and 36 species), followed by the subphylum Crustacea (33.6% of the specimens and 23 species). The collection stands out for its representativeness of species typical of coastal environments, including sandy beaches, mangroves and rocky outcrops. The remarkable taxonomic diversity of the collection expands its use as a valuable source of data for research on regional marine biodiversity. With more than two decades of existence, CZIM has consolidated itself as an important didactic resource, offering support to the teaching of zoology and contributing to university extension projects and actions to popularize marine sciences in the Amazon.

Keywords: Marine biodiversity. Zoological collections. Zoology teaching. Extension Project.

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INTRODUÇÃO

Uma coleção biológica compreende um acervo de organismos, ou partes destes, conservados e organizados com o objetivo de documentar a diversidade biológica e servir como recurso fundamental para pesquisa e educação (Marinoni, 2024). Tradicionalmente associadas aos estudos de sistemática e taxonomia, as coleções biológicas se tornaram bases indispensáveis para pesquisas em diversas áreas, como evolução, ecologia, conservação e gestão ambiental, impactos ambientais e saúde pública (Suarez & Tsutsui, 2004; Lavoie, 2013; Kamenski et al., 2016). Mais do que repositórios de espécimes, os acervos biológicos possuem grande relevância como ferramentas educativas, seja nas práticas do ensino formal, seja nas atividades extensionistas de sensibilização e educação ambiental (Azevedo et al., 2012; NASEM, 2020).

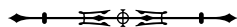
As coleções biológicas podem ser classificadas de acordo com sua forma de utilização (Papavero, 1994), por exemplo: (1) coleções de pesquisa gerais (institucionais e particulares), com grandes acervos voltados principalmente para a taxonomia e a sistemática, a descrição de espécies e os estudos comparativos, funcionando como acervos de referência; (2) coleções regionais, que reúnem espécimes de determinada área ou localidade; (3) coleções especiais (de interesse econômico ou médico), dedicadas à pesquisa aplicada e à resolução de problemas; (4) coleções de identificação com acervos que servem de apoio à identificação de material zoológico para as mais diversas finalidades; e (5) coleções didáticas educacionais, estruturadas para fins pedagógicos, favorecendo a aprendizagem por meio da observação direta e da manipulação dos espécimes. Embora apresentem finalidades distintas, essas categorias não são excludentes, podendo coexistir em uma mesma instituição, ampliando o alcance científico, formativo e social do acervo.

Na educação formal, as coleções didáticas biológicas proporcionam aos alunos uma melhoria em

sua aprendizagem, por meio de observação, análise, manipulação e curadoria dos espécimes depositados nos acervos (Santos & Souto, 2011; Azevedo et al., 2012). O uso de espécimes em aulas práticas estimula a curiosidade científica e potencializa a assimilação do conteúdo (Santos & Souto, 2011). Quando se incorporam espécies regionais, comuns dos ambientes cotidianos ou de prévio conhecimento dos estudantes, o processo de aprendizagem é ainda mais efetivo (Cachapuz et al., 2005). No ensino superior, a integração das coleções científicas está alinhada com as práticas de educação STEAM (Ciência, Tecnologia, Engenharia, Artes e Matemática, do inglês *Science, Technology, Engineering, Arts and Mathematics*), promovendo uma aprendizagem baseada em investigação e no desenvolvimento de habilidades (Kwan & Wong, 2021).

No âmbito da educação não formal e da extensão universitária, as coleções didáticas funcionam ainda como conexões que aproximam a sociedade do conhecimento produzido na universidade, permitindo uma troca contínua de experiências e saberes entre pesquisadores e cidadãos. Em especial, a apresentação de conjuntos sistemáticos de seres vivos contribui para a compreensão mais ampla da diversidade biológica e da importância da preservação dos seus ecossistemas (Azevedo et al., 2012). Isso é primordial no caso dos ecossistemas marinhos, que desempenham papéis essenciais à manutenção da vida no planeta, incluindo regulação climática, ciclagem de nutrientes, provisão de alimento, proteção costeira e suporte à biodiversidade. Esses serviços ecossistêmicos sustentam atividades econômicas e garantem o bem-estar humano (Beaumont et al., 2007).

Apesar de sua importância global, os ambientes marinhos permanecem relativamente pouco conhecidos pelo público em geral. Uma pesquisa recente realizada no Brasil mostrou que 27% dos entrevistados desconhecem como o oceano influencia em suas vidas, enquanto 40% desconhecem que são influenciados por ele



(Fundação Grupo Boticário, 2022). Isso em parte reflete a falta de conteúdos sobre os oceanos nos currículos escolares, uma realidade notada em nível mundial, que levou ao movimento da 'cultura oceânica', uma iniciativa global que busca conscientizar a sociedade sobre a importância dos oceanos para a vida na Terra (Cardoso et al., 2025). Além disso, reconhecendo a importância de aprofundar o conhecimento sobre o oceano, a Organização das Nações Unidas (ONU) instituiu a 'década da ciência oceânica para o desenvolvimento sustentável (2021-2030)'. Essa iniciativa tem como propósito engajar pesquisadores, gestores públicos e a sociedade civil na produção e na disseminação de conhecimento científico, fomentando ações voltadas à conservação e ao uso sustentável dos recursos oceânicos (IOC, 2020).

A utilização de coleções, principalmente as didáticas, tem se mostrado uma ferramenta importante para promover a cultura oceânica, levando a uma melhor compreensão sobre a estrutura e o funcionamento dos ecossistemas marinhos, subsidiando ações de educação e conservação ambiental no Brasil (Alves et al., 2021; Pontes & Silva, 2021; João et al., 2022; Cardoso et al., 2025).

A Universidade Federal do Pará (UFPA), por meio da Coleção Zoológica de Invertebrados Marinhos (CZIM), mantém um acervo que integra características de coleção científica, de referência e didática. Criada em meados de 2003 pelo professor José Souto Rosa Filho (Instituto de Geociências), a coleção surgiu com o objetivo de subsidiar aulas práticas de disciplinas da Faculdade de Oceanografia (FAOC), tendo ampliado seu acervo e sua atuação ao longo dos anos. Enquanto coleção clássica (*sensu* Kamenski et al., 2016), desde 2025, a CZIM preserva e cataloga invertebrados marinhos da região costeira amazônica, com dados registrados no Sistema de Informação sobre a Biodiversidade Brasileira (SiBBr), contribuindo para a documentação da biodiversidade nacional. Simultaneamente, o acervo biológico é utilizado para subsidiar aulas práticas, principalmente em disciplinas da

área de oceanografia biológica, do curso de Bacharelado em Oceanografia. A coleção também apoia projetos de extensão da UFPA, promovendo o contato com a comunidade não acadêmica, incluindo escolas de ensino fundamental e médio da região metropolitana de Belém, no estado do Pará.

Diante disso, o objetivo deste artigo é apresentar a CZIM, da UFPA, caracterizando sua estrutura e a diversidade taxonômica, bem como o seu uso como ferramenta didática no ensino das ciências do mar na Amazônia.

MATERIAL E MÉTODOS

O acervo da CZIM está abrigado atualmente no Laboratório de Pesquisa em Monitoramento Ambiental Marinho (LAPMAR), situado no Setor Básico (*Campus I*) da Cidade Universitária Professor José da Silveira Netto, *Campus* do Guamá da UFPA em Belém, Brasil. Os espécimes da CZIM estão preservados em meio líquido (álcool 70%) e organizados conforme seu grupo taxonômico (filo, classe, ordem etc.) (Figura 1). O acervo abriga, na maior parte, exemplares da costa amazônica coletados durante as atividades de campo nas disciplinas da FAOC da UFPA, bem como aqueles provindos de diversos projetos executados por docentes e pesquisadores da FAOC, como o projeto "Potenciais impactos ambientais do transporte de petróleo e derivados na zona costeira amazônica" (PIATAM Oceano e PIATAM-MAR) e o "Programa de mapeamento de sensibilidade ao óleo – Cartas SAO".

Foi realizado um levantamento completo do acervo da CZIM, para obtenção de número de tomos, número de indivíduos e informações sobre procedência, como data, localidade e coordenadas geográficas. As identificações taxonômicas dos espécimes foram revisadas e atualizadas. A composição da coleção foi compilada para uma listagem taxonômica e a diversidade dos grupos faunísticos foi quantificada pela riqueza de táxons. Os dados foram submetidos a análises descritivas de frequências absoluta e relativa.



Figura 1. A) Localização física da Coleção de Invertebrados Marinhos (CZIM) no prédio do Laboratório de Pesquisa em Monitoramento Ambiental Marinho (LAPMAR); B) vista parcial do acervo da CZIM. Fotos: Y. Porto (2020) (A) e L. G. G. de Almeida (2025) (B).

Figure 1. A) Physical location of the Marine Invertebrate Collection (CZIM), in the building of Marine Environmental Monitoring Research Laboratory (LAPMAR); B) partial view of the CZIM collection. Photos: Y. Porto (2020) (A) and L. G. G. de Almeida (2025) (B).

RESULTADOS E DISCUSSÃO

COMPOSIÇÃO GERAL DO ACERVO

A CZIM/UFGA reúne um acervo de tamanho expressivo, com 1.562 espécimes, distribuídos em oito filos, 61 famílias, 74 gêneros e 67 espécies de invertebrados marinhos (Tabela 1). O acervo tem predominância de exemplares dos filos Mollusca (843 exemplares) e Arthropoda, sobretudo do subfilo Crustacea (525 exemplares), os quais são seguidos por Annelida (73 exemplares) e Echinodermata (26 exemplares), com demais filos pouco representativos no acervo (Figuras 2 e 3).

Os representantes de Mollusca e Arthropoda (Crustacea) correspondem a mais de 80% do total de indivíduos catalogados (Figura 2). A dominância de ambos os *taxa* na CZIM é esperada, pois esses são os invertebrados mais comuns e diversos da macrofauna e megafauna no ambiente marinho, além de geralmente serem facilmente coletados (Herman et al., 1999; Brusca et al., 2018). Além disso, são também os mais comuns nos

estuários amazônicos, de onde provêm a maior parte dos espécimes da CZIM (Rosa Filho et al., 2018).

Aliada a isso, a presença de estruturas rígidas, como a concha de moluscos e o exoesqueleto de crustáceos, torna mais fácil a coleta de exemplares íntegros, assim como a sua identificação e conservação (Ravinesh & Kumar, 2022). Essa característica também os torna bastante adequados para uso como material didático, particularmente em atividades práticas de ensino. Por outro lado, filos menos expressivos, como os de vermiformes, exigem métodos de coleta específicos e técnicas de fixação mais delicadas (Gibson, 1995; Lavrov & Ereskovsky, 2022; Zattara & Fernández-Alvarez, 2022). Outros, como Porifera, Cnidaria e Echinodermata, são mais ricos em ambientes da plataforma externa, onde as variações de salinidade e turbidez da água são menores e existe maior disponibilidade de substrato consolidado, como no sistema recifal amazônico (Pinto et al., 2022; Oliveira Silva et al., 2025). Contudo, esses *habitats* estão muito mal representados na CZIM.

Tabela 1. Composição taxonômica da Coleção Zoológica de Invertebrados Marinhos da Universidade Federal do Pará (CZIM/UFPA).
 Legendas: N = número de exemplares; A.R = abundância relativa das categorias. (Continua)

Table 1. Taxonomic composition of the Marine Invertebrate Zoological Collection of the Federal University of Pará (CZIM/UFPA). Captions: N = number of specimens; A.R = relative abundance of categories. (Continue)

Filo	Classe	Ordem	Família	Espécie	N	A.R%		
Porifera	Demospongiae	Spongilida	Metaniidae		11	0,70		
					3	0,19		
Cnidaria	Hexacorallia	Actiniaria	Actiniidae	<i>Bunodosoma cangicum</i> Belém & Preslercravo, 1973	20	1,28		
				Scleractinia	Astrangiidae	<i>Astrangia rathibuni</i> Vaughan, 1906	1	0,06
						Caryophylliidae	<i>Caryophyllia ambrosia caribbeana</i> Cairns, 1979	1
				Hydrozoa	Siphonophorae	Physaliidae	<i>Stephanocyathus diadema</i> (Moseley, 1876)	1
	<i>Physalia physalis</i> (Linnaeus, 1758)	8	0,51					
	Scyphozoa	Rhizostomeae	Lychnorhizidae	<i>Lychnorhiza lucerna</i> Haeckel, 1880	2	0,13		
				Pelagiidae	<i>Chrysaora lactea</i> Eschscholtz, 1829	1	0,06	
					Stomolophidae	<i>Stomolophus meleagris</i> Agassiz, 1860	6	0,38
								23
	Mollusca	Bivalvia	Arcida	Arcidae	<i>Anadara secernenda</i> (E. Lamy, 1907)	2	0,13	
Cardiida					Donacidae	<i>Donax striatus</i> Linnaeus, 1767	38	2,43
						Psammobiidae	<i>Sanguinolaria psammantella</i> (Gmelin, 1791)	13
Myida			Corbulidae	<i>Austromacoma constricta</i> (Bruguière, 1792)	2		0,13	
				<i>Macoma</i> sp.	13	0,83		
				<i>Corboula</i> sp.	3	0,19		
Mytilida			Teredinidae	<i>Psiloteredo healdi</i> (Bartsch, 1931)	7	0,45		
				Modiolidae	<i>Modiolus</i> sp.	1	0,06	
			Mytilidae		<i>Mytella guyanensis</i> (Lamarck, 1819)	73	4,67	
				<i>Mytella strigata</i> (Hanley, 1843)	39	2,50		
Mytilidae			<i>Mytilaster solisianus</i> (A. d'Orbigny, 1846)	75	4,80			
			<i>Mytilus</i> sp.	4	0,26			
			Unionida	Hyriidae	<i>Prisodon symmatophorus</i> (Gmelin, 1791)	3	0,19	
<i>Triplodon corrugatus</i> (Lamarck, 1819)					1	0,06		
Venerida			Chamidae	<i>Chama</i> sp.	2	0,13		
	Veneridae	<i>Anomalocardia flexuosa</i> (Linnaeus, 1767)		19	1,22			



Tabela 1. | *Table 1.*

(Continua) | *(Continue)*

Filo	Classe	Ordem	Família	Espécie	N	A.R%
				<i>Leukoma pectorina</i> (Lamarck, 1818)	22	1,41
				<i>Tivela mactroides</i> (Born, 1778)	1	0,06
				<i>Tivela zonaria</i> (Lamarck, 1818)	2	0,13
	Gastropoda	Aplysiida	Aplysiidae	<i>Aplysia</i> sp.	4	0,26
		Littorinimorpha	Cassidae	<i>Semicassis granulatum</i> (Born, 1778)	8	0,51
			Naticidae	<i>Natica</i> sp.	2	0,13
				<i>Naticarius canrena</i> (Linnaeus, 1758)	23	1,47
		Cycloneritida	Neritidae	<i>Nerita</i> sp.	1	0,06
				<i>Vitta virginea</i> (Linnaeus, 1758)	112	7,17
				<i>Vitta zebra</i> (Bruguière, 1792)	38	2,43
		Neogastropoda	Buccinidae		1	0,06
			Melongenidae	<i>Pugilina</i> sp.	5	0,32
				<i>Pugilina tupiniquim</i> Abbate & Simone, 2015	5	0,32
			Muricidae	<i>Stramonita</i> sp.	191	12,23
				<i>Thaisella</i> sp.	24	1,54
		Stylommatophora	Achatinidae	<i>Lissachatina fulica</i> (Bowdich, 1822)	3	0,19
	Cephalopoda	Octopoda			10	0,64
		Sepiida	Sepiolidae	<i>Semirossia tenera</i> (A. E. Verrill, 1880)	1	0,06
		Teuthida			95	6,08
Annelida	Clitellata	Oligochaeta			4	0,26
		Hirundinea			7	0,45
	Polychaeta	Phyllodocida	Glyceridae		2	0,13
			Nephtyidae	<i>Nephtys simoni</i> Perkins, 1980	1	0,06
			Syllidae		1	0,06
		Spionida	Magelonidae	<i>Magelona papillicornis</i> F. Müller, 1858	1	0,06
		Eunicida	Eunicidae	<i>Marphysa</i> sp.	2	0,13
			Nereididae	<i>Alitta succinea</i> (Leuckart, 1847)	2	0,13
				<i>Laeonereis culvieri</i> (Webster, 1879)	21	1,34
				<i>Namalycastis abiuma</i>	1	0,06
				<i>Namalycastis geayi</i> (Gravier, 1901)	1	0,06
				<i>Namalycastis macroplatis</i> Glasby, 1999	5	0,32
				<i>Namanereis amboinensis</i> (Pflugfelder, 1933)	1	0,06
				<i>Neanthes</i> sp.	3	0,19
				<i>Nereis oligohalina</i> (Rioja, 1946)	2	0,13
			Onuphidae	<i>Diopatra cuprea</i> (Bosc, 1802)	2	0,13

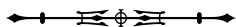


Tabela 1. | *Table 1.*

(Continua) | *(Continue)*

Filo	Classe	Ordem	Família	Espécie	N	A.R%		
		Sabellida	Sabellariidae	<i>Sabellaria wilsoni</i> Lana & Gruet, 1989	4	0,26		
		Terebellida	Terebellidae		2	0,13		
	Clitellata	Lumbriculida			3	0,19		
		Rhynconchobdellida			7	0,45		
		Tubificida			1	0,06		
Arthropoda		Malacostraca	Decapoda	Callichiridae	<i>Lepidophthalmus siriboia</i> Felder & Rodrigues, 1993	175	11,20	
	Diogenidae			<i>Clibanarius vitattus</i> (Bosc, 1801)	38	2,43		
				<i>Clibanarius symmetricus</i> (Randall, 1840)	10	0,64		
				Diogenidae	<i>Paguristes</i> sp.	14	0,90	
				Grabsidae	<i>Goniopsis cruentata</i> (Latreille, 1803)	6	0,38	
				Hippidae	<i>Emerita brasiliensis</i> Schmitt, 1935	52	3,33	
				Leucosiidae	<i>Myropsis quinquespinosa</i> Stimpson, 1871	2	0,13	
				Menippidae	<i>Menippe nodifrons</i> Stimpson, 1859	1	0,06	
				Nephropidae	<i>Nephropsis</i> sp.	3	0,19	
				Ocypodidae	<i>Uca</i> sp.	69	4,42	
					<i>Ocypode quadrata</i> (Fabricius, 1787)	3	0,19	
					<i>Uca maracoani</i> (Latreille, 1803)	38	2,43	
					<i>Ucides cordatus</i> (Linnaeus, 1763)	12	0,77	
					<i>Minuca mordax</i> (Smith, 1870)	12	0,77	
					Palaemonidae	<i>Macrobrachium</i> sp.	1	0,06
						<i>Macrobrachium carcinus</i> (Linnaeus, 1758)	2	0,13
				Parthenopidae	<i>Leiolambrus nitidus</i> Rathbun, 1901	2	0,13	
				Penaeidae		38	2,43	
				Panopeidae	<i>Eurytium limosum</i> (Say, 1818)	1	0,06	
					<i>Panopeus occidentalis</i> Saussure, 1857	1	0,06	
				Polychelidae	<i>Polycheles</i> sp.	1	0,06	
				Portunidae	<i>Calinectes</i> sp.	1	0,06	
					<i>Callinectes bocourti</i> A. Milne-Edwards, 1879	17	1,09	
		<i>Callinectes danae</i> Smith, 1869	5		0,32			
		Sesarmidae	<i>Aratus</i> sp.		1	0,06		
			<i>Aratus pisonii</i> (H. Milne Edwards, 1837)	3	0,19			
			<i>Armases benedicti</i> (Rathbun, 1897)	2	0,13			



Tabela 1. | *Table 1.* (Conclusão) | *(Conclusion)*

Filo	Classe	Ordem	Família	Espécie	N	A.R%
			Trichodactylidae	<i>Dilocarcinus pagei</i> Stimpson, 1861	2	0,13
			Trichodactylidae	<i>Syriocarcinus devillei</i> H. Milne Edwards, 1853	1	0,06
			Xanthidae		3	0,19
		Isopoda	Cirolanidae	<i>Bathynomus giganteus</i> A. Milne-Edwards, 1879	2	0,13
			Ligiidae	<i>Ligia</i> sp.	3	0,19
		Lophogastrida			2	0,13
	Thecostraca	Balanomorpha	Balanidae	<i>Austromegabalanus</i> sp.	2	0,13
Echinodermata	Echinoidea	Arbacioida	Arbaciidae	<i>Coelopleurus</i> sp.	3	0,19
		Camarodonta	Echinometridae	<i>Echinometra lucunter</i> (Linnaeus, 1758)	2	0,13
		Echinolampadacea	Mellitidae	<i>Mellita quiquiesperforata</i> (Leske, 1778)	14	0,90
	Asteroidea				1	0,06
	Holoturoidea				3	0,19
	Ophiuroidea				3	0,19
Chordata	Ascidiacea				6	0,38

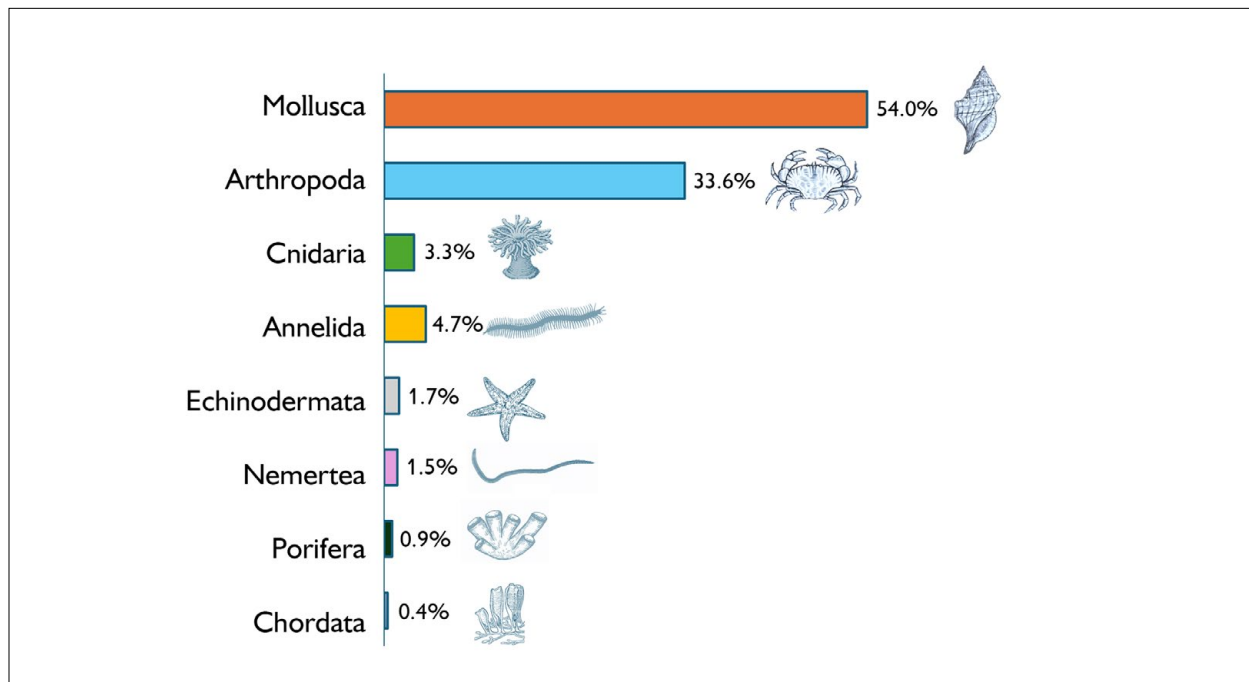


Figura 2. Abundância relativa dos exemplares por filo da CZIM.

Figure 2. Relative abundance of specimens by phylum of the CZIM Collection.

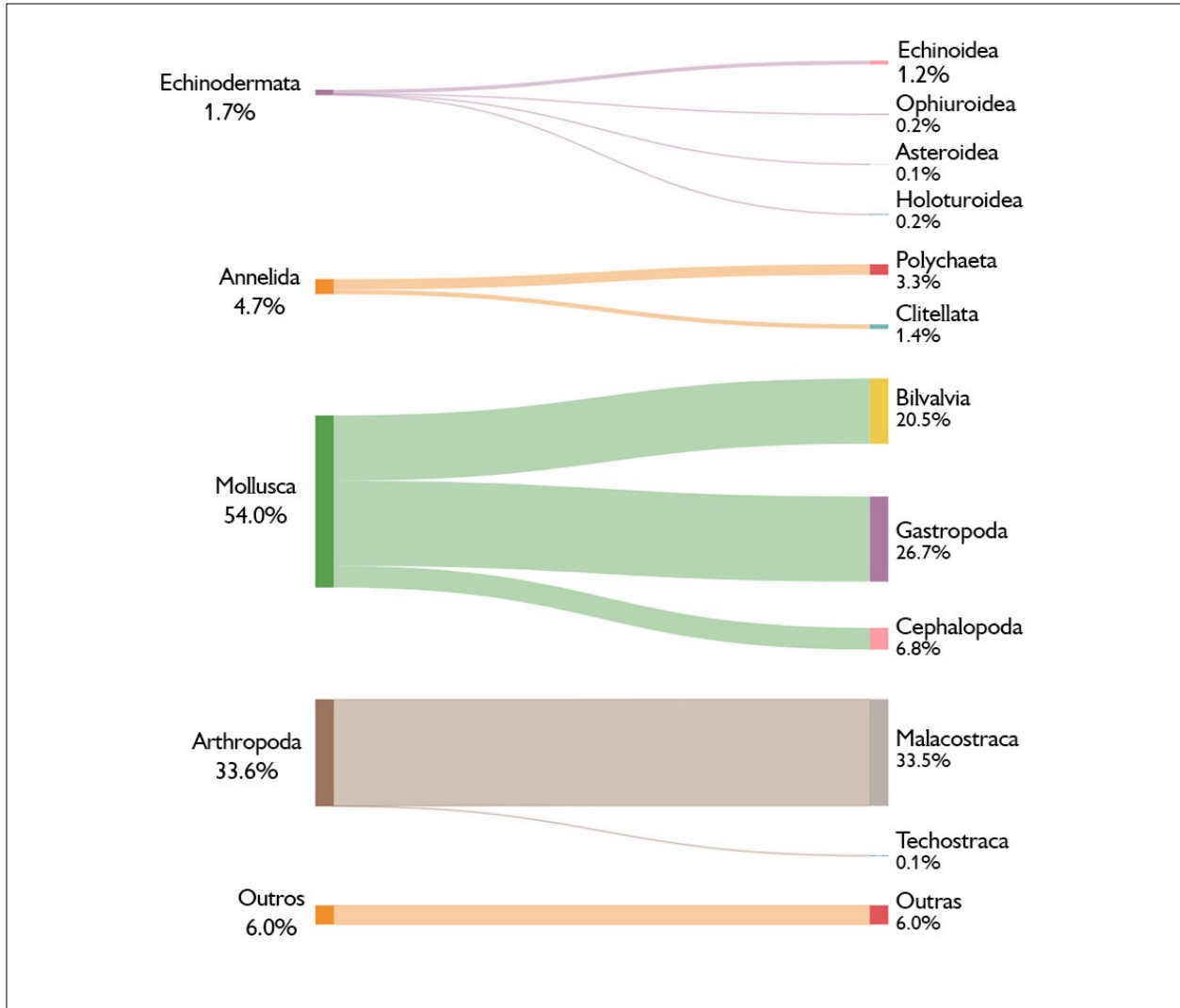


Figura 3. Abundância relativa (%) dos exemplares nos principais filos e classes da CZIM.

Figure 3. Relative abundance (%) of CZIM specimens in main the phyla and classes of the CZIM Collection.

No acervo, o filo Mollusca é composto majoritariamente por representantes das classes Gastropoda e Bivalvia (Figura 4), um reflexo da alta diversidade encontrada nessas classes (Xu et al., 2024). A maioria dos espécimes de Gastropoda pertence a Muricidae, na qual destacam-se espécies de *Thaisella*, gastrópodes carnívoros que alcançam altas densidades em afloramentos rochosos no entremarés das praias e nos manguezais paraenses (Anjos, 2019). Na classe Bivalvia, Mytilidae e Veneridae concentram

a maior abundância relativa na coleção, com destaque para mariscos de valor ecológico e econômico na região. A família Mytilidae abrange mexilhões (*Mytella* spp.) explorados na costa amazônica (Câmara et al., 2023). Dentre os venerídeos, o sarnambi *Leukoma pectorina* (Lamarck, 1818) é amplamente consumido em comunidades costeiras do Pará (Silva et al., 2020). O berbigão *Anomalocardia flexuosa* (Linnaeus, 1767), que também está representado no acervo, apesar de ocorrer no litoral amazônico, é mais abundante

e consumido nas regiões Nordeste, Sudeste e Sul do Brasil (Mourão et al., 2021).

No acervo, duas espécies de bivalves de água doce estão presentes, pertencentes a Hyriidae, *Triplodon corrugatus* (Lamarck, 1819) e *Prisodon syrmatophorus* (Gmelin, 1791). Os exemplares são provenientes de áreas estuarinas oligohalinas com domínio fluvial. Essas são espécies nativas de bivalves de água doce endêmicas da bacia hidrográfica amazônica (Simone, 2006; Pimpão & Mansur, 2009).

O filo Arthropoda é representado no acervo principalmente pela classe Malacostraca, sobretudo por integrantes da ordem Decapoda (Figura 5). Callichiridae, que abrange os popularmente conhecidos camarões-fantasma ou corruptos, foi a mais representativa

(Figura 4). Entre as espécies dessa família, destaca-se *Lepidophthalmus siriboia* (Felder & Rodrigues, 1993), que é um bioturbador comum e frequentemente abundante na zona entremarés de planícies de maré e praias arenosas do Pará (Rosa Filho et al., 2013). Outras famílias de crustáceos com considerável representatividade foram as dos braquiúros Ocypodidae e Portunidae, anomuros e camarões Penaeidae (Figura 5).

Os representantes de Ocypodidae incluem o caranguejo-uça *Ucides cordatus* (Linnaeus, 1763), que tem grande importância ecológica e socioeconômica na costa do Pará, e os caranguejos chama-maré (gêneros *Minuca* e *Uca*), típicos habitantes de manguezais (Koch et al., 2005). Entre os Portunidae, os exemplares da coleção

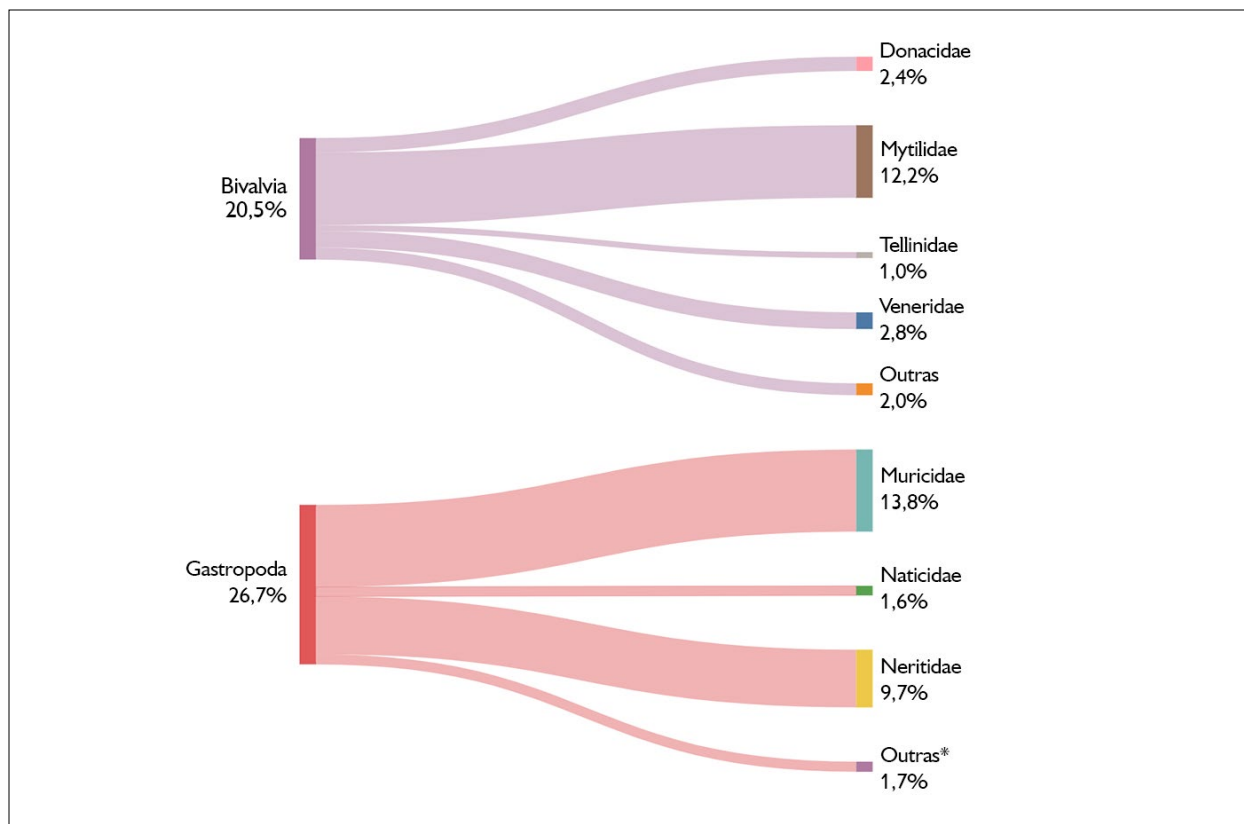


Figura 4. Abundância relativa dos exemplares por classes (Gastropoda e Bivalvia) e famílias do filo Mollusca. Outras*: famílias que representaram menos de 1% do total de exemplares da CZIM.

Figure 4. Relative abundance of specimens by families of the phylum Mollusca (classes Bivalvia and Gastropoda). Others*: families representing less than 1% of the total specimens from CZIM.

são de siris do gênero *Callinectes* sp., provindos de ambientes estuarinos. Esses crustáceos são particularmente abundantes nos estuários amazônicos, sendo frequentes em poças de maré margeadas por afloramentos rochosos (Oliveira et al., 2022). Os siris são amplamente utilizados como alimento por comunidades tradicionais amazônicas, desempenhando um papel social e econômico significativo na região (Silva et al., 2005). Entre os representantes de Penaeidae, a maior parte dos exemplares do CZIM é composta por camarão-rosa, *Penaeus* (*Farfantepenaeus*) *subtilis* (Pérez Farfante, 1967), intensamente explorado pela pesca industrial na plataforma continental amazônica (Lobo & Cañete, 2024). Por fim, a abundância do ermitão

Clibanarius symmetricus (Randall, 1840) em praias, afloramentos e manguezais da costa do Pará (Danin et al., 2020) também explica a representatividade da família Diogenidae no acervo.

Em relação à abrangência geográfica, 90,4% dos registros da CZIM são provindos de localidades do Pará, outros provêm do Maranhão (6,1%), do Piauí (1,4%), do Amapá (1,1%) e de Santa Catarina (0,8%). Entre os poucos exemplares que não são oriundos da costa amazônica, estão os do gênero *Emerita* (Hippidae), com organismos doados à coleção, uma vez que não há registro de populações bentônicas desse gênero na costa amazônica. Os registros dos espécimes da coleção datam de 1981 a 2025.

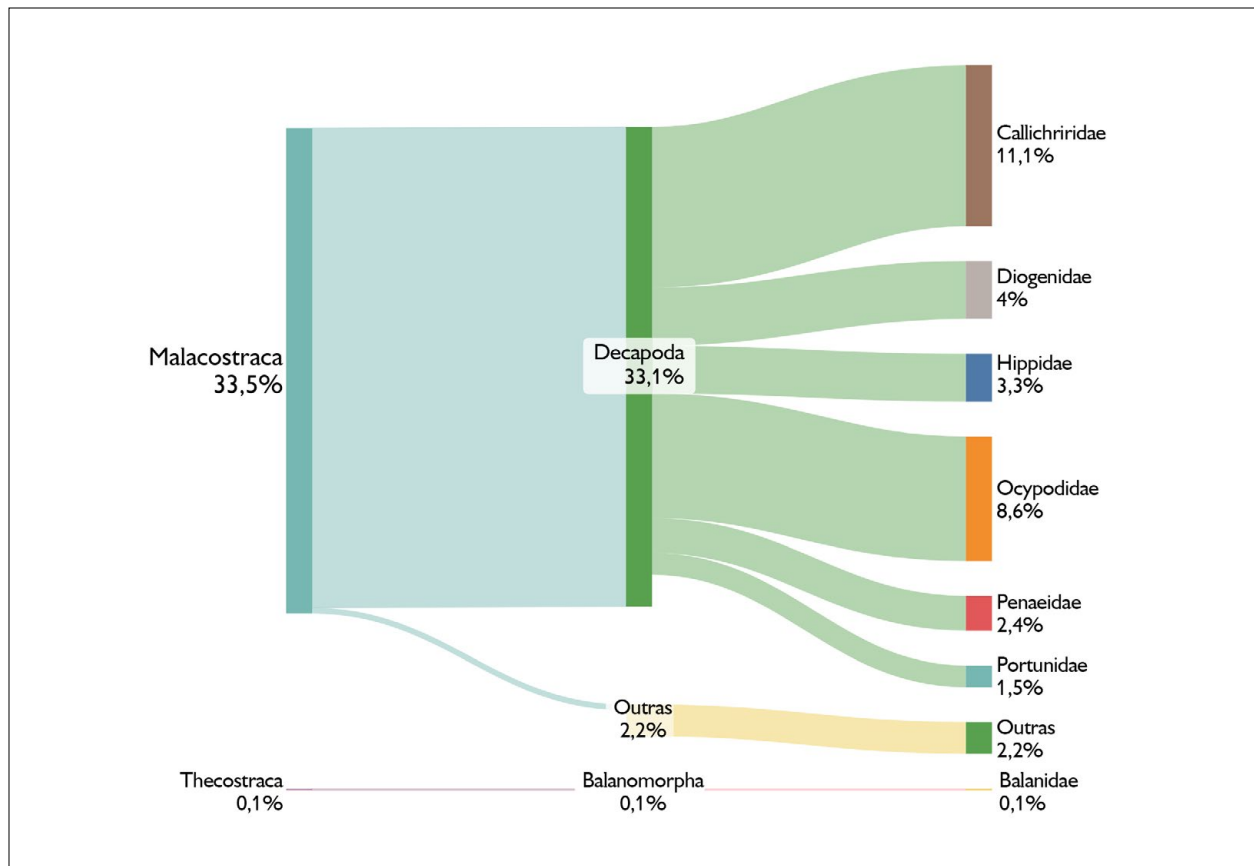


Figura 5. Abundância relativa dos exemplares por classes, ordens e famílias do filo Arthropoda. Outras*: famílias que representaram menos de 1% do total de exemplares da CZIM.

Figure 5. Relative abundance of specimens by class, orders, families of the phylum Arthropoda. Others*: families representing less than 1% of the total specimens from CZIM.

ATIVIDADES DE ENSINO, PESQUISA E EXTENSÃO

A CZIM, com mais de duas décadas de existência, surgiu como um relevante acervo biológico utilizado para subsidiar aulas práticas (Figura 6), principalmente em disciplinas da área de oceanografia biológica da FAOC, sendo também utilizada por outras faculdades da UFPA, como a de Ciências Biológicas. Como recurso didático, a CZIM facilita a análise morfológica de organismos aquáticos, bem como a interação entre conteúdos de zoologia e ecologia.

O uso de coleções zoológicas no ensino é uma estratégia pedagógica bem consolidada, proporcionando uma experiência prática que une observação crítica,

manejo técnico e curadoria de acervos biológicos. Essa é uma abordagem que permite a compreensão aprofundada da biodiversidade e garante um maior preparo técnico para futuros professores e pesquisadores (Azevedo et al., 2012). Ademais, a promoção de um ambiente de aprendizagem ativa e colaborativa – que integra diferentes áreas do conhecimento e fomenta o diálogo entre os estudantes – alinha-se às propostas da educação STEAM e aos compromissos da Agenda 2030 da ONU, especificamente ao objetivo de desenvolvimento sustentável 4 (ODS 4), que visa assegurar uma educação de qualidade de forma global (Pereira, 2020).

O acervo da CZIM também tem sido um recurso fundamental nas atividades de extensão conduzidas



Figura 6. A) Aula prática da disciplina “Invertebrados marinhos” (FAOC/UFPA) com uso dos exemplares da CZIM; B) exemplares de invertebrados marinhos da CZIM utilizados durante aulas práticas. Fotos: L. G. G. de Almeida (2025).

Figure 6. A) Practical class of the “Marine Invertebrates” discipline (FAOC/UFPA) using CZIM specimens; B) specimens of CZIM marine invertebrates used during practical classes. Photos: L. G. G. de Almeida (2025).



pelos docentes e discentes da FAOC (Tabela 2). Muitas dessas iniciativas visam popularizar o conhecimento sobre invertebrados marinhos, destacando a relevância da biodiversidade e a urgência da conservação do ambiente marinho. Um dos principais públicos-alvo dessas ações são estudantes da educação básica de Belém, que as recebem nas suas instituições ou visitam a universidade durante os eventos.

Um exemplo de projeto de extensão em que a CZIM desempenhou papel central é o “Acidentes com

animais aquáticos: prevenção e informação (2014-2016)”, desenvolvido pelo Laboratório de Oceanografia Biológica (LOB) da UFPA. O foco desse projeto foi informar ao público sobre espécies de animais aquáticos que podem causar acidentes ao homem, com orientações sobre prevenção, cuidados e tratamento. A iniciativa se destacou pela sua participação multidisciplinar, envolvendo professores, alunos da UFPA, pescadores artesanais e entidades como o Corpo de Bombeiros, escolas e gestores municipais.

Tabela 2. Principais ações de ensino e extensão universitária nas quais a Coleção de Invertebrados Marinhos (CZIM) esteve envolvida entre 2003 e 2025.

Table 2. Teaching and university extension activities involving the Marine Invertebrate Collection (CZIM) between 2003 and 2025.

Nome da atividade/evento	Público-alvo	Ano(s)	Foco principal das atividades com a CZIM
Aulas práticas – conteúdos de zoologia (UFPA)	Discentes dos cursos de Oceanografia e Ciências Biológicas	2003-2025	Auxiliar no aprendizado dos conteúdos teóricos; promover a observação crítica, o manejo técnico e a curadoria de acervos biológicos
Projeto “Acidentes com animais aquáticos: prevenção e informação”	Pescadores artesanais, alunos da educação básica, entidades públicas (Corpo de Bombeiros)	2014–2016	Orientação do público sobre espécies aquáticas potencialmente perigosas ao homem, prevenção e tratamento de acidentes
Exposição da Biodiversidade (EXPOBIO - UFPA)	Público geral, acadêmico e sociedade civil (alunos e professores da educação básica)	2022-2023	Divulgar pesquisas sobre biodiversidade marinha e promover a popularização do conhecimento científico
Semana do Calouro de Biologia (UFPA)	Discentes (calouros) dos cursos de Ciências Biológicas	2022	Apresentar conteúdos de zoologia de invertebrados e projetos com biodiversidade marinha desenvolvidos
Projeto “Biopraias - década dos oceanos: praias e sua biodiversidade”	Público geral (acadêmico e sociedade civil)	2023-2024	Informar e orientar a sociedade sobre a importância de preservar as praias e sua biodiversidade, com foco em invertebrados bentônicos
76ª Reunião Anual da Sociedade para o Progresso da Ciência (SBPC) / SBPC Jovem	Estudantes e professores do ensino básico	2024	Promover o contato de crianças e jovens com a cultura oceânica e a ciência, despertando o interesse pela biodiversidade marinha
XXXV Semana Nacional de Oceanografia (SNO) / Exposição Encontro das Águas	Participantes da SNO (alunos e professores do ensino superior)	2025	Exposições de laboratórios do Instituto de Geociências; apresentar a CZIM e os projetos realizados pelos grupos de pesquisa
Feira de Geociências da UFPA	Estudantes e professores do ensino básico	2025	Aumentar o conhecimento da sociedade sobre a atuação dos profissionais da área de Geociências, com foco na biodiversidade e conservação dos ambientes marinhos



Muitas das ações extensionistas que envolveram a CZIM fazem referência a 'década dos oceanos (2021-2030)' (IOC, 2020) no sentido da compreensão da conservação da biodiversidade marinha e dos oceanos para o desenvolvimento sustentável. Entre essas atividades, destaca-se a Exposição da Biodiversidade (EXPOBIO) realizada na UFPA, aberta para o público em geral, nos anos de 2022 e 2023 (Figura 7). Outras ações mais recentes, incluem a 76ª Reunião Anual da Sociedade para

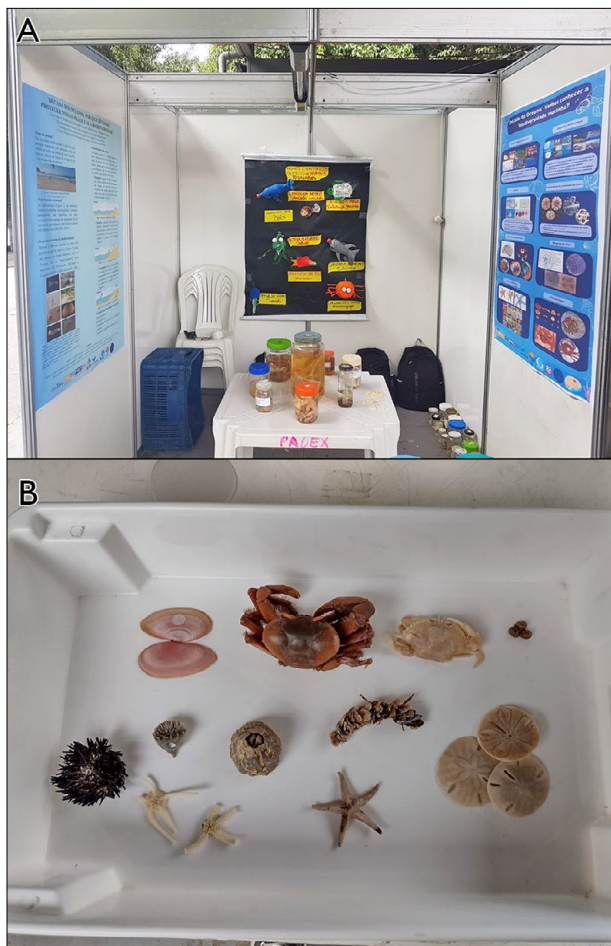


Figura 7. A) Estande da CZIM durante a II Exposição da Biodiversidade (EXPOBIO) (2023); B) alguns dos espécimes de invertebrados marinhos selecionados para a exposição. Fotos: L.C. R. Espírito Santo (2023).

Figure 7. A) CZIM Stand during the II Biodiversity Exhibition (EXPOBIO) (2023); B) some of the marine invertebrate specimens selected for exhibition. Photos: L.C. R. Espírito Santo (2023).

o Progresso da Ciência (SBPC), realizada no *campus* de Belém da UFPA durante o mês de julho de 2024, a qual contou com 27 mil inscritos e mais de 50 mil visitantes. Durante a SBPC, uma amostra dos exemplares da CZIM foi exposta em dois estandes ('sistema Terra' e 'diálogos amazônicos') (Figura 8A), facilitando e estimulando a interação de monitores do evento e docentes com os visitantes. Em julho de 2025, itens da CZIM também foram utilizados na Feira de Geociências (Figura 8B-8C), que consistiu na visitação de alunos e professores de diversas escolas de ensino médio de Belém, para os quais foram exemplificados as atividades e o campo de atuação dos profissionais da área de Geociências, principalmente do curso de Oceanografia.



Figura 8. A) Exemplares da CZIM expostos durante a 76ª Reunião da Sociedade para o Progresso da Ciência (SBPC) (2024); B-C) exemplares da CZIM expostos durante a Feira de Geociências (2025). Fotos: J. M. Martinelli-Lemos (2024) (A) e R. Lobo (2025) (B).

Figure 8. A) Copies of CZIM exhibited during the 76th Meeting of the Society for the Advancement of Science (SBPC) (2024); B-C) CZIM specimens exhibited during the Geosciences Fair (2025). Photos: J. M. Martinelli-Lemos (2024) (A) e R. Lobo (2025) (B).

Para além do acesso ao acervo físico, as ações extensionistas também envolvem a elaboração e a divulgação de produtos digitais, a exemplo de cartilhas (Anexo 1), vídeos, publicações em mídias sociais etc.

O POTENCIAL DA CZIM E OS DESAFIOS ATUAIS

Além do ensino e da extensão, a diversidade taxonômica da CZIM amplia as possibilidades do uso do seu acervo em atividades de pesquisa, pois ainda que a coleção apresente uma composição assimétrica, com grande domínio de moluscos e crustáceos, isso não diminui sua relevância científica. Para assegurar essa função, a CZIM mantém uma parcela do acervo preservada exclusivamente para pesquisa, resguardada do manuseio frequente em aulas práticas, feiras e exposições. Somado a isso, em 2024, a CZIM foi devidamente cadastrada no Sistema de Informação sobre a Biodiversidade Brasileira (SiBBr), uma plataforma *online* que integra e disponibiliza dados sobre a biodiversidade das coleções biológicas do Brasil. O SiBBr atua como o nó oficial do Sistema de Informação sobre Biodiversidade Oceânica (*Ocean Biodiversity Information System - OBIS*) no Brasil, possibilitando a integração dos dados de biodiversidade marinha à infraestrutura nacional e global de informação (SiBBr, 2025). Dessa forma, o acervo pode contribuir com as investigações sobre biodiversidade de invertebrados marinhos do sistema costeiro amazônico e a articulação entre ciência e políticas públicas voltadas à conservação marinha.

Apesar de sua relevância, a CZIM ainda demanda melhorias tanto na qualificação taxonômica de parte do seu acervo quanto em sua infraestrutura física. Uma parcela considerável dos espécimes não se encontra identificada no nível específico, principalmente em razão da escassez de taxonomistas fixados na região Norte do Brasil, o que inclui especialistas de praticamente todos os filos de invertebrados marinhos. Nesse contexto, a divulgação dos dados do acervo constitui uma estratégia fundamental para atrair colaborações nacionais e

internacionais, impulsionando, assim, o conhecimento sobre a biodiversidade marinha na Amazônia.

Em termos de estrutura, a gestão e a manutenção da CZIM têm sido viabilizadas, em grande parte, por meio de editais de monitoria da UFPA. No entanto, isso tem se mostrado insuficiente diante da necessidade de recursos humanos e custos contínuos com insumos e materiais de preservação. Adicionalmente, o acervo carece de melhorias em seu ambiente físico, incluindo a implementação de controle climático, manutenção predial e estrutural, além de intervenções voltadas ao controle de agentes biológicos, como fungos e bactérias. Diante do seu elevado valor, futuros esforços serão dedicados à captação de recursos para a curadoria e a ampliação do acervo da CZIM.

CONCLUSÃO

Os resultados desse estudo revelaram que a CZIM/UFPA possui uma expressiva diversidade taxonômica, abrigando inúmeras espécies provenientes de diferentes ambientes marinhos da região amazônica, desde a zona entremarés até *habitats* da plataforma continental externa. Dessa forma, o acervo é uma valiosa fonte de dados para a pesquisa em biodiversidade marinha na região amazônica. A CZIM tem importante papel nas atividades de ensino e extensão universitárias. As ações realizadas a partir da CZIM exemplificam bem a indissociabilidade entre os três pilares que constituem as universidades: ensino, pesquisa e extensão.

AGRADECIMENTOS

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manter e, por vezes, divulgar a CZIM, entre os quais mencionamos Alexandre Siqueira, Ayrlen Freitas de Castro, Edma Mayara Pereira Cardoso, Nicolle de Souza Corrêa e Stefanie Matos. Expressamos aos professores da FAOC da UFPA, que contribuíram para a divulgação da CZIM, nosso agradecimento. E agradecemos ao Prof. Dr. Marcelo Rollnic, coordenador do Laboratório de Pesquisa em Monitoramento Ambiental Marinha (LAPMAR), por ceder o espaço físico no qual a CZIM está atualmente alocada. Por fim, agradecemos a todos que contribuíram de alguma forma para a manutenção, a preservação, a ampliação e a divulgação da CZIM da UFPA.

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Anexo 1. Capa da cartilha educativa “Descobrimdo os invertebrados”, no âmbito do projeto do programa monitoria da FAOC, Instituto de Geociências, da UFPA.

Annex 1. Cover of the educational booklet “Discovering Invertebrates,” as part of the FAOC monitoring program project, Institute of Geosciences, UFPA.



Benthic biodiversity of the Brazilian Equatorial Margin: a systematic review with recommendations for conservation priorities and research

Biodiversidade bentônica da Margem Equatorial Brasileira: uma revisão sistemática com recomendações para prioridades de conservação e pesquisa

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Abstract: The Brazilian Equatorial Continental Margin, encompassing Maranhão, Pará, and Amapá, hosts ecologically and economically significant marine ecosystems that remain poorly investigated. In recent years, the region has gained international attention due to proposed hydrocarbon exploration and the discovery of extensive reef systems near the Amazon River mouth, raising concerns about potential impacts on sensitive coastal and shelf environments. Here, we present the first systematic review of benthic biodiversity across the continental shelf and slope of this margin. Following PRISMA guidelines, literature searches in major scientific databases and complementary manual screening retrieved over 4,000 records, of which 13 met the inclusion criteria. These studies documented 15 phyla, 407 genera, and 498 benthic species, with Nematoda, Cnidaria, Arthropoda, and Mollusca comprising the most diverse groups. Research effort shows a strong taxonomic bias toward megabenthos and megafauna (11 studies), whereas meiofauna and microbenthos remain largely understudied. Nearly half of the selected publications appeared within the last four years, reflecting growing scientific and industrial interest. However, deep-sea habitats (> 2,000 m) and long-term monitoring initiatives are still scarce. Comparison with other Brazilian margins and tropical regions underscores substantial knowledge gaps and the need for coordinated research and conservation strategies in this Atlantic frontier.

Keywords: Amazon shelf. PRISMA flowchart. Macrofauna. Megafauna. Meiofauna. Marine conservation.

Resumo: A Margem Continental Equatorial do Brasil, que abrange os estados do Maranhão, Pará e Amapá, abriga ecossistemas marinhos únicos e pouco estudados, com elevada importância ecológica e econômica. Esta região tem recebido atenção internacional devido ao potencial de exploração de hidrocarbonetos e à recente descoberta de extensos sistemas recifais na foz do rio Amazonas. Neste estudo, apresentamos a primeira revisão sistemática da biodiversidade bentônica na plataforma continental e no talude desta margem. Foram analisados mais de 4.000 documentos de grandes bases científicas, identificando-se 13 estudos que atenderam a critérios rigorosos de inclusão. Esses estudos relatam, coletivamente, 15 filos, 407 gêneros e 498 espécies bentônicas, sendo Nematoda, Cnidaria, Arthropoda e Mollusca os grupos mais diversos. No entanto, a pesquisa tem se concentrado fortemente em megabentos/megafauna (11 estudos), enquanto meiofauna e microbentos permanecem gravemente sub-representados. Quase metade de todos os estudos foi conduzida nos últimos quatro anos, refletindo o crescente interesse científico e industrial na região. Apesar desses avanços, habitats de águas profundas (> 2.000 m) e monitoramento de longo prazo ainda são escassos. Discutimos as implicações desses padrões à luz da literatura internacional, destacando lacunas de conhecimento urgentes e prioridades de conservação para uma das últimas grandes fronteiras marinhas do Atlântico.

Palavras-chave: Plataforma amazônica. Fluxograma PRISMA. Macrofauna. Megafauna. Meiofauna. Conservação marinha.

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INTRODUCTION

The continental margin comprises both the continental shelf and the continental slope, forming a broad continuum from shallow coastal environments to deep-sea basins (Snelgrove, 1999). Together, these regions represent one of the largest marine habitats on Earth (Menot et al., 2010; Ramirez-Llodra et al., 2010). Despite appearing uniform, continental margins are shaped by strong bathymetric gradients, diverse substrate types, and complex biological interactions (Menot et al., 2010; Ramirez-Llodra et al., 2010). A large proportion of the organic matter deposited on the seafloor is remineralized within continental margin sediments, highlighting the pivotal role of these environments in regulating global biogeochemical cycles (Middelburg et al., 1993). Beyond this, they also sustain essential ecological services, including nursery support, nutrient regeneration, and long-term carbon storage (Levin & Sibuet, 2012).

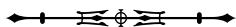
Benthic communities play fundamental roles in marine ecosystems by driving nutrient cycling, organic matter remineralization, and sediment bioturbation (Snelgrove, 1999). They also provide essential ecosystem services such as food resources, fisheries support, and habitat structuring through bioengineering species (Danovaro et al., 2008; Lemieux & Cusson, 2014). Understanding benthic biodiversity and community dynamics is therefore critical for assessing ecosystem health and informing sustainable management strategies, particularly in frontier regions, defined here as areas characterized by limited baseline knowledge of benthic ecology and biodiversity and increasing anthropogenic pressures.

The occurrence and distribution of benthic organisms are strongly correlated with the predominant environmental characteristics of the ecosystem (Giere, 2009; Gray & Elliott, 2009). Hydrodynamics and sediment properties (i.e. grain size, organic matter, and carbonate content) are consistently reported as major drivers of variability in soft-bottom communities (Snelgrove & Butman, 1994; Gray & Elliott, 2009). These factors are largely influenced by bottom currents that regulate sedimentation, resuspension, and transport

processes, particularly in shallow-water environments (Gray & Elliott, 2009). In addition, food availability and water column physicochemical conditions, including salinity, O₂ concentration, and temperature, directly affect the richness, diversity and abundance of benthic organisms (Gray & Elliott, 2009). Tropical continental margins are of particular relevance in this context, as they receive the majority of global riverine water and sediment inputs, profoundly shaping benthic ecosystems (Jennerjahn et al., 2010).

Brazil hosts one of the largest continental margins in the world, characterized by pronounced heterogeneity in geomorphology, oceanography, and biodiversity (Ciotti et al., 2010; Jennerjahn et al., 2010). Among the sedimentary basins that compose this vast margin are the Pará–Maranhão Basin and the Foz do Amazonas Basin, which together form the Brazilian Equatorial Margin. The Pará–Maranhão Basin occupies the northern portion of the Brazilian Continental Shelf, along the coasts of Pará and Maranhão states, whereas the Foz do Amazonas Basin lies in the western sector of the Brazilian Equatorial Margin, offshore the Amazon River mouth (Pellegrini & Ribeiro, 2018; Silveira et al., 2020). The Brazilian Equatorial Margin extends for approximately 2,200 km, accounting for about 35% of the total length of the Brazilian Continental Shelf (Pellegrini & Ribeiro, 2018; Silveira et al., 2020; ANP, 2022), and is of particular importance not only because of its geological and geomorphological features, but also as a frontier region for hydrocarbon exploration and marine biodiversity research in Brazil (R. L. Moura et al., 2016).

Benthic communities on the Brazilian Continental Shelf have been the focus of numerous regional surveys, but efforts are unevenly distributed along the coast. Most studies have concentrated on the southeastern and southern margins that are often associated with long-term oceanographic programs and hydrocarbon exploration (e.g. Netto et al., 2005; Bernardino et al., 2016; Falcão et al., 2017; Fonsêca-Genevois et al., 2017; Lavrado et al., 2010, 2017). By contrast, the northern coast of Brazil remains one of the least studied regions of the Western Atlantic.



Early investigations focused on sedimentary processes and soft-bottom fauna near the Amazon River plume (e.g. Aller & Aller, 1986; Silva et al., 2003), but systematic surveys of benthic biodiversity have only recently intensified, particularly after the discovery of the Amazon reef system (R. L. Moura et al., 2016). Even so, available studies remain sparse and taxonomically biased, with a strong emphasis on larger size fractions (macro- and megafauna), whereas smaller components such as meiofauna and microbial assemblages are almost completely absent from the literature (Pereira et al., 2022). This could be a serious issue as the increasing human footprint on the Brazilian Equatorial Margin might compromise its biodiversity but also its ecological functioning even before these are fully known, particularly because smaller organisms play a central role in ecosystem processes such as nutrient cycling, organic matter remineralization, and energy transfer (R. B. Moura et al., 2023).

Despite this growing interest, benthic biodiversity studies in this region remain scarce and spatially fragmented, with most available information derived from a limited number of local or taxon-specific investigations, in contrast to the extensive literature available for other tropical and temperate continental margins (e.g. Ramirez-Llodra et al., 2010; R. B. Moura et al., 2023). A systematic review of benthic biodiversity on the Brazilian Equatorial Margin provides not only an updated inventory of known taxa but also identifies critical knowledge gaps, aligns regional studies with global research efforts, and informs conservation and management strategies in one of the last major marine frontiers of the Atlantic but with rapidly expanding research and development interests.

Therefore, here, we present the first systematic synthesis of benthic biodiversity on the continental shelf and slope of Maranhão, Pará, and Amapá. We compiled (I) all available studies reporting benthic taxa in the region, (II) assessed temporal and thematic patterns of research effort, (III) summarized the taxonomic composition of reported assemblages, and (IV) discussed knowledge gaps and conservation implications in a global context.

MATERIAL AND METHODS

This study was developed through a systematic literature review with a scientometric approach. Scientometrics is a field of research that focuses on the measurement and analysis of scientific production, enabling the identification of knowledge gaps in specific areas (Vieira et al., 2021), as well as trends and patterns that can guide future studies (Luiza-Andrade et al., 2017).

LITERATURE SEARCH STRATEGY

A bibliographic survey of studies (peer-reviewed articles, grey literature, and technical reports) was conducted using the databases Web of Science (n.d.), Scopus (n.d.), SciELO (n.d.), EBSCOhost (n.d.) and EBSCO UFGA (UFGA, n.d.), covering publications available up to August 2024.

The search was based on a set of keywords in both English and Portuguese: “benthos” or “benthic” or “megabenthos” or “megafauna” or “macrofauna” or “macrobenthos” or “meiofauna” or “meiobenthos” or “microfauna” or “microbenthos” or “benthic organism” or “benthic invertebrate” and “Pará” or “Amapá” or “Maranhão” or “equatorial continental margin” or “Equatorial Atlantic Margin” or “Amazon coast”.

For SciELO, the search strategy was adjusted to improve coverage by including both general benthic terms and major taxonomic denominations. In addition to keywords related to benthic organisms (e.g. “benthos”, “benthic”, “macrofauna”, “macrobenthos”, “meiofauna”, “meiobenthos”, “megafauna”), individual searches were also conducted using major marine taxonomic groups (“Nematoda”, “Arthropoda”, “Crustacea”, “Decapoda”, “Mollusca”, “Gastropoda”, “Bivalve”, “Annelida”, “Polychaeta”, “Oligochaeta”) in combination with geographic and habitat-related keywords. This approach aimed to retrieve studies that did not explicitly use generic benthic terminology in their titles, abstracts, or keywords, thereby reducing potential search bias.

INCLUSION AND EXCLUSION CRITERIA

The inclusion criteria defined for the screening of studies were: (I) original scientific articles; (II) only articles



available in full text; (III) time frame from 01 January 1986 to 31 August 2024; (IV) studies addressing benthic organisms on the continental shelf and slope of Maranhão, Pará, and Amapá; (V) relevant studies matching the scope but not retrieved through the databases (e.g. Aller & Aller, 1986; R. L. Moura et al., 2016); and (VI) technical reports (e.g. Silva et al., 2003; Porto et al., 2005) were also included. The exclusion criteria were: (I) grey literature; (II) literature reviews; (III) studies that did not address benthic taxa, including those focused exclusively on benthic habitats or sedimentary, geochemical, physical, or geomorphological characteristics without biological data; (IV) duplicate records retrieved from more than one database; (V) that presented duplicates in more than one database; (VI) studies restricted to intertidal zones or conducted exclusively at depths shallower than 10 m were excluded from the analysis; (VII) studies published in journals cited in predatory journal lists (Prado et al., 2017; Beall, 2020; Predatory Reports, 2023). No restriction was made based on the language of the articles.

BENTHIC SIZE CLASSIFICATION

Benthic organisms were classified according to body size categories traditionally adopted in marine benthic ecology: microfauna (< 0.044–0.062 mm), meiofauna (0.044–0.5 mm), macrofauna (0.5 mm–2 cm), and megafauna (> 2 cm). These fractions are generally defined based on sieve mesh size and organism body dimensions and represent a standard framework for structuring benthic ecological studies (Higgins & Thiel, 1988; Snelgrove, 1999).

The related terms microbenthos, meiobenthos, macrobenthos, and megabenthos are widely used in the literature to designate benthic organisms within these size ranges. Whereas 'fauna' refers strictly to animal components, 'benthos' is an ecological term encompassing organisms living in association with the seabed and may include both fauna and, in some contexts, conspicuous sessile biota. In practice, microfauna/microbenthos, meiofauna/meiobenthos, and macrofauna/macrobenthos

are often used interchangeably when referring to animal assemblages retained within the respective sieve fractions (Danovaro et al., 2010).

STATISTICAL ANALYSIS

Since the dataset was non-linear, a Generalized Additive Model (GAM) with Poisson distribution was applied to test the relationship between the year of publication and the number of studies addressing benthic organisms on the Brazilian Equatorial Margin. The model was fitted with 12 basis functions (k) and smoothed using restricted maximum likelihood (REML). Model assumptions and goodness of fit were evaluated by inspecting residual diagnostics, including residuals versus fitted values, quantile–quantile plots, and checks for overdispersion, which indicated an adequate model fit.

The PRISMA flowchart was constructed to illustrate the literature screening process. The geographical distribution of studies was plotted using QGIS version 3.22 (QGIS Development Team, 2023). To visualize relationships between benthic groups and their size classification, a weighted bipartite network was built. All statistical analyses and plots (except Figures 1 and 2) were created using R software version 3.5.1 (R Core Team, 2023), with the packages bipartite (Dormann et al., 2008), mgcv (Wood, 2004), and ggplot2 (Wickham, 2016).

RESULTS

A total of 5,284 studies were identified. Among them, 1,674 were records in Web of Science, 333 in Scopus (including secondary documents), 1,677 in SciELO, 767 in EBSCOhost, and 833 in EBSCO UFPA. After the application of inclusion and exclusion criteria, only nine met the selection criteria and were selected for the construction of this study. Additionally, a manual search was conducted in the institutional repository of Federal University of Pará (UFPA), and four studies were found. To minimize potential under-representation due to search terminology, complementary searches using major

benthic taxonomic groups (e.g. Nematoda, Polychaeta, Mollusca, Crustacea) combined with geographic and habitat-related keywords were also conducted; however, these searches did not yield additional eligible studies beyond those already included. Thus, in total, 13 studies were included in the review (Figure 1). For species counts, taxa identified only to genus level were considered as representing a single species.

The earliest scientific record of benthic organisms on the Brazilian Equatorial Margin was a study by Aller and Aller (1986), which examined macrofauna, meiofauna,

and microbial communities from muddy sediments near the Amazon River plume. A research gap persisted throughout the 1990s, followed by renewed activity in the 2000s. Since then, publication output has increased, with nearly half of all benthic studies (seven of 13) published between 2021 and 2024 (Figure 2A). The temporal distribution of benthic records extracted from these studies revealed considerable variation in the number of records per year (Figure 2B). A marked increase was observed from 2016 onward, reflecting not only the rise in the number of publications but also the broader and more detailed taxonomic coverage of more recent studies, which together accounted for hundreds of records.

The dataset revealed a strong taxonomic bias: 11 studies focused on megabenthos/megafauna, four on macrobenthos, and only two each on meiofauna and microbenthos (Figure 3A). Overall, 15 phyla, 407 genera, and 498 species were reported across the continental shelf and slope of Maranhão, Pará, and Amapá until August 2024 (Appendix 1). The most diverse phylum

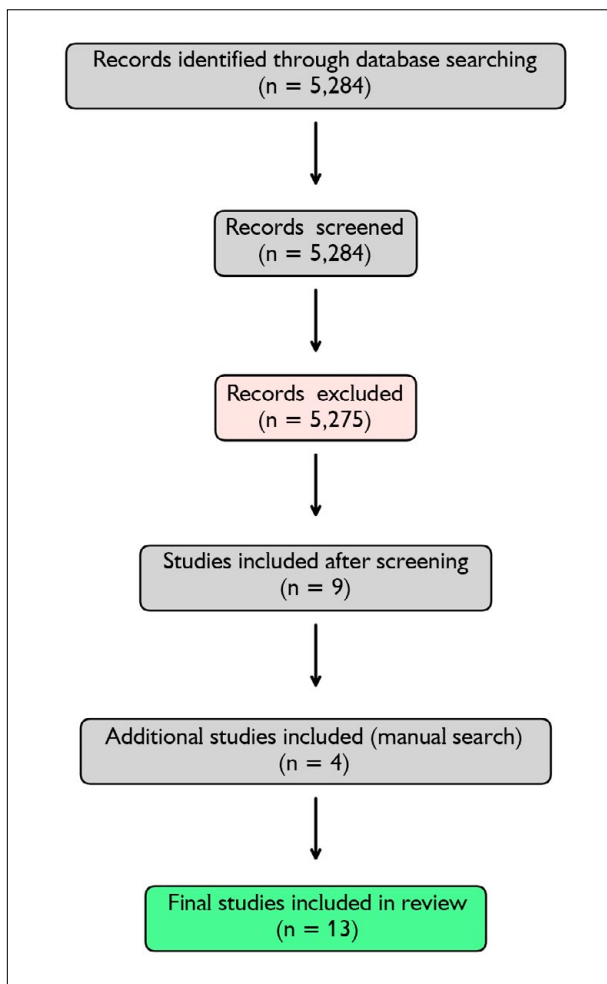


Figure 1. PRISMA flow diagram of the literature selection process for studies addressing benthic organisms on the continental shelf and slope of Maranhão, Pará, and Amapá (Brazilian Equatorial Margin).

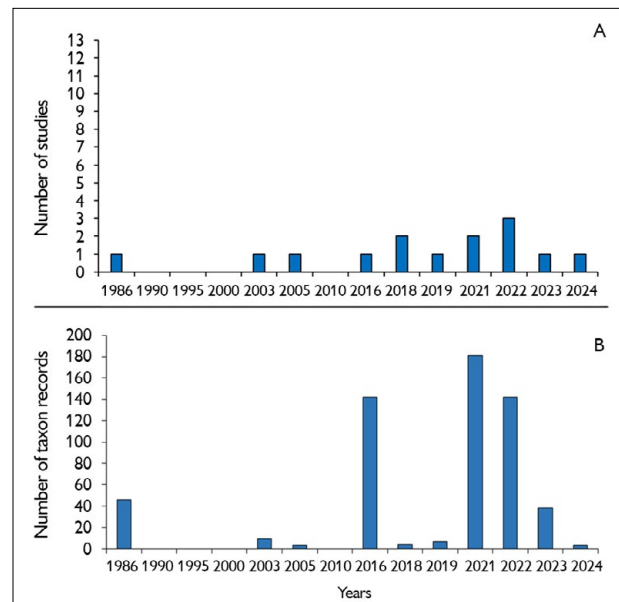


Figure 2. Number of published studies on benthic biodiversity (A) and temporal distribution of benthic organism records (B) extracted from the studies on the Brazilian Equatorial Margin between 1986 and 2024.

in terms of number of genera was Nematoda (120 genera), followed by Cnidaria (94), Arthropoda (92), Porifera (90), Rhodophyta (70) and Mollusca (67). Other recorded phyla include Annelida, Chlorophyta, Chordata, Cyanobacteria, Echinodermata, Foraminifera, Kinorhyncha, Ochrophyta, Platyhelminthes, Porifera, and Rhodophyta (Figure 3B).

The bipartite network illustrates the relationships between size classes and reported phyla along the Brazilian Equatorial Margin (Figure 4). The visualization highlights that megabenthos and macrobenthos are associated with a broad range of phyla, particularly Arthropoda, Mollusca, and Cnidaria. In contrast, meiofauna records are concentrated almost exclusively in Nematoda, while microbenthos are scarcely represented and restricted to a few phyla.

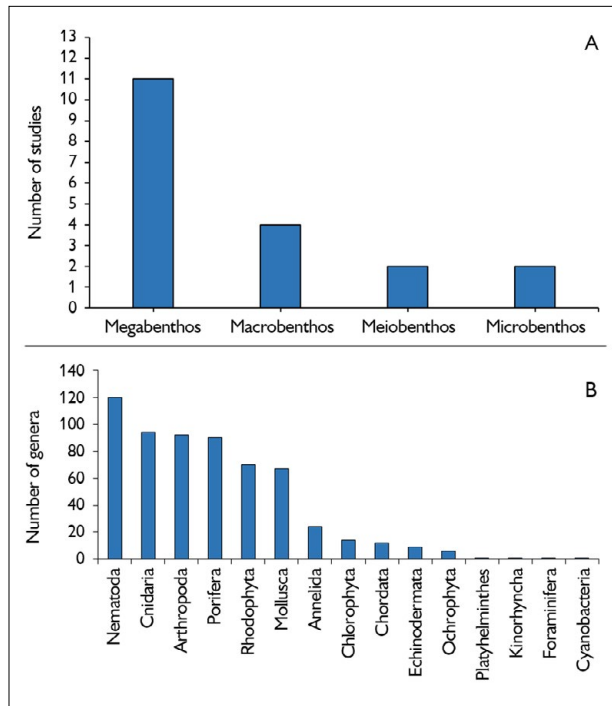


Figure 3. Number of studies conducted on the Brazilian Equatorial Margin according to the classification of benthic organisms by size (megafauna, megabenthos, macrobenthos, meiobenthos, and microbenthos) (A) and number of genera recorded for each phylum (B) extracted from the studies on the Brazilian Equatorial Margin between 1986 and 2024.

Depth coverage was also uneven. Among the ten studies reporting sampling depths, half were conducted at < 200 m, whereas only three extended into bathyal and abyssal zones (> 2,000 m). Shallow-water ecosystems therefore dominate available knowledge, whereas deep-sea habitats remain poorly represented (Table 1).

The Generalized Additive Model (GAM) applied to the temporal distribution of publications showed significant variation ($p = 0.02$; $edf = 8.34$), with 99.6% of the deviation explained ($R^2_{adj} = 0.996$). The residuals did not show any evident pattern, indicating a satisfactory model fit. The geographic distribution of the studies encompassed all three states of the Brazilian Equatorial Margin, although with unequal representation. Amapá and Pará accounted for the majority of records, whereas Maranhão had comparatively fewer published studies (Table 1; Figure 5).

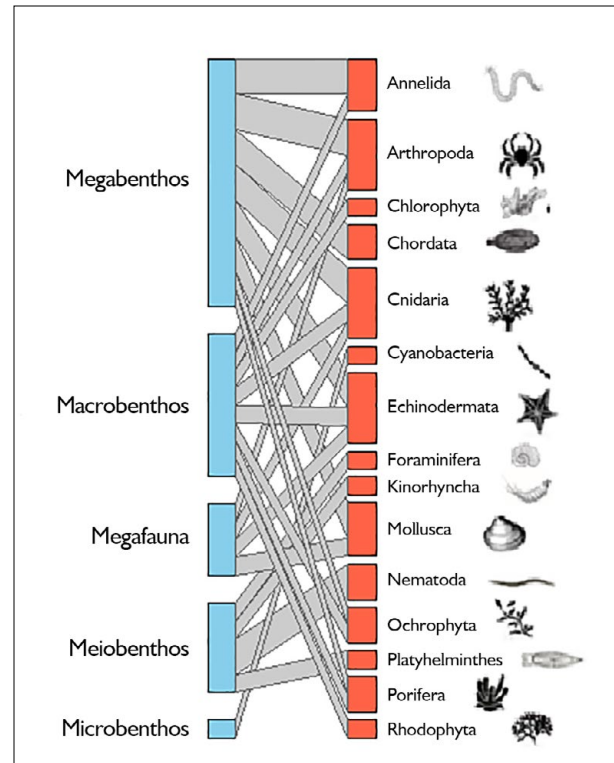


Figure 4. Bipartite network showing the relationship between benthic size classes (left) and reported phyla (right) on the Brazilian Equatorial Margin. The width of the links represent the contribution of each size class to the records of a given phylum.

Table 1. List of studies conducted on the Continental Shelf and Slope of Maranhão, Pará, and Amapá. Legends: N.I. = not informed; * = numbers between parentheses in the coordinates represent the sampling stations. (Continue)

Study	Latitude (decimal)	Longitude (decimal)	State	Size class	Phyla	Depth (m)
Aller and Aller (1986)	N.I.	N.I.	Amapá and Pará	Macrofauna, meiofauna and microbenthos	Annelida, Arthropoda, Chordata, Cnidaria, Echinodermata, Foraminifera, Kinorhyncha, Mollusca, Nematoda, Platyhelminthes	3–123
Silva et al. (2003)	(1) 1.05; (2) 1.45; (3) 1.97; (4) 1.46; (5) 2.65; (6) 2.10; (7) 2.48; (8) 2.71; (9) 2.73; (10) 3.18; (11) 3.40; (12) 3.71; (13) 3.73; (14) 4.11; (15) 4.15	(1) 46.35; (2) 46.72; (3) 47.55; (4) 46.76; (5) 47.71; (6) 48.31; (7) 47.56; (8) 47.65; (9) 47.66; (10) 48.90; (11) 49.11; (12) 48.88; (13) 48.55; (14) 49.35; (15) 49.36	Amapá and Pará	Megafauna	Arthropoda	75–626
Porto et al. (2005)	N.I.	N.I.	Amapá and Pará	Megafauna	Arthropoda	N.I.
R. L. Moura et al. (2016)	N.I.	N.I.	Amapá, Maranhão and Pará	Megabenthos	Arthropoda, Chlorophyta, Cnidaria, Echinodermata, Ochrophyta, Porifera, Rhodophyta	40–2480
Francini-Filho et al. (2018)	N.I.	N.I.	N.I.	Megafauna	Arthropoda, Cnidaria, Echinodermata	N.I.
Neto et al. (2018)	N.I.	N.I.	Pará	Megabenthos	Porifera	N.I.
Sales et al. (2019)	(1) 3.57; (2) 0.09	(1) 50.06; (2) 47.23	N.I.	Megafauna	Mollusca	80
Cordeiro et al. (2020)	N.I.	N.I.	Maranhão	Megabenthos and microbenthos	Annelida, Chlorophyta, Cnidaria, Cyanobacteria, Ochrophyta, Rhodophyta	5–27
Nóbrega et al. (2021)	Between 0.8–4.7	Between 47.85–51.17	Amapá and Pará	Megafauna and macrofauna	Annelida, Arthropoda, Echinodermata, Mollusca, Porifera	35–85
Menezes et al. (2022)	(1) 0.23; (2) 0.75; (3) 1.28; (4) 3.58	(1) 44.90; (2) 46.63; (3) 46.76; (4) 49.11	Amapá, Maranhão and Pará	Megabenthos	Porifera	23–120



Table 1. (Conclusion)

Study	Latitude (decimal)	Longitude (decimal)	State	Size class	Phyla	Depth (m)
Pereira et al. (2022)	(1) 5.18; (2) 4.86; (3) 4.79; (4) 5.30; (5) 5.11; (6) 5.05; (7) 5.09; (8) 4.94; (9) 5.31; (10) 0.71; (11) 0.58; (12) 0.30; (13) 0.33; (14) 1.95; (15) 1.95; (16) 1.80; (17) 1.80	(1) 50.43; (2) 50.20; (3) 50.08; (4) 50.44; (5) 50.31; (6) 50.20; (7) 50.06; (8) 49.81; (9) 50.30; (10) 45.16; (11) 45.16; (12) 44.56; (13) 44.52; (14) 41.70; (15) 41.55; (16) 41.70; (17) 41.55	Amapá, Maranhão and Pará	Meiofauna	Annelida, Arthropoda, Nematoda and others not specified	632–2618
R. B. Moura et al. (2023)	N.I.	N.I.	Amapá, Maranhão and Pará	Megafauna and macrofauna	Cnidaria	0–3888
Jovane et al. (2024)	(1) 4.96; (2) 4.96; (3) 5.06; (4) 5.28	(1) 50.46; (2) 50.45; (3) 50.43; (4) 50.61	Amapá	Megafauna and macrofauna	Annelida, Arthropoda, Chordata, Cnidaria, Echinodermata, Mollusca, Ochrophyta	206–309

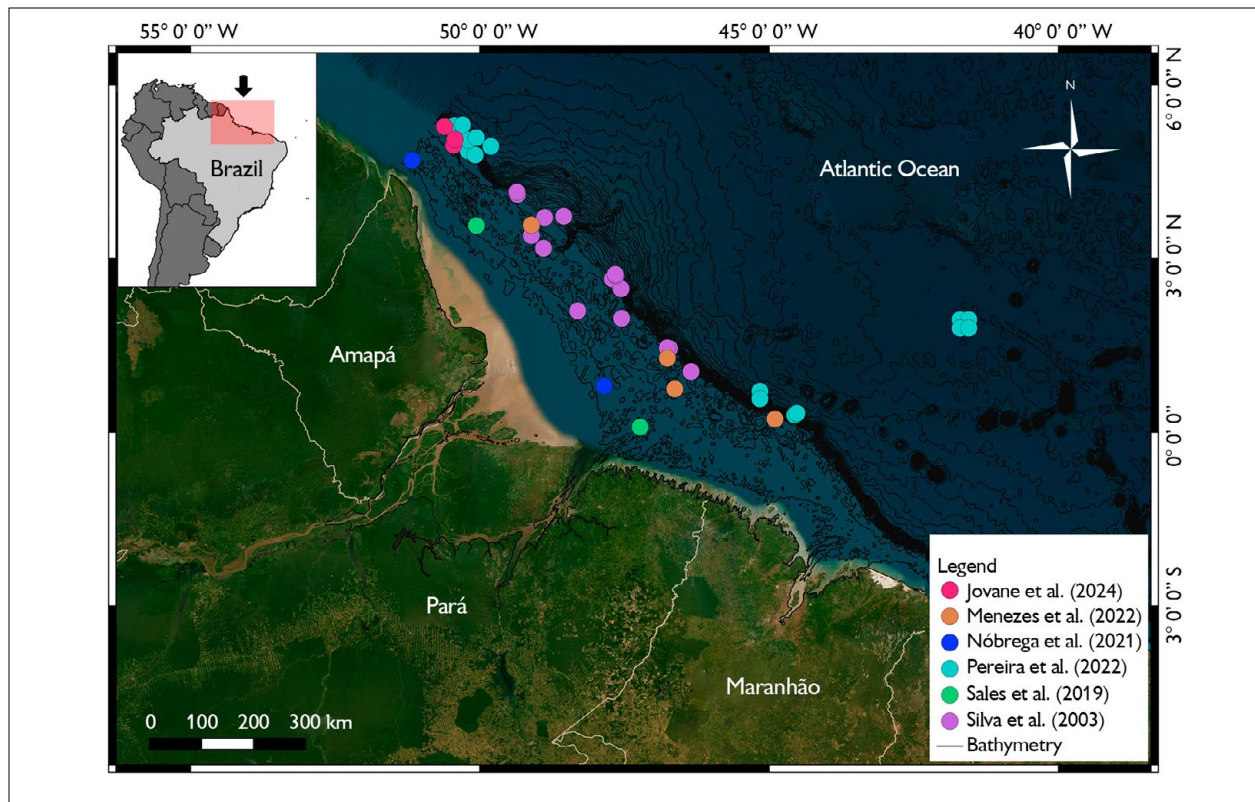


Figure 5. Location of benthic biodiversity studies on the Brazilian Equatorial Margin, covering the states of Amapá, Pará, and Maranhão. Colored dots indicate the works compiled in this review. The studies by Aller and Aller (1986), Porto et al. (2005), R. L. Moura et al. (2016), Francini-Filho et al. (2018), Neto et al. (2018), Cordeiro et al. (2020) and R. B. Moura et al. (2023), were not included in the map because coordinates were not provided in their works. Their locations are described in Table 1. Map: Thuareag Santos (2025).



DISCUSSION

Our systematic review highlights that, although benthic biodiversity on the Brazilian Equatorial Margin is considerable, scientific knowledge remains highly fragmented and concentrated in a few taxonomic groups, habitats, and temporal windows. The 13 studies included in this synthesis represent nearly four decades of research, yet their distribution reveals strong temporal, taxonomic, depth-related, and geographic biases. When compared to other sectors of the Brazilian Continental Margin, such as the Southeastern and Southern margins, where dozens of studies and comprehensive taxonomic inventories are available for multiple benthic groups, the research effort on the Brazilian Equatorial Margin is strikingly limited (e.g. Bernardino et al., 2016, 2017). This contrast indicates that the observed gaps reflect not low biodiversity, but rather a pronounced under-sampling of benthic assemblages in the Equatorial Margin.

TEMPORAL TREND

The temporal distribution of publications reveals a prolonged knowledge gap. After the study by Aller and Aller (1986), which reported macrofauna, meiofauna, and microbial communities in muddy sediments near the Amazon River plume, nearly a decade passed without new records. Research activity resumed in the 2000s, but only in recent years has scientific production intensified, with nearly half of all reviewed studies published between 2021 and 2024. In addition to the temporal distribution of studies, the analysis of benthic taxon records extracted from the literature revealed marked variation in the number of records reported per year, with a sharp increase from 2016 onward. This trend reflects not only the higher number of studies published in recent years but also the broader and more detailed taxonomic coverage adopted by these investigations, which together accounted for hundreds of records.

The sudden increase in publications between 2021 and August 2024 appears to coincide with two key drivers: the discovery of the Amazon reef system

(R. L. Moura et al., 2016) and the expansion of environmental assessments, licensing processes, and exploratory activities related to hydrocarbon prospects in the Brazilian Equatorial Margin (Pellegrini & Ribeiro, 2018). These developments likely stimulated scientific attention to the region, particularly in the context of environmental baseline characterization.

The marked concentration of publications in the last four years of the reviewed period (2021 – August 2024) suggests that recent scientific output in the region may be associated with shifting industrial and conservation priorities. This temporal pattern coincides with increased national attention to the Brazilian Equatorial Margin as a strategic frontier for oil and gas exploration, reflected in intensified regulatory activity and environmental licensing processes that commonly require baseline ecological surveys and risk assessment studies (Pellegrini & Ribeiro, 2018; R. B. Moura et al., 2023). In Brazil, offshore exploratory activities are regulated by federal agencies such as Brazilian Institute of Environment and Renewable Natural Resources (IBAMA) and the National Agency of Petroleum, Natural Gas and Biofuels (ANP), whose licensing frameworks demand multidisciplinary environmental characterization, including benthic biodiversity assessments (ANP, 2022). In parallel, industry reports have indicated projected investments on the order of several billion Brazilian *reals* per year toward 2025 for research, development, and innovation associated with new offshore exploration frontiers, including the Brazilian Equatorial Margin (IBP, 2023, 2024). Together, these regulatory and prospective investment drivers may help explain the recent increase in scientific output observed in this review.

The research trajectory in the Brazilian Equatorial Margin reflects a pattern commonly observed in frontier regions: long gaps after initial exploratory work, followed by sudden growth in publications driven by industrial or conservation agendas. A similar trend was documented in the Gulf of Mexico and the West African Margin, where hydrocarbon exploration triggered rapid increases in benthic surveys (Ramirez-Llodra et al., 2011;



Danovaro et al., 2020a, 2020b). As explained above, in the Amazon region, the sharp rise in publications after 2016 coincides with the discovery of the Amazon reef system and intensified interest in offshore oil and gas. However, compared to long-term monitoring initiatives in temperate continental margins (e.g. the European Atlantic and North Sea), the research in the Brazilian Equatorial Margin remains short-term and fragmented.

TAXONOMIC ANALYSIS

The review identified 15 phyla, 407 genera, and 498 species of benthic organisms across the states of Maranhão, Pará, and Amapá (Appendix 1). However, the dataset shows a strong emphasis on larger benthic organisms (i.e. macrofauna and megafauna), which were investigated in 11 of the 13 studies. In contrast, meiofauna and microbenthos, globally recognized as among the most diverse and functionally important benthic components (Giere, 2009), remain severely underrepresented. For comparison, other sectors of the Brazilian Continental Margin and adjacent South Atlantic regions have documented substantially higher numbers of benthic species, particularly where meiofaunal and infaunal assemblages have been systematically surveyed.

In the present dataset, although Nematoda emerged as the most diverse group with 120 genera, this pattern results from a single taxon-focused study (Pereira et al., 2022). Without this contribution, nematodes would be nearly absent from the review, illustrating how current biodiversity estimates for the Brazilian Equatorial Margin remain highly dependent on isolated taxonomic efforts rather than sustained, integrative sampling programs. This bias is not unique to Brazil, and global syntheses have shown that large, conspicuous taxa dominate benthic literature worldwide, while meiofauna and microbial communities are systematically underrepresented (Giere, 2009). For example, in the Mediterranean and Northeast Atlantic, meiofauna accounts for less than 10% of benthic publications despite being the most abundant and diverse component of benthic ecosystems (Danovaro et al., 2010).

This imbalance reveals a strong taxonomic bias, with research focused on larger organisms that are easier to identify visually or obtain through capture methods. For example, megabenthos are the subject of more studies due to their ease of visualization and identification, which can even be done through photography (Hanafi-Portier et al., 2021, 2023), coupled with the fact that they can be captured by fishing gear such as trawl nets (Clark et al., 2016). Macrofauna, on the other hand, are more studied than meiofauna because they are more easily identifiable and countable (Schratzberger et al., 2000). On the other hand, smaller organisms, despite their ecological importance, remain largely unstudied due to the complexity of sample processing (Giere, 2009) and the lack of specialized expertise in Brazil (Baldeija & Lercari, 2024), especially in the Amazon region (Venekey et al., 2010). In addition, traditional protocols for processing and identifying meiofauna samples are time-consuming and require specialized taxonomic skills that, unfortunately, are not always easy to find (Wheeler et al., 2004; Faria et al., 2018).

DEPTH TRENDS

Our synthesis shows that from the ten studies that reported sampling depths, five were conducted exclusively in shallow waters (< 200 m), two at intermediate depths (200–2,000 m), and only three extended into abyssal environments (> 2,000 m). This result shows that most current knowledge is derived from shallow-water ecosystems, which are more accessible and easier to sample. Deep-sea ecosystems, which dominate the Brazilian Equatorial Margin in terms of area and likely harbor unique biodiversity, remain almost completely unstudied. The logistical and technological challenges of deep-sea exploration in Brazil are clear, but the lack of data severely limits our understanding of ecological processes and potential vulnerabilities in these habitats.

The concentration of studies in shallow (< 200 m) and shelf environments is consistent with global trends, as logistical and financial constraints have historically restricted access to deep-sea habitats. Since the early 2000s, however,



continental margins worldwide. including the Mid-Atlantic Ridge, Mediterranean canyons, and Pacific trenches, have experienced a marked expansion in deep-sea surveys driven by advances in sampling technologies, international collaborative programs, and growing interest in biodiversity conservation and resource management (Ramirez-Llodra et al., 2010; Danovaro et al., 2020a). A similar pattern is observed along other sectors of the Brazilian Continental Margin, such as the Campos, Espírito Santo, and Potiguar basins, where sustained offshore research programs and long-standing industry–academia collaborations have supported repeated deep-sea surveys, resulting in substantial advances in biodiversity assessments and the description of numerous new taxa (e.g., Carvalho et al., 2016; Almada & Bernardino, 2017; Segadilha & Serejo, 2022).

In contrast, the Brazilian Equatorial Margin remains severely undersampled below 2,000 m, with systematic deep-sea exploration and biodiversity documentation only beginning to emerge in recent years, as reflected in the temporal pattern of studies identified in this review. Given that abyssal ecosystems cover vast areas of the Brazilian Equatorial Margin, this research gap is particularly critical. Evidence from comparable deep-sea systems, such as the Congo Fan and the Gulf of Guinea, demonstrates that these environments can host highly distinctive benthic communities with key functional roles in carbon cycling and nutrient turnover (Vanreusel et al., 2010). Similar discoveries are likely awaiting documentation along the Brazilian Equatorial Margin once exploration expands.

GEOGRAPHIC DISTRIBUTION

The studies included in this review are unevenly distributed across states, with most records concentrated in Amapá and Pará, whereas Maranhão remains comparatively underrepresented. This pattern is noteworthy given that Maranhão hosts major industrial, aerospace, and port infrastructures, including the Port of Itaqui and the Alcântara Launch Center. However, industrial presence does not necessarily translate into benthic biodiversity

research, which depends on targeted biological sampling, taxonomic expertise, and sustained ecological monitoring. In Maranhão, available studies have historically focused on geomorphological, sedimentological, and physicochemical aspects of coastal and port environments (Barreto et al., 2024), whereas systematic benthic biodiversity surveys remain comparatively limited, reflecting broader geographic and taxonomic biases documented for the Brazilian marine realm, particularly the underrepresentation of northern regions. This spatial disparity indicates that significant areas of the Brazilian Equatorial Margin have not yet been adequately studied, limiting the ability to generalize biodiversity patterns across the region.

In addition, this unevenness reflects patterns observed on other large continental margins, where biodiversity data are often concentrated in areas associated with industrial activities or specific economic interests, while adjacent sectors remain poorly studied. For example, in regions targeted for deep-sea mineral exploration, benthic surveys have largely focused on prospective mining areas, with comparatively limited sampling in surrounding regions (Miller et al., 2018). A similar pattern appears to occur along the Maranhão coast, where scientific attention is concentrated in specific industrial and port-related areas, whereas large portions of the coastline and offshore environments remain comparatively neglected. This suggests that logistical accessibility, funding priorities, and industrial activities strongly influence where benthic biodiversity data are generated in Brazil.

IMPLICATIONS AND RESEARCH PRIORITIES

By situating the Brazilian Equatorial Margin in a broader context, it becomes clear that this region remains one of the last major marine frontiers in the Atlantic. The patterns identified in this review reveal critical gaps in baseline knowledge, particularly for meiofauna, microbenthos, and deep-sea ecosystems. These gaps represent an urgent challenge for biodiversity science and marine conservation, as small-bodied benthic organisms and deep-sea communities



play central roles in ecosystem functioning, nutrient cycling, and carbon sequestration. Without addressing these knowledge deficits, it will remain difficult to evaluate ecosystem resilience or to reliably assess the impacts of human activities such as bottom trawling, hydrocarbon extraction, and climate-driven environmental change.

In contrast to temperate continental margins, where decades of coordinated monitoring programs (e.g. those supported by the International Council for the Exploration of the Sea, ICES) have generated robust baselines and long-term ecological datasets (Rees et al., 2007), Brazilian tropical margins are only beginning to establish systematic biodiversity records (Lavrado & Ignacio, 2006; Miloslavich et al., 2011; Menegotto & Rangel, 2018). This discrepancy limits both national environmental governance and the inclusion of tropical systems in global syntheses of benthic biodiversity and ecosystem functioning (Snelgrove et al., 2014). Expanding research efforts in the Brazilian Equatorial Margin is therefore critical not only for informing environmental licensing and conservation policies, but also for advancing global understanding of tropical benthic ecosystems under accelerating climate change, industrial exploitation, and biodiversity loss (Ramirez-Llodra et al., 2011).

Bridging these gaps will require strategic investment aligned with international best practices: (I) Expanding sampling into deep-sea habitats is essential, as evidence from other continental margins demonstrates that bathyal and abyssal zones often harbor highly endemic and functionally distinct benthic communities that would otherwise remain undetected (Ramirez-Llodra et al., 2010; Levin & Sibuet, 2012); (II) Strengthening taxonomic expertise, particularly in meiofauna and microbial assemblages, is a prerequisite for producing reliable biodiversity inventories. Global assessments have highlighted that taxonomic capacity remains a major bottleneck for biodiversity research, especially in understudied and small-bodied groups (Costello et al., 2010; Danovaro et al., 2008); (III) The incorporation of molecular tools, such as DNA barcoding and metabarcoding, can greatly accelerate species detection, reveal cryptic

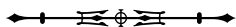
diversity, and complement traditional taxonomy, particularly in groups where morphological identification is time-consuming or expertise is scarce (Hebert et al., 2003; Bik et al., 2012); (IV) The development of long-term monitoring frameworks, similar to those implemented in the North Sea and Mediterranean, is crucial for detecting ecological change, establishing baselines for impact assessments, and distinguishing natural variability from anthropogenic effects (Rees et al., 2007; Danovaro et al., 2020b).

Finally, (V) the systematic integration of benthic biodiversity data into environmental licensing and marine conservation policies would ensure that ecological information contributes to cumulative knowledge, adaptive management, and evidence-based decision-making (IPBES, 2019; Danovaro et al., 2020b). Together, these investments would not only reduce current knowledge gaps in the Brazilian Equatorial Margin, but also position Brazil to play a more active role in international efforts to understand and conserve tropical marine biodiversity.

CONCLUSIONS

This systematic review provides the first comprehensive synthesis of benthic biodiversity research along the Brazilian Equatorial Margin. Despite the identification of 15 phyla, 407 genera, and 498 species, our findings reveal that knowledge of this vast and ecologically significant region is still shaped by strong temporal, taxonomic, depth-related, and geographic biases. Most of what is known today derives from a small number of recent studies, with a disproportionate focus on megafauna, shallow waters (< 200 m depth), and specific states such as Amapá and Pará.

When compared with other continental margins worldwide, the Brazilian Equatorial Margin emerges as one of the least studied tropical marine regions. In addition, deep-sea habitats, meiofauna, and microbial communities are still almost entirely overlooked. These gaps highlight the urgent need for Brazil to expand research coverage, strengthen taxonomic expertise, and adopt innovative tools and long-term monitoring frameworks. Equally important is



the consolidation of biodiversity governance mechanisms, including the systematic registration, curation, and public accessibility of benthic biodiversity records, as well as their effective incorporation into environmental legislation, impact assessment procedures, and marine spatial planning. Beyond its national relevance, advancing scientific knowledge in the Brazilian Equatorial Margin will contribute to global understanding of tropical benthic ecosystems and support evidence-based conservation strategies in the face of climate change, biodiversity loss, and expanding industrial activities.

The Brazilian Equatorial Margin therefore stands as one of the last great marine frontiers of the Atlantic. Building a robust and internationally integrated research agenda is not only a scientific necessity but also a strategic step to ensure that the ecological richness of this unique region is documented, understood, and protected for future generations.

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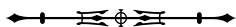
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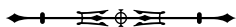
AUTHOR'S CONTRIBUTION

T. M. T. dos Santos contributed to formal analysis, methodology, investigation and writing (original draft); E. Baia contributed to formal analysis, methodology, investigation and writing (review and editing); A. P. dos Santos contributed to formal analysis and investigation; and V. Venekey contributed to supervision, conceptualization, data curation, validation and writing (review and editing).



Appendix 1. List of species, genera, and phyla recorded in each study conducted on the continental shelf and slope of Maranhão, Pará, and Amapá. ** = The high number of taxa identified only to genus or higher taxonomic levels reflects limitations in the original studies included in the review and does not represent taxonomic uncertainty introduced by the present work. (Continue)

Study	Phylum	Genus	Species
Cordeiro et al. (2020)	Cyanobacteria	<i>Lyngbya</i>	Species not identified 1
R. L. Moura et al. (2016)	Ochrophyta	<i>Dictyota</i>	Species not identified 1
R. L. Moura et al. (2016)	Ochrophyta	<i>Dictyota</i>	Species not identified 2
R. L. Moura et al. (2016)	Ochrophyta	<i>Lobophora</i>	<i>Lobophora variegata</i> (J.V.Lamouroux) Womersley ex E.C.Oliveira, 1977
R. L. Moura et al. (2016)	Ochrophyta	<i>Sargassum</i>	Species not identified 1
Cordeiro et al. (2020)	Ochrophyta	<i>Dictyota</i>	Species not identified 1
Jovane et al. (2024)	Ochrophyta	Genus not identified 1	Species not identified 1
R. L. Moura et al. (2016)	Chlorophyta	<i>Anadyomene</i>	Species not identified 1
R. L. Moura et al. (2016)	Chlorophyta	<i>Caulerpa</i>	<i>Caulerpa racemosa</i> (Forsskål) J.Agardh, 1873
R. L. Moura et al. (2016)	Chlorophyta	<i>Cladophora</i>	Species not identified 1
R. L. Moura et al. (2016)	Chlorophyta	<i>Cladophora</i>	Species not identified 2
R. L. Moura et al. (2016)	Chlorophyta	<i>Halimeda</i>	Species not identified 1
R. L. Moura et al. (2016)	Chlorophyta	<i>Ulva</i>	Species not identified 1
R. L. Moura et al. (2016)	Chlorophyta	<i>Ulvella</i>	<i>Ulvella viridis</i> (Reinke) R.Nielsen, C.J.O'Kelly & B.Wysor, 2013
Cordeiro et al. (2020)	Chlorophyta	<i>Bryopsis</i>	<i>Bryopsis hypnoides</i> J.V.Lamouroux, 1809
Cordeiro et al. (2020)	Chlorophyta	<i>Bryopsis</i>	<i>Bryopsis pennata</i> J.V.Lamouroux, 1809
Cordeiro et al. (2020)	Chlorophyta	<i>Caulerpa</i>	<i>Caulerpa racemosa</i>
Cordeiro et al. (2020)	Chlorophyta	<i>Caulerpa</i>	Species not identified 1
Cordeiro et al. (2020)	Chlorophyta	<i>Caulerpa</i>	<i>Caulerpa verticillata</i> J.Agardh, 1847
Cordeiro et al. (2020)	Chlorophyta	<i>Codium</i>	Species not identified 1
Cordeiro et al. (2020)	Chlorophyta	<i>Halimeda</i>	Species not identified 1
R. L. Moura et al. (2016)	Rhodophyta	<i>Acrochaetium</i>	<i>Acrochaetium antillarum</i> W.R.Taylor, 1942
R. L. Moura et al. (2016)	Rhodophyta	<i>Amphiroa</i>	<i>Amphiroa fragilissima</i> (L.)
R. L. Moura et al. (2016)	Rhodophyta	<i>Amphiroa</i>	<i>Amphiroa rigida</i> J.V.Lamouroux, 1816
R. L. Moura et al. (2016)	Rhodophyta	<i>Ceramium</i>	Species not identified 1
R. L. Moura et al. (2016)	Rhodophyta	<i>Chondria</i>	Species not identified 1
R. L. Moura et al. (2016)	Rhodophyta	<i>Chrysiomenia</i>	Species not identified 1
R. L. Moura et al. (2016)	Rhodophyta	<i>Erythrotrichia</i>	<i>Erythrotrichia carnea</i> (Dillwyn) J.Agardh, 1883
R. L. Moura et al. (2016)	Rhodophyta	<i>Gelidiopsis</i>	Species not identified 1
R. L. Moura et al. (2016)	Rhodophyta	<i>Gelidium</i>	<i>Gelidium pusillum</i> (Stackhouse) Le Jolis, 1863
R. L. Moura et al. (2016)	Rhodophyta	<i>Gelidium</i>	Species not identified 1
R. L. Moura et al. (2016)	Rhodophyta	<i>Gracilaria</i>	Species not identified 1
R. L. Moura et al. (2016)	Rhodophyta	<i>Halymenia</i>	<i>Halymenia floresii</i> (Clemente) C.Agardh, 1817



Appendix 1.

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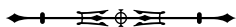
Study	Phylum	Genus	Species
R. L. Moura et al. (2016)	Rhodophyta	<i>Herposiphonia</i>	<i>Herposiphonia secunda</i> (C.Agardh) Ambronn, 1880
R. L. Moura et al. (2016)	Rhodophyta	<i>Hydrolithon</i>	<i>Hydrolithon rupestre</i> (Foslie) Penrose, 1996
R. L. Moura et al. (2016)	Rhodophyta	<i>Hypoglossum</i>	<i>Hypoglossum tenuifolium</i> (Harvey) J.Agardh, 1898
R. L. Moura et al. (2016)	Rhodophyta	<i>Jania</i>	<i>Jania adhaerens</i> J.V.Lamouroux, 1816
R. L. Moura et al. (2016)	Rhodophyta	<i>Kallymenia</i>	Species not identified 1
R. L. Moura et al. (2016)	Rhodophyta	<i>Lithothamnion</i>	<i>Lithothamnion crispatum</i> Hauck, 1878
R. L. Moura et al. (2016)	Rhodophyta	<i>Mesophyllum</i>	<i>Mesophyllum erubescens</i> (Foslie) Me.Lemoine, 1928
R. L. Moura et al. (2016)	Rhodophyta	<i>Nitophyllum</i>	Species not identified 1
R. L. Moura et al. (2016)	Rhodophyta	<i>Peyssonnelia</i>	Species not identified 1
R. L. Moura et al. (2016)	Rhodophyta	<i>Polysiphonia</i>	Species not identified 1
R. L. Moura et al. (2016)	Rhodophyta	<i>Rhodymenia</i>	Species not identified 1
R. L. Moura et al. (2016)	Rhodophyta	<i>Sahlingia</i>	<i>Sahlingia subintegra</i> (Rosenvinge) Kornmann, 1989
R. L. Moura et al. (2016)	Rhodophyta	<i>Sporolithon</i>	<i>Sporolithon ptychoides</i> Heydrich, 1897
Cordeiro et al. (2020)	Rhodophyta	<i>Acrochaetium</i>	<i>Acrochaetium microscopicum</i> (Nägeli ex Kützing) Nägeli, 1858
Cordeiro et al. (2020)	Rhodophyta	<i>Aglaothamnion</i>	<i>Aglaothamnion felipponei</i> (Howe) Aponte, Ballantine & J.N.Norris, 1994
Cordeiro et al. (2020)	Rhodophyta	<i>Amphiroa</i>	<i>Amphiroa anastomosans</i> Weber-van Bosse, 1904
Cordeiro et al. (2020)	Rhodophyta	<i>Antithamnionella</i>	<i>Antithamnionella graeffei</i> (Grunow) Athanasiadis, 1996
Cordeiro et al. (2020)	Rhodophyta	<i>Asparagopsis</i>	<i>Asparagopsis taxiformis</i> (Delile) Trevisan de Saint-Léon, 1845
Cordeiro et al. (2020)	Rhodophyta	<i>Asteromenia</i>	<i>Asteromenia peltata</i> (W.R.Taylor) Huisman & A.J.K.Millar, 1996
Cordeiro et al. (2020)	Rhodophyta	<i>Branchioglossum</i>	Species not identified 1
Cordeiro et al. (2020)	Rhodophyta	<i>Callithamnion</i>	<i>Callithamnion corymbosum</i> (Smith) Lyngbye, 1819
Cordeiro et al. (2020)	Rhodophyta	<i>Canistrocarpus</i>	<i>Canistrocarpus cervicornis</i> (Kützing) De Paula & De Clerck, 2006
Cordeiro et al. (2020)	Rhodophyta	<i>Ceramium</i>	<i>Ceramium comptum</i> Børgesen, 1924
Cordeiro et al. (2020)	Rhodophyta	<i>Ceramium</i>	<i>Ceramium nitens</i> (C.Agardh) J.Agardh, 1851
Cordeiro et al. (2020)	Rhodophyta	<i>Ceramium</i>	Species not identified 1
Cordeiro et al. (2020)	Rhodophyta	<i>Ceramium</i>	<i>Ceramium tenuicorne</i> (Kützing) Rueness & Kornfeldt, 1992
Cordeiro et al. (2020)	Rhodophyta	<i>Ceramium</i>	<i>Ceramium virgatum</i> Roth, 1797
Cordeiro et al. (2020)	Rhodophyta	<i>Champia</i>	<i>Champia parvula</i> (C.Agardh) Harvey, 1853
Cordeiro et al. (2020)	Rhodophyta	<i>Crouania</i>	<i>Crouania attenuata</i> (C.Agardh) J.Agardh, 1842
Cordeiro et al. (2020)	Rhodophyta	<i>Derbesia</i>	<i>Derbesia marina</i> (Lyngbye) Solier, 1846
Cordeiro et al. (2020)	Rhodophyta	<i>Dictyopteris</i>	<i>Dictyopteris delicatula</i> J.V.Lamouroux, 1809
Cordeiro et al. (2020)	Rhodophyta	<i>Dictyota</i>	<i>Dictyota ciliolata</i> Sonder ex Kützing, 1859
Cordeiro et al. (2020)	Rhodophyta	<i>Dictyota</i>	<i>Dictyota crenulata</i> J.Agardh, 1847
Cordeiro et al. (2020)	Rhodophyta	<i>Dictyota</i>	<i>Dictyota hamifera</i> Setchell, 1926
Cordeiro et al. (2020)	Rhodophyta	<i>Dictyota</i>	<i>Dictyota humifusa</i> Hörnig, Schnetter & Coppejans, 1992



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Study	Phylum	Genus	Species
Cordeiro et al. (2020)	Rhodophyta	<i>Dictyota</i>	<i>Dictyota menstrualis</i> (Hoyt) Schnetter, Hörning & Weber-Peukert, 1987
Cordeiro et al. (2020)	Rhodophyta	<i>Dictyota</i>	<i>Dictyota pinnatifida</i> Kützing, 1859
Cordeiro et al. (2020)	Rhodophyta	<i>Erythrotrichia</i>	<i>Erythrotrichia carnea</i> (Dillwyn) J.Agardh, 1883
Cordeiro et al. (2020)	Rhodophyta	<i>Gelidium</i>	<i>Gelidium pusillum</i> (Stackhouse) Le Jolis, 1863
Cordeiro et al. (2020)	Rhodophyta	<i>Griffithsia</i>	<i>Griffithsia globulifera</i> Harvey ex Kützing, 1862
Cordeiro et al. (2020)	Rhodophyta	<i>Griffithsia</i>	<i>Griffithsia schousboei</i> Montagne, 1840
Cordeiro et al. (2020)	Rhodophyta	<i>Haloplegma</i>	<i>Haloplegma duperreyi</i> Montagne, 1842
Cordeiro et al. (2020)	Rhodophyta	<i>Hydrolithon</i>	<i>Hydrolithon farinosum</i> (J.V.Lamouroux) Penrose & Y.M.Chamberlain, 1993
Cordeiro et al. (2020)	Rhodophyta	<i>Hypnea</i>	<i>Hypnea spinella</i> (C.Agardh) Kützing, 1847
Cordeiro et al. (2020)	Rhodophyta	<i>Hypnea</i>	Species not identified 1
Cordeiro et al. (2020)	Rhodophyta	<i>Hypoglossum</i>	<i>Hypoglossum hypoglossoides</i> (Stackhouse) Collins & Hervey, 1917
Cordeiro et al. (2020)	Rhodophyta	<i>Jania</i>	<i>Jania adhaerens</i> J.V.Lamouroux, 1816
Cordeiro et al. (2020)	Rhodophyta	<i>Jania</i>	<i>Jania cubensis</i> Montagne ex Kützing, 1849
Cordeiro et al. (2020)	Rhodophyta	<i>Jania</i>	Species not identified 1
Cordeiro et al. (2020)	Rhodophyta	<i>Laurencia</i>	<i>Laurencia filiformis</i> (C.Agardh) Montagne, 1845
Cordeiro et al. (2020)	Rhodophyta	<i>Laurencia</i>	<i>Laurencia oliveirana</i> Yoneshigue, 1985
Cordeiro et al. (2020)	Rhodophyta	<i>Laurencia</i>	Species not identified 1
Cordeiro et al. (2020)	Rhodophyta	<i>Lithothamnion</i>	<i>Lithothamnion crispatum</i> Hauck, 1878
Cordeiro et al. (2020)	Rhodophyta	<i>Ochtodes</i>	<i>Ochtodes secundiramea</i> (Montagne) M.A.Howe, 1920
Cordeiro et al. (2020)	Rhodophyta	<i>Peyssonnelia</i>	Species not identified 1
Cordeiro et al. (2020)	Rhodophyta	<i>Porolithon</i>	<i>Porolithon antillarum</i> (Foslie & M.Howe) Foslie & M.Howe, 1909
Cordeiro et al. (2020)	Rhodophyta	<i>Wrangelia</i>	<i>Wrangelia argus</i> (Montagne) Montagne, 1856
Cordeiro et al. (2020)	Rhodophyta	<i>Amphiroa</i>	Species not identified 1
Aller and Aller (1986)	Foraminifera	Genus not identified 1	Species not identified 1
R. L. Moura et al. (2016)	Porifera	<i>Aaptos</i>	Species not identified 1
R. L. Moura et al. (2016)	Porifera	<i>Acanthella</i>	Species not identified 1
R. L. Moura et al. (2016)	Porifera	<i>Acarus</i>	Species not identified 1
R. L. Moura et al. (2016)	Porifera	<i>Agelas</i>	<i>Agelas clathrodes</i> (Schmidt, 1870)
R. L. Moura et al. (2016)	Porifera	<i>Agelas</i>	<i>Agelas dispar</i> Duchassaing & Michelotti, 1864
R. L. Moura et al. (2016)	Porifera	<i>Agelas</i>	<i>Agelas sventres</i> Lehnert & van Soest, 1996
R. L. Moura et al. (2016)	Porifera	<i>Aiolochoxia</i>	<i>Aiolochoxia crassa</i> (Hyatt, 1875)
R. L. Moura et al. (2016)	Porifera	<i>Amphimedon</i>	Species not identified 1
R. L. Moura et al. (2016)	Porifera	<i>Amphimedon</i>	Species not identified 2
R. L. Moura et al. (2016)	Porifera	<i>Aplysina</i>	<i>Aplysina cauliformis</i> (Carter, 1882)
R. L. Moura et al. (2016)	Porifera	<i>Aplysina</i>	<i>Aplysina fulva</i> (Pallas, 1766)



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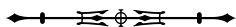
Study	Phylum	Genus	Species
R. L. Moura et al. (2016)	Porifera	<i>Aplysina</i>	<i>Aplysina lacunosa</i> (Lamarck, 1814)
R. L. Moura et al. (2016)	Porifera	<i>Arenosciera</i>	Species not identified 1
R. L. Moura et al. (2016)	Porifera	<i>Asteropus</i>	Species not identified 1
R. L. Moura et al. (2016)	Porifera	<i>Callyspongia</i>	Species not identified 1
R. L. Moura et al. (2016)	Porifera	<i>Callyspongia</i>	<i>Callyspongia vaginalis</i> (Lamarck, 1814)
R. L. Moura et al. (2016)	Porifera	<i>Chondrosia</i>	Species not identified 1
R. L. Moura et al. (2016)	Porifera	<i>Cinachyrella</i>	<i>Cinachyrella kuekenthali</i> (Uliczka, 1929)
R. L. Moura et al. (2016)	Porifera	<i>Clathria</i>	Species not identified 1
R. L. Moura et al. (2016)	Porifera	<i>Clathria</i>	<i>Clathria (Microcionia) calla</i> (de Laubenfels, 1934)
R. L. Moura et al. (2016)	Porifera	<i>Clathria</i>	<i>Clathria echinata</i> (Alcolado, 1984)
R. L. Moura et al. (2016)	Porifera	<i>Clathria</i>	<i>Clathria (Clathria) nicoleae</i> Barros, Santos & Pinheiro, 2013
R. L. Moura et al. (2016)	Porifera	<i>Cliona</i>	<i>Cliona schmidtii</i> (Ridley, 1881)
R. L. Moura et al. (2016)	Porifera	<i>Cliona</i>	Species not identified 1
R. L. Moura et al. (2016)	Porifera	<i>Didiscus</i>	<i>Didiscus verdensis</i> Hiemstra & van Soest, 1991
R. L. Moura et al. (2016)	Porifera	<i>Drarmacidon</i>	<i>Drarmacidon reticulatum</i> (Ridley & Dendy, 1886)
R. L. Moura et al. (2016)	Porifera	<i>Dysidea</i>	Species not identified 1
R. L. Moura et al. (2016)	Porifera	<i>Echinodictyum</i>	<i>Echinodictyum dendroides</i> Hechtel, 1983
R. L. Moura et al. (2016)	Porifera	<i>Ecionemia</i>	Species not identified 1
R. L. Moura et al. (2016)	Porifera	<i>Geodia</i>	<i>Geodia corticostylifera</i> Hajdu, Muricy, Custodio, Russo & Peixinho, 1992
R. L. Moura et al. (2016)	Porifera	<i>Geodia</i>	<i>Geodia gibberosa</i> Lamarck, 1815
R. L. Moura et al. (2016)	Porifera	<i>Geodia</i>	<i>Geodia neptuni</i> (Sollas, 1886)
R. L. Moura et al. (2016)	Porifera	<i>Geodia</i>	Species not identified 1
R. L. Moura et al. (2016)	Porifera	<i>Halichondria</i>	Species not identified 1
R. L. Moura et al. (2016)	Porifera	<i>Hyattella</i>	<i>Hyattella cavernosa</i> (Pallas, 1766)
R. L. Moura et al. (2016)	Porifera	<i>Ircinia</i>	<i>Ircinia strobilina</i> (Lamarck, 1816)
R. L. Moura et al. (2016)	Porifera	<i>Lissodendoryx</i>	Species not identified 1
R. L. Moura et al. (2016)	Porifera	<i>Melophlus</i>	Species not identified 1
R. L. Moura et al. (2016)	Porifera	<i>Monanchora</i>	<i>Monanchora arbuscula</i> (Duchassaing & Michelotti, 1864)
R. L. Moura et al. (2016)	Porifera	<i>Myrmekioderma</i>	Species not identified 1
R. L. Moura et al. (2016)	Porifera	<i>Niphates</i>	<i>Niphates erecta</i> Duchassaing & Michelotti, 1864
R. L. Moura et al. (2016)	Porifera	<i>Niphates</i>	Species not identified 1
R. L. Moura et al. (2016)	Porifera	<i>Oceanapia</i>	<i>Oceanapia bartschi</i> (de Laubenfels, 1934)
R. L. Moura et al. (2016)	Porifera	<i>Petromica</i>	Species not identified 1
R. L. Moura et al. (2016)	Porifera	<i>Petrosia</i>	Species not identified 1
R. L. Moura et al. (2016)	Porifera	<i>Plakinastrella</i>	<i>Plakinastrella globularis</i> Domingos, Moraes & Muricy, 2013
R. L. Moura et al. (2016)	Porifera	<i>Plakinastrella</i>	Species not identified 1



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(Continue)

Study	Phylum	Genus	Species
R. L. Moura et al. (2016)	Porifera	<i>Prosuberites</i>	Species not identified 1
R. L. Moura et al. (2016)	Porifera	<i>Pseudosuberites</i>	Species not identified 1
R. L. Moura et al. (2016)	Porifera	Genus not identified 1	Species not identified 1
R. L. Moura et al. (2016)	Porifera	Genus not identified 2	Species not identified 2
R. L. Moura et al. (2016)	Porifera	Genus not identified 3	Species not identified 3
R. L. Moura et al. (2016)	Porifera	Genus not identified 4	Species not identified 4
R. L. Moura et al. (2016)	Porifera	<i>Stelletta</i>	Species not identified 1
R. L. Moura et al. (2016)	Porifera	<i>Stelletta</i>	Species not identified 2
R. L. Moura et al. (2016)	Porifera	<i>Tedania</i>	<i>Thalysias ignis</i> Duchassaing & Michelotti, 1864
R. L. Moura et al. (2016)	Porifera	<i>Theonella</i>	<i>Theonella atlantica</i> van Soest & Stentoft, 1988
R. L. Moura et al. (2016)	Porifera	<i>Topsentia</i>	<i>Topsentia ophiraphidites</i> (de Laubenfels, 1934)
R. L. Moura et al. (2016)	Porifera	<i>Tribrachium</i>	<i>Tribrachium schmidtii</i> Weltner, 1882
R. L. Moura et al. (2016)	Porifera	<i>Xestospongia</i>	<i>Xestospongia muta</i> (Schmidt, 1870)
R. L. Moura et al. (2016)	Porifera	<i>Xestospongia</i>	Species not identified 1
Neto et al. (2018)	Porifera	<i>Oceanapia</i>	<i>Oceanapia stalagmitica</i> (Wiedenmayer, 1977)
Nóbrega et al. (2021)	Porifera	<i>Adrana</i>	<i>Adrana electa</i> (A. Adams, 1856)
Nóbrega et al. (2021)	Porifera	<i>Aplysina</i>	<i>Aplysina pseudolacunosa</i> Pinheiro, Hajdu & Custódio, 2007
Nóbrega et al. (2021)	Porifera	<i>Clathria</i>	<i>Clathria (Clathria) nicoleae</i> Barros, Santos & Pinheiro, 2013
Nóbrega et al. (2021)	Porifera	<i>Ircinia</i>	Species not identified 1
Nóbrega et al. (2021)	Porifera	<i>Voluta</i>	<i>Voluta ebraea</i> Linnaeus, 1758
Menezes et al. (2022)	Porifera	<i>Agelas</i>	<i>Agelas clathrodes</i> (Schmidt, 1870)
Menezes et al. (2022)	Porifera	<i>Agelas</i>	<i>Agelas dispar</i> Duchassaing & Michelotti, 1864
Menezes et al. (2022)	Porifera	<i>Aiolochoxia</i>	<i>Aiolochoxia crassa</i> (Hyatt, 1875)
Menezes et al. (2022)	Porifera	<i>Amphimedon</i>	<i>Amphimedon compressa</i> Duchassaing & Michelotti, 1864
Menezes et al. (2022)	Porifera	<i>Aplysina</i>	<i>Aplysina fistularis</i> (Linnaeus, 1759)
Menezes et al. (2022)	Porifera	<i>Arenosclera</i>	<i>Arenosclera amazonensis</i> Leal, Moraes, Thompson & Hajdu, 2017
Menezes et al. (2022)	Porifera	<i>Callyspongia</i>	<i>Callyspongia (Cladochalina) aculeata</i> (Linnaeus, 1759)
Menezes et al. (2022)	Porifera	<i>Cinachyrella</i>	<i>Cinachyrella kuekenthali</i> (Uliczka, 1929)
Menezes et al. (2022)	Porifera	<i>Clathria</i>	<i>Clathria (Clathria) nicoleae</i> Barros, Santos & Pinheiro, 2013
Menezes et al. (2022)	Porifera	<i>Coelocarteria</i>	<i>Coelocarteria amadoi</i> Leal, Salani, Moraes & Hajdu, 2023
Menezes et al. (2022)	Porifera	<i>Coelocarteria</i>	<i>Coelocarteria bartschi</i> (de Laubenfels, 1934)
Menezes et al. (2022)	Porifera	<i>Echinoclathria</i>	Species not identified 1
Menezes et al. (2022)	Porifera	<i>Euryspongia</i>	Species not identified 1
Menezes et al. (2022)	Porifera	<i>Geodia</i>	<i>Geodia corticostylifera</i> Hajdu, Muricy, Custodio, Russo & Peixinho, 1992
Menezes et al. (2022)	Porifera	<i>Geodia</i>	<i>Geodia neptuni</i> (Sollas, 1886)
Menezes et al. (2022)	Porifera	<i>Geodia</i>	Species not identified 1



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Study	Phylum	Genus	Species
Menezes et al. (2022)	Porifera	<i>Ircinia</i>	<i>Ircinia strobilina</i> (Lamarck, 1816)
Menezes et al. (2022)	Porifera	<i>Monanchora</i>	<i>Monanchora arbuscula</i> (Duchassaing & Michelotti, 1864)
Menezes et al. (2022)	Porifera	<i>Neopetrosia</i>	<i>Neopetrosia proxima</i> (Duchassaing & Michelotti, 1864)
Menezes et al. (2022)	Porifera	<i>Perissinella</i>	<i>Perissinella fosteri</i> Hechtel, 1983
Menezes et al. (2022)	Porifera	<i>Topsentia</i>	<i>Topsentia ophiraphidites</i> (de Laubenfels, 1934)
Menezes et al. (2022)	Porifera	<i>Tribrachium</i>	<i>Tribrachium schmidtii</i> Weltner, 1882
Aller and Aller (1986)	Cnidaria	<i>Astrangia</i>	Species not identified 1
R. L. Moura et al. (2016)	Cnidaria	<i>Acanthogorgia</i>	<i>Acanthogorgia aspera</i> Pourtalès, 1867
R. L. Moura et al. (2016)	Cnidaria	<i>Acanthogorgia</i>	<i>Acanthogorgia schrammi</i> (Duchassaing & Michelotti, 1864)
R. L. Moura et al. (2016)	Cnidaria	<i>Agaricia</i>	<i>Agaricia agaricites</i> (Linnaeus, 1758)
R. L. Moura et al. (2016)	Cnidaria	<i>Agaricia</i>	<i>Agaricia fragilis</i> Dana, 1846
R. L. Moura et al. (2016)	Cnidaria	<i>Antipathes</i>	<i>Antipathes furcata</i> Gray, 1857
R. L. Moura et al. (2016)	Cnidaria	<i>Astrangia</i>	<i>Astrangia rathbuni</i> Vaughan, 1906
R. L. Moura et al. (2016)	Cnidaria	<i>Astrangia</i>	<i>Astrangia solitaria</i> (Le Sueur, 1817)
R. L. Moura et al. (2016)	Cnidaria	<i>Bebryce</i>	<i>Bebryce parastellata</i> Deichmann, 1936
R. L. Moura et al. (2016)	Cnidaria	<i>Carijoa</i>	<i>Carijoa riisei</i> (Duchassaing & Michelotti, 1860)
R. L. Moura et al. (2016)	Cnidaria	<i>Cirripathes</i>	Species not identified 1
R. L. Moura et al. (2016)	Cnidaria	<i>Diodogorgia</i>	<i>Diodogorgia nodulifera</i> (Hargitt in Hargitt & Rogers, 1901)
R. L. Moura et al. (2016)	Cnidaria	<i>Ellisella</i>	<i>Ellisella elongata</i> (Pallas, 1766)
R. L. Moura et al. (2016)	Cnidaria	<i>Favia</i>	<i>Favia gravida</i> Verrill, 1868
R. L. Moura et al. (2016)	Cnidaria	<i>Heterogorgia</i>	<i>Heterogorgia uatumani</i> Castro, 1990
R. L. Moura et al. (2016)	Cnidaria	<i>Iciligorgia</i>	<i>Iciligorgia schrammi</i> Duchassaing, 1870
R. L. Moura et al. (2016)	Cnidaria	<i>Leptogorgia</i>	<i>Leptogorgia euryale</i> (Bayer, 1952)
R. L. Moura et al. (2016)	Cnidaria	<i>Leptogorgia</i>	<i>Leptogorgia miniata</i> (Milne Edwards & Haime, 1857)
R. L. Moura et al. (2016)	Cnidaria	<i>Leptogorgia</i>	<i>Leptogorgia punicea</i> (Milne Edwards & Haime, 1857)
R. L. Moura et al. (2016)	Cnidaria	<i>Leptogorgia</i>	<i>Leptogorgia setacea</i> (Pallas, 1766)
R. L. Moura et al. (2016)	Cnidaria	<i>Leptogorgia</i>	<i>Leptogorgia stheno</i> (Bayer, 1952)
R. L. Moura et al. (2016)	Cnidaria	<i>Madracis</i>	<i>Madracis decactis</i> (Lyman, 1859)
R. L. Moura et al. (2016)	Cnidaria	<i>Meandrina</i>	<i>Meandrina braziliensis</i> Milne Edwards & Haime, 1848
R. L. Moura et al. (2016)	Cnidaria	<i>Millepora</i>	<i>Millepora alcicornis</i> Linnaeus, 1758
R. L. Moura et al. (2016)	Cnidaria	<i>Montastraea</i>	<i>Montastraea cavernosa</i> (Linnaeus, 1767)
R. L. Moura et al. (2016)	Cnidaria	<i>Muriceopsis</i>	<i>Muriceopsis petila</i> Bayer, 1961
R. L. Moura et al. (2016)	Cnidaria	<i>Muriceopsis</i>	Species not identified 1
R. L. Moura et al. (2016)	Cnidaria	<i>Mussismilia</i>	<i>Mussismilia hispida</i> (Verrill, 1901)
R. L. Moura et al. (2016)	Cnidaria	<i>Nicella</i>	<i>Nicella guadalupensis</i> (Duchassaing & Michelotti, 1860)
R. L. Moura et al. (2016)	Cnidaria	<i>Nidalia</i>	<i>Nidalia occidentalis</i> Gray, 1835
R. L. Moura et al. (2016)	Cnidaria	<i>Nidalia</i>	Species not identified 1



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(Continue)

Study	Phylum	Genus	Species
R. L. Moura et al. (2016)	Cnidaria	<i>Olindagorgia</i>	<i>Olindagorgia gracilis</i> (Verrill, 1868)
R. L. Moura et al. (2016)	Cnidaria	<i>Paciffigorgia</i>	Species not identified 1
R. L. Moura et al. (2016)	Cnidaria	<i>Phyllangia</i>	<i>Phyllangia americana</i> Milne Edwards & Haime, 1849
R. L. Moura et al. (2016)	Cnidaria	<i>Primnoella</i>	<i>Primnoella delicatissima</i> Kükenthal, 1909
R. L. Moura et al. (2016)	Cnidaria	<i>Rhizosmilia</i>	<i>Rhizosmilia maculata</i> (Pourtalès, 1874)
R. L. Moura et al. (2016)	Cnidaria	<i>Scleracis</i>	<i>Scleracis</i> sp.
R. L. Moura et al. (2016)	Cnidaria	<i>Scolymia</i>	<i>Scolymia wellsii</i> Laborel, 1967
R. L. Moura et al. (2016)	Cnidaria	<i>Tanacetipathes</i>	<i>Tanacetipathes tanacetum</i> (Pourtalès, 1880)
R. L. Moura et al. (2016)	Cnidaria	<i>Thelogorgia</i>	<i>Thelogorgia studeri</i> Bayer, 1991
R. L. Moura et al. (2016)	Cnidaria	<i>Thesea</i>	<i>Thesea bicolor</i> Deichmann, 1936
R. L. Moura et al. (2016)	Cnidaria	<i>Thesea</i>	<i>Thesea gracilis</i> (Gray, 1868)
R. L. Moura et al. (2016)	Cnidaria	<i>Trichogorgia</i>	<i>Trichogorgia brasiliensis</i> Castro, Medeiros & Loiola, 2010
Francini-Filho et al. (2018)	Cnidaria	<i>Madracis</i>	<i>Madracis decactis</i> (Lyman, 1859)
Cordeiro et al. (2020)	Cnidaria	<i>Favia</i>	<i>Favia gravida</i> Verrill, 1868
Cordeiro et al. (2020)	Cnidaria	<i>Meandrina</i>	<i>Meandrina brasiliensis</i> (Milne Edwards & Haime, 1848)
Cordeiro et al. (2020)	Cnidaria	<i>Montastraea</i>	<i>Montastraea cavernosa</i> (Linnaeus, 1767)
Cordeiro et al. (2020)	Cnidaria	<i>Palythoa</i>	<i>Palythoa caribaeorum</i> Duchassaing & Michelotti, 1860
Cordeiro et al. (2020)	Cnidaria	<i>Porites</i>	<i>Porites astreoides</i> Lamarck, 1816
Cordeiro et al. (2020)	Cnidaria	<i>Siderastrea</i>	<i>Siderastrea stellata</i> Verrill, 1868
Nóbrega et al. (2021)	Cnidaria	<i>Renilla</i>	Species not identified 1
R. B. Moura et al. (2023)	Cnidaria	<i>Aglaophenia</i>	<i>Aglaophenia acacia</i> Allman, 1883
R. B. Moura et al. (2023)	Cnidaria	<i>Aglaophenia</i>	<i>Aglaophenia latecarinata</i> Allman, 1877
R. B. Moura et al. (2023)	Cnidaria	<i>Aglaophenia</i>	<i>Aglaophenia rhynchocarpa</i> Allman, 1877
R. B. Moura et al. (2023)	Cnidaria	<i>Aglaophenia</i>	Species not identified 1
R. B. Moura et al. (2023)	Cnidaria	<i>Amphisbetia</i>	<i>Amphisbetia distans</i> (Lamouroux, 1816)
R. B. Moura et al. (2023)	Cnidaria	<i>Antennella</i>	<i>Antennella incerta</i> Galea, 2010
R. B. Moura et al. (2023)	Cnidaria	<i>Antennella</i>	<i>Antennella secundaria</i> (Gmelin, 1791)
R. B. Moura et al. (2023)	Cnidaria	<i>Clytia</i>	<i>Clytia linearis</i> (Thorneley, 1900)
R. B. Moura et al. (2023)	Cnidaria	<i>Diphasia</i>	<i>Diphasia digitalis</i> (Busk, 1852)
R. B. Moura et al. (2023)	Cnidaria	<i>Dynamena</i>	<i>Dynamena crisioides</i> Lamouroux, 1824
R. B. Moura et al. (2023)	Cnidaria	<i>Eudendrium</i>	<i>Eudendrium carneum</i> Clarke, 1882
R. B. Moura et al. (2023)	Cnidaria	<i>Gymnangium</i>	<i>Gymnangium allmani</i> (Marktanner-Turneretscher, 1890)
R. B. Moura et al. (2023)	Cnidaria	<i>Gymnangium</i>	<i>Gymnangium sinuosum</i> (Fraser, 1925)
R. B. Moura et al. (2023)	Cnidaria	<i>Halecium</i>	Species not identified 1
R. B. Moura et al. (2023)	Cnidaria	<i>Halopteris</i>	<i>Halopteris carinata</i> Allman, 1877
R. B. Moura et al. (2023)	Cnidaria	<i>Halopteris</i>	Species not identified 1
R. B. Moura et al. (2023)	Cnidaria	<i>Hincksella</i>	<i>Hincksella formosa</i> (Fewkes, 1881)



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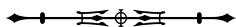
Study	Phylum	Genus	Species
R. B. Moura et al. (2023)	Cnidaria	<i>Hincksella</i>	<i>Hincksella cylindrica</i> var. <i>pusilla</i> (Ritchie, 1910)
R. B. Moura et al. (2023)	Cnidaria	<i>Idiellana</i>	<i>Idiellana pristin</i> (Lamouroux, 1816)
R. B. Moura et al. (2023)	Cnidaria	<i>Lytocarpia</i>	<i>Lytocarpia tridentata</i> (Versluys, 1899)
R. B. Moura et al. (2023)	Cnidaria	<i>Macrorhynchia</i>	<i>Macrorhynchia allmani</i> (Nutting, 1900)
R. B. Moura et al. (2023)	Cnidaria	<i>Monostaechas</i>	<i>Monostaechas quadridens</i> (McCrary, 1859)
R. B. Moura et al. (2023)	Cnidaria	<i>Obelia</i>	<i>Obelia oxydentata</i> Stechow, 1914
R. B. Moura et al. (2023)	Cnidaria	<i>Parawrightia</i>	<i>Parawrightia robusta</i> Warren, 1907
R. B. Moura et al. (2023)	Cnidaria	<i>Plumularia</i>	<i>Plumularia margareta</i> (Nutting, 1900)
R. B. Moura et al. (2023)	Cnidaria	<i>Plumularia</i>	Species not identified 1
R. B. Moura et al. (2023)	Cnidaria	<i>Sertularella</i>	<i>Sertularella diaphana</i> (Allman, 1885)
R. B. Moura et al. (2023)	Cnidaria	<i>Sertularella</i>	Species not identified 1
R. B. Moura et al. (2023)	Cnidaria	<i>Sertularelloides</i>	<i>Sertularelloides cylindritheca</i> (Allman, 1888)
R. B. Moura et al. (2023)	Cnidaria	<i>Syntheticium</i>	<i>Syntheticium tubithecum</i> (Allman, 1877)
R. B. Moura et al. (2023)	Cnidaria	<i>Thuiaria</i>	<i>Thuiaria articulata</i> (Pallas, 1766)
R. B. Moura et al. (2023)	Cnidaria	<i>Thyroscyphus</i>	<i>Thyroscyphus marginatus</i> (Allman, 1877)
R. B. Moura et al. (2023)	Cnidaria	<i>Thyroscyphus</i>	<i>Thyroscyphus ramosus</i> Allman, 1877
R. B. Moura et al. (2023)	Cnidaria	<i>Tridentata</i>	<i>Tridentata</i> sp.
R. B. Moura et al. (2023)	Cnidaria	<i>Tridentata</i>	<i>Tridentata loculosa</i> (Busk, 1852)
R. B. Moura et al. (2023)	Cnidaria	<i>Tridentata</i>	<i>Ridentata marginata</i> (Kirchenpauer, 1864)
R. B. Moura et al. (2023)	Cnidaria	<i>Tridentata</i>	<i>Tridentata trigonostoma</i> (Busk, 1852)
R. B. Moura et al. (2023)	Cnidaria	<i>Tridentata</i>	<i>Tridentata turbinata</i> (Lamouroux, 1816)
Jovane et al. (2024)	Cnidaria	<i>Actinoscyphia</i>	Species not identified 1
Jovane et al. (2024)	Cnidaria	Genus not identified 1	Species not identified 1
Jovane et al. (2024)	Cnidaria	Genus not identified 2	Species not identified 2
Jovane et al. (2024)	Cnidaria	Genus not identified 3	Species not identified 3
Aller and Aller (1986)	Platyhelminthes	Genus not identified 1	Species not identified 1
Aller and Aller (1986)	Kinorhyncha	Genus not identified 1	Species not identified 1
Aller and Aller (1986)	Nematoda	Genus not identified 1	Species not identified 1
Aller and Aller (1986)	Nematoda	<i>Theristus</i>	<i>Theristus</i> sp.
Pereira et al. (2022)	Nematoda	<i>Acantholaimus</i>	<i>Acantholaimus</i> sp.
Pereira et al. (2022)	Nematoda	<i>Actarjania</i>	<i>Actarjania</i> sp.
Pereira et al. (2022)	Nematoda	<i>Aegialolaimus</i>	<i>Aegialolaimus</i> sp.
Pereira et al. (2022)	Nematoda	<i>Amphimonhystrella</i>	<i>Amphimonhystrella</i> sp.
Pereira et al. (2022)	Nematoda	<i>Anonchus</i>	<i>Anonchus</i> sp.
Pereira et al. (2022)	Nematoda	<i>Anoplostoma</i>	<i>Anoplostoma</i> sp.
Pereira et al. (2022)	Nematoda	<i>Anticoma</i>	<i>Anticoma</i> sp.
Pereira et al. (2022)	Nematoda	<i>Antomicron</i>	<i>Antomicron</i> sp.



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Study	Phylum	Genus	Species
Pereira et al. (2022)	Nematoda	<i>Aponema</i>	<i>Aponema</i> sp.
Pereira et al. (2022)	Nematoda	<i>Araeolaimus</i>	<i>Araeolaimus</i> sp.
Pereira et al. (2022)	Nematoda	<i>Axonolaimus</i>	<i>Axonolaimus</i> sp.
Pereira et al. (2022)	Nematoda	<i>Bathyeuristomina</i>	<i>Bathyeuristomina</i> sp.
Pereira et al. (2022)	Nematoda	<i>Bathylaimus</i>	<i>Bathylaimus</i> sp.
Pereira et al. (2022)	Nematoda	<i>Belbola</i>	<i>Belbola</i> sp.
Pereira et al. (2022)	Nematoda	<i>Campylaimus</i>	<i>Campylaimus</i> sp.
Pereira et al. (2022)	Nematoda	<i>Cephalanticoma</i>	<i>Cephalanticoma</i> sp.
Pereira et al. (2022)	Nematoda	<i>Cervonema</i>	<i>Cervonema</i> sp.
Pereira et al. (2022)	Nematoda	<i>Chaetonema</i>	<i>Chaetonema</i> sp.
Pereira et al. (2022)	Nematoda	<i>Cheironchus</i>	<i>Cheironchus</i> sp.
Pereira et al. (2022)	Nematoda	<i>Choanolaimus</i>	<i>Choanolaimus</i> sp.
Pereira et al. (2022)	Nematoda	<i>Chromadorella</i>	<i>Chromadorella</i> sp.
Pereira et al. (2022)	Nematoda	<i>Chromadorina</i>	<i>Chromadorina</i> sp.
Pereira et al. (2022)	Nematoda	<i>Chromadorita</i>	<i>Chromadorita</i> sp.
Pereira et al. (2022)	Nematoda	<i>Cobbia</i>	<i>Cobbia</i> sp.
Pereira et al. (2022)	Nematoda	<i>Comesa</i>	<i>Comesa</i> sp.
Pereira et al. (2022)	Nematoda	<i>Crenopharynx</i>	<i>Crenopharynx</i> sp.
Pereira et al. (2022)	Nematoda	<i>Cyartonema</i>	<i>Cyartonema</i> sp.
Pereira et al. (2022)	Nematoda	<i>Daptonema</i>	<i>Daptonema</i> sp.
Pereira et al. (2022)	Nematoda	<i>Desmodora</i>	<i>Desmodora</i> sp.
Pereira et al. (2022)	Nematoda	<i>Desmodorella</i>	<i>Desmodorella</i> sp.
Pereira et al. (2022)	Nematoda	<i>Desmoscolex</i>	<i>Desmoscolex</i> sp.
Pereira et al. (2022)	Nematoda	<i>Dichromadora</i>	<i>Dichromadora</i> sp.
Pereira et al. (2022)	Nematoda	<i>Diplolaimella</i>	<i>Diplolaimella</i> sp.
Pereira et al. (2022)	Nematoda	<i>Diplolaimelloides</i>	<i>Diplolaimelloides</i> sp.
Pereira et al. (2022)	Nematoda	<i>Diplopeltis</i>	<i>Diplopeltis</i> sp.
Pereira et al. (2022)	Nematoda	<i>Diplopeltula</i>	<i>Diplopeltula</i> sp.
Pereira et al. (2022)	Nematoda	<i>Dorylaimopsis</i>	<i>Dorylaimopsis</i> sp.
Pereira et al. (2022)	Nematoda	<i>Eleuterelaimus</i>	<i>Eleuterelaimus</i> sp.
Pereira et al. (2022)	Nematoda	<i>Elzalia</i>	<i>Elzalia</i> sp.
Pereira et al. (2022)	Nematoda	<i>Endeolophus</i>	<i>Endeolophus</i> sp.
Pereira et al. (2022)	Nematoda	<i>Enoploides</i>	<i>Enoploides</i> sp.
Pereira et al. (2022)	Nematoda	<i>Enoplolaimus</i>	<i>Enoplolaimus</i> sp.
Pereira et al. (2022)	Nematoda	<i>Eumorpholaimus</i>	<i>Eumorpholaimus</i> sp.
Pereira et al. (2022)	Nematoda	<i>Fenestrolaimus</i>	<i>Fenestrolaimus</i> sp.
Pereira et al. (2022)	Nematoda	<i>Filtonchus</i>	<i>Filtonchus</i> sp.



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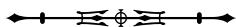
Study	Phylum	Genus	Species
Pereira et al. (2022)	Nematoda	<i>Gammanema</i>	<i>Gammanema</i> sp.
Pereira et al. (2022)	Nematoda	<i>Geomonhystera</i>	<i>Geomonhystera</i> sp.
Pereira et al. (2022)	Nematoda	<i>Greeffiella</i>	<i>Greeffiella</i> sp.
Pereira et al. (2022)	Nematoda	<i>Halalaimus</i>	<i>Halalaimus</i> sp.
Pereira et al. (2022)	Nematoda	<i>Halichoanolaimus</i>	<i>Halichoanolaimus</i> sp.
Pereira et al. (2022)	Nematoda	<i>Haliplectus</i>	<i>Haliplectus</i> sp.
Pereira et al. (2022)	Nematoda	<i>Halomonhystera</i>	<i>Halomonhystera</i> sp.
Pereira et al. (2022)	Nematoda	<i>Laimella</i>	<i>Laimella</i> sp.
Pereira et al. (2022)	Nematoda	<i>Latronema</i>	<i>Latronema</i> sp.
Pereira et al. (2022)	Nematoda	<i>Leptolaimus</i>	<i>Leptolaimus</i> sp.
Pereira et al. (2022)	Nematoda	<i>Linhomoeus</i>	<i>Linhomoeus</i> sp.
Pereira et al. (2022)	Nematoda	<i>Linhystera</i>	<i>Linhystera</i> sp.
Pereira et al. (2022)	Nematoda	<i>Litinium</i>	<i>Litinium</i> sp.
Pereira et al. (2022)	Nematoda	<i>Longicyatholaimus</i>	<i>Longicyatholaimus</i> sp.
Pereira et al. (2022)	Nematoda	<i>Metachromadora</i>	<i>Metachromadora</i> sp.
Pereira et al. (2022)	Nematoda	<i>Metacomesoma</i>	<i>Metacomesoma</i> sp.
Pereira et al. (2022)	Nematoda	<i>Metalinhomoeus</i>	<i>Metalinhomoeus</i> sp.
Pereira et al. (2022)	Nematoda	<i>Metasphaerolaimus</i>	<i>Metasphaerolaimus</i> sp.
Pereira et al. (2022)	Nematoda	<i>Microlaimus</i>	<i>Microlaimus</i> sp.
Pereira et al. (2022)	Nematoda	<i>Minolaimus</i>	<i>Minolaimus</i> sp.
Pereira et al. (2022)	Nematoda	<i>Molgolaimus</i>	<i>Molgolaimus</i> sp.
Pereira et al. (2022)	Nematoda	<i>Monhystrella</i>	<i>Monhystrella</i> sp.
Pereira et al. (2022)	Nematoda	<i>Nannolaimus</i>	<i>Nannolaimus</i> sp.
Pereira et al. (2022)	Nematoda	<i>Nemanema</i>	<i>Nemanema</i> sp.
Pereira et al. (2022)	Nematoda	<i>Neochromadora</i>	<i>Neochromadora</i> sp.
Pereira et al. (2022)	Nematoda	<i>Neotonchus</i>	<i>Neotonchus</i> sp.
Pereira et al. (2022)	Nematoda	<i>Odontophora</i>	<i>Odontophora</i> sp.
Pereira et al. (2022)	Nematoda	<i>Oncholaimus</i>	<i>Oncholaimus</i> sp.
Pereira et al. (2022)	Nematoda	<i>Oxystomina</i>	<i>Oxystomina</i> sp.
Pereira et al. (2022)	Nematoda	<i>Paracanthonchus</i>	<i>Paracanthonchus</i> sp.
Pereira et al. (2022)	Nematoda	<i>Paracomesoma</i>	<i>Paracomesoma</i> sp.
Pereira et al. (2022)	Nematoda	<i>Paracyatholaimus</i>	<i>Paracyatholaimus</i> sp.
Pereira et al. (2022)	Nematoda	<i>Paralinhomoeus</i>	<i>Paralinhomoeus</i> sp.
Pereira et al. (2022)	Nematoda	<i>Paralongicyatholaimus</i>	<i>Paralongicyatholaimus</i> sp.
Pereira et al. (2022)	Nematoda	<i>Paramesacanthion</i>	<i>Paramesacanthion</i> sp.
Pereira et al. (2022)	Nematoda	<i>Paramesonchium</i>	<i>Paramesonchium</i> sp.
Pereira et al. (2022)	Nematoda	<i>Paramonhystera</i>	<i>Paramonhystera</i> sp.



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Study	Phylum	Genus	Species
Pereira et al. (2022)	Nematoda	<i>Paramphimonhystrella</i>	<i>Paramphimonhystrella</i> sp.
Pereira et al. (2022)	Nematoda	<i>Parasphaerolaimus</i>	<i>Parasphaerolaimus</i> sp.
Pereira et al. (2022)	Nematoda	<i>Parodontophora</i>	<i>Parodontophora</i> sp.
Pereira et al. (2022)	Nematoda	<i>Phanoderma</i>	<i>Phanoderma</i> sp.
Pereira et al. (2022)	Nematoda	<i>Phanodermella</i>	<i>Phanodermella</i> sp.
Pereira et al. (2022)	Nematoda	<i>Pierrickia</i>	<i>Pierrickia</i> sp.
Pereira et al. (2022)	Nematoda	<i>Polygastrophora</i>	<i>Polygastrophora</i> sp.
Pereira et al. (2022)	Nematoda	<i>Polysigma</i>	<i>Polysigma</i> sp.
Pereira et al. (2022)	Nematoda	<i>Pomponema</i>	<i>Pomponema</i> sp.
Pereira et al. (2022)	Nematoda	<i>Prochromadora</i>	<i>Prochromadora</i> sp.
Pereira et al. (2022)	Nematoda	<i>Prorhynchonema</i>	<i>Prorhynchonema</i> sp.
Pereira et al. (2022)	Nematoda	<i>Pselionema</i>	<i>Pselionema</i> sp.
Pereira et al. (2022)	Nematoda	<i>Rhabdocoma</i>	<i>Rhabdocoma</i> sp.
Pereira et al. (2022)	Nematoda	<i>Rhips</i>	<i>Rhips</i> sp.
Pereira et al. (2022)	Nematoda	<i>Sabatieria</i>	<i>Sabatieria</i> sp.
Pereira et al. (2022)	Nematoda	<i>Scaptrella</i>	<i>Scaptrella</i> sp.
Pereira et al. (2022)	Nematoda	<i>Siphonolaimus</i>	<i>Siphonolaimus</i> sp.
Pereira et al. (2022)	Nematoda	<i>Southernia</i>	<i>Southernia</i> sp.
Pereira et al. (2022)	Nematoda	<i>Southerniella</i>	<i>Southerniella</i> sp.
Pereira et al. (2022)	Nematoda	<i>Sphaerolaimus</i>	<i>Sphaerolaimus</i> sp.
Pereira et al. (2022)	Nematoda	<i>Spirinia</i>	<i>Spirinia</i> sp.
Pereira et al. (2022)	Nematoda	<i>Subsphaerolaimus</i>	<i>Subsphaerolaimus</i> sp.
Pereira et al. (2022)	Nematoda	<i>Synonchiella</i>	<i>Synonchiella</i> sp.
Pereira et al. (2022)	Nematoda	<i>Synonchus</i>	<i>Synonchus</i> sp.
Pereira et al. (2022)	Nematoda	<i>Syringolaimus</i>	<i>Syringolaimus</i> sp.
Pereira et al. (2022)	Nematoda	<i>Terschellingia</i>	<i>Terschellingia</i> sp.
Pereira et al. (2022)	Nematoda	<i>Thalassironus</i>	<i>Thalassironus</i> sp.
Pereira et al. (2022)	Nematoda	<i>Thalassoalaimus</i>	<i>Thalassoalaimus</i> sp.
Pereira et al. (2022)	Nematoda	<i>Thalassomonhystera</i>	<i>Thalassomonhystera</i> sp.
Pereira et al. (2022)	Nematoda	<i>Theristus</i>	<i>Theristus</i> sp.
Pereira et al. (2022)	Nematoda	<i>Trefusia</i>	<i>Trefusia</i> sp.
Pereira et al. (2022)	Nematoda	<i>Tricoma</i>	<i>Tricoma</i> sp.
Pereira et al. (2022)	Nematoda	<i>Tripyloides</i>	<i>Tripyloides</i> sp.
Pereira et al. (2022)	Nematoda	<i>Trissonchulus</i>	<i>Trissonchulus</i> sp.
Pereira et al. (2022)	Nematoda	<i>Trochamus</i>	<i>Trochamus</i> sp.
Pereira et al. (2022)	Nematoda	<i>Vasostoma</i>	<i>Vasostoma</i> sp.
Pereira et al. (2022)	Nematoda	<i>Viscosia</i>	<i>Viscosia</i> sp.



Appendix 1.

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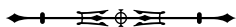
Study	Phylum	Genus	Species
Pereira et al. (2022)	Nematoda	<i>Weseria</i>	<i>Weseria</i> sp.
Aller and Aller (1986)	Annelida	<i>Chloeia</i>	<i>Chloeia viridis</i> Schmarada, 1861
Aller and Aller (1986)	Annelida	<i>Eunice</i>	<i>Eunice</i> sp.
Aller and Aller (1986)	Annelida	<i>Hesione</i>	<i>Hesione picta</i> Müller in Grube, 1858
Aller and Aller (1986)	Annelida	<i>Lumbrineris</i>	<i>Lumbrineris</i> sp.
Aller and Aller (1986)	Annelida	<i>Nephtys</i>	<i>Nephtys squamosa</i> Ehlers, 1887
Aller and Aller (1986)	Annelida	<i>Opioglycera</i>	<i>Opioglycera</i> sp.
Aller and Aller (1986)	Annelida	<i>Owenia</i>	<i>Owenia fusiformis</i> Delle Chiaje, 1844
Aller and Aller (1986)	Annelida	<i>Scoloplos</i>	<i>Scoloplos agrestis</i> Nonato & Luna, 1970
Aller and Aller (1986)	Annelida	Genus not identified 1	Species not identified 1
Aller and Aller (1986)	Annelida	Genus not identified 2	Species not identified 2
Aller and Aller (1986)	Annelida	Genus not identified 3	Species not identified 3
Aller and Aller (1986)	Annelida	Genus not identified 4	Species not identified 4
Aller and Aller (1986)	Annelida	Genus not identified 5	Species not identified 5
Aller and Aller (1986)	Annelida	Genus not identified 6	Species not identified 6
Aller and Aller (1986)	Annelida	Genus not identified 7	Species not identified 7
Aller and Aller (1986)	Annelida	Genus not identified 8	Species not identified 8
Aller and Aller (1986)	Annelida	Genus not identified 9	Species not identified 9
Aller and Aller (1986)	Annelida	<i>Typosyllis</i>	<i>Typosyllis</i> sp.
Aller and Aller (1986)	Annelida	<i>Vermiliopsis</i>	<i>Vermiliopsis</i> sp.
Cordeiro et al. (2020)	Annelida	<i>Bispira</i>	<i>Bispira</i> sp.
Nóbrega et al. (2021)	Annelida	Genus not identified 1	Species not identified 1
Nóbrega et al. (2021)	Annelida	Genus not identified 2	Species not identified 2
Nóbrega et al. (2021)	Annelida	Genus not identified 3	Species not identified 3
Jovane et al. (2024)	Annelida	<i>Eunice</i>	<i>Eunice</i> sp.
Aller and Aller (1986)	Mollusca	Genus not identified 1	Species not identified 1
Aller and Aller (1986)	Mollusca	Genus not identified 2	Species not identified 2
Aller and Aller (1986)	Mollusca	Genus not identified 3	Species not identified 3
Aller and Aller (1986)	Mollusca	Genus not identified 4	Species not identified 4
Aller and Aller (1986)	Mollusca	Genus not identified 5	Species not identified 5
Sales et al. (2019)	Mollusca	<i>Amphioctopus</i>	<i>Amphioctopus</i> sp.
Sales et al. (2019)	Mollusca	<i>Doryteuthis</i>	<i>Doryteuthis pealeii</i> (Lesueur, 1821)
Sales et al. (2019)	Mollusca	<i>Doryteuthis</i>	<i>Doryteuthis pleii</i> (Blainville, 1823)
Sales et al. (2019)	Mollusca	<i>Lepidoctopus</i>	<i>Lepidoctopus joaquini</i> Haimovici & Sales, 2019
Sales et al. (2019)	Mollusca	<i>Macrotritopus</i>	<i>Macrotritopus</i> sp.
Sales et al. (2019)	Mollusca	<i>Octopus</i>	<i>Octopus vulgaris</i> Cuvier, 1797
Sales et al. (2019)	Mollusca	<i>Scaergus</i>	<i>Scaergus unicirrhus</i> (Delle Chiaje, 1841)



Appendix 1.

(Continue)

Study	Phylum	Genus	Species
Nóbrega et al. (2021)	Mollusca	<i>Abra</i>	<i>Abra lioica</i> (Dall, 1881)
Nóbrega et al. (2021)	Mollusca	<i>Americardia</i>	<i>Americardia media</i> (Linnaeus, 1758)
Nóbrega et al. (2021)	Mollusca	<i>Americoliva</i>	<i>Americoliva circinata</i> (Marrat, 1871)
Nóbrega et al. (2021)	Mollusca	<i>Anachis</i>	<i>Anachis catenata</i> (G. B. Sowerby I, 1844)
Nóbrega et al. (2021)	Mollusca	<i>Arcinella</i>	<i>Arcinella brasilliana</i> (Nicol, 1953)
Nóbrega et al. (2021)	Mollusca	<i>Atrina</i>	<i>Atrina seminuda</i> (Lamarck, 1819)
Nóbrega et al. (2021)	Mollusca	<i>Aurantilaria</i>	<i>Aurantilaria aurantiaca</i> (Lamarck, 1816)
Nóbrega et al. (2021)	Mollusca	<i>Calliostoma</i>	Species not identified 1
Nóbrega et al. (2021)	Mollusca	<i>Calyptrea</i>	<i>Calyptrea centralis</i> (Conrad, 1841)
Nóbrega et al. (2021)	Mollusca	<i>Caryocorbula</i>	<i>Caryocorbula swiftiana</i> (C. B. Adams, 1852)
Nóbrega et al. (2021)	Mollusca	<i>Chicoreus</i>	<i>Chicoreus brevifrons</i> (Lamarck, 1822)
Nóbrega et al. (2021)	Mollusca	<i>Crepidula</i>	<i>Crepidula intratesta</i> Simone, 2006
Nóbrega et al. (2021)	Mollusca	<i>Dentalium</i>	Species not identified 1
Nóbrega et al. (2021)	Mollusca	<i>Distorsio</i>	<i>Distorsio clathrata</i> (Lamarck, 1816)
Nóbrega et al. (2021)	Mollusca	<i>Divalinga</i>	<i>Divalinga quadrisulcata</i> (A. d'Orbigny, 1846)
Nóbrega et al. (2021)	Mollusca	<i>Eurytellina</i>	<i>Eurytellina trinitatis</i> Tomlin, 1929
Nóbrega et al. (2021)	Mollusca	<i>Euvola</i>	<i>Euvola hazaliei</i> (Dautzenberg, 1900)
Nóbrega et al. (2021)	Mollusca	<i>Euvola</i>	<i>Euvola marensis</i> (Weisbord, 1964)
Nóbrega et al. (2021)	Mollusca	<i>Fusinus</i>	<i>Fusinus helenae</i> Bartsch, 1939
Nóbrega et al. (2021)	Mollusca	<i>Lirophora</i>	<i>Lirophora paphia</i> (Linnaeus, 1767)
Nóbrega et al. (2021)	Mollusca	<i>Marsupina</i>	<i>Marsupina bufo</i> (Bruguière, 1792)
Nóbrega et al. (2021)	Mollusca	<i>Modiolus</i>	<i>Modiolus americanus</i> Leach, 1815
Nóbrega et al. (2021)	Mollusca	<i>Monoplex</i>	<i>Monoplex parthenopeus</i> (Salis Marschlin, 1793)
Nóbrega et al. (2021)	Mollusca	<i>Musculus</i>	<i>Musculus lateralis</i> (Say, 1822)
Nóbrega et al. (2021)	Mollusca	<i>Natica</i>	<i>Natica marochiensis</i> (Gmelin, 1791)
Nóbrega et al. (2021)	Mollusca	<i>Octopus</i>	<i>Octopus insularis</i> Leite & Haimovici, 2008
Nóbrega et al. (2021)	Mollusca	<i>Phrontis</i>	<i>Phrontis alba</i> (Say, 1826)
Nóbrega et al. (2021)	Mollusca	<i>Phrontis</i>	<i>Phrontis vibex</i> (Say, 1822)
Nóbrega et al. (2021)	Mollusca	<i>Pinctada</i>	<i>Pinctada imbricata</i> Röding, 1798
Nóbrega et al. (2021)	Mollusca	<i>Pitar</i>	<i>Pitar albidus</i> (Gmelin, 1791)
Nóbrega et al. (2021)	Mollusca	<i>Plicatula</i>	<i>Plicatula gibbosa</i> Lamarck, 1801
Nóbrega et al. (2021)	Mollusca	<i>Prunum</i>	<i>Prunum storeria</i> (Couthouy, 1837)
Nóbrega et al. (2021)	Mollusca	<i>Pteria</i>	<i>Pteria colymbus</i> (Röding, 1798)
Nóbrega et al. (2021)	Mollusca	<i>Saccella</i>	<i>Saccella larranagai</i> (Klappenbach & Scarabino, 1969)
Nóbrega et al. (2021)	Mollusca	<i>Conus</i>	Species not identified 1
Nóbrega et al. (2021)	Mollusca	<i>Crassinella</i>	Species not identified 1
Nóbrega et al. (2021)	Mollusca	<i>Haliris</i>	Species not identified 1



Appendix 1.

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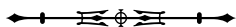
Study	Phylum	Genus	Species
Nóbrega et al. (2021)	Mollusca	<i>Olivella</i>	Species not identified 1
Nóbrega et al. (2021)	Mollusca	<i>Ostrea</i>	Species not identified 1
Nóbrega et al. (2021)	Mollusca	<i>Sicyonia</i>	<i>Sicyonia typica</i> (Boeck, 1864)
Nóbrega et al. (2021)	Mollusca	<i>Sinum</i>	<i>Sinum perspectivum</i> (Say, 1831)
Nóbrega et al. (2021)	Mollusca	<i>Solenocera</i>	<i>Solenocera atlantidis</i> Burkenroad, 1939
Nóbrega et al. (2021)	Mollusca	<i>Solenocera</i>	<i>Solenocera geijskesi</i> Holthuis, 1959
Nóbrega et al. (2021)	Mollusca	<i>Squilla</i>	<i>Squilla lijdingi</i> Holthuis, 1959
Nóbrega et al. (2021)	Mollusca	<i>Stigmaulax</i>	<i>Stigmaulax cayennensis</i> (Récluz, 1850)
Nóbrega et al. (2021)	Mollusca	<i>Stramonita</i>	<i>Stramonita brasiliensis</i> Claremont & D. Reid, 2011
Nóbrega et al. (2021)	Mollusca	<i>Strigilla</i>	<i>Strigilla carmaria</i> (Linnaeus, 1758)
Nóbrega et al. (2021)	Mollusca	<i>Terebra</i>	<i>Terebra taurina</i> ([Lightfoot], 1786)
Nóbrega et al. (2021)	Mollusca	<i>Tivela</i>	<i>Tivela fulminata</i> (Bory de Saint-Vincent, 1827)
Nóbrega et al. (2021)	Mollusca	<i>Tonna</i>	<i>Tonna galea</i> (Linnaeus, 1758)
Nóbrega et al. (2021)	Mollusca	<i>Turbinella</i>	<i>Turbinella laevigata</i> Anton, 1838
Jovane et al. (2024)	Mollusca	Genus not identified 1	Species not identified 1
Jovane et al. (2024)	Mollusca	Genus not identified 2	Species not identified 2
Jovane et al. (2024)	Mollusca	Genus not identified 3	Species not identified 3
Aller and Aller (1986)	Arthropoda	<i>Callianassa</i>	<i>Callianassa</i> sp.
Aller and Aller (1986)	Arthropoda	<i>Lepas</i>	<i>Lepas</i> sp.
Aller and Aller (1986)	Arthropoda	<i>Pagurus</i>	<i>Pagurus</i> sp.
Aller and Aller (1986)	Arthropoda	Genus not identified 1	Species not identified 1
Aller and Aller (1986)	Arthropoda	Genus not identified 2	Species not identified 2
Aller and Aller (1986)	Arthropoda	Genus not identified 3	Species not identified 3
Aller and Aller (1986)	Arthropoda	Genus not identified 4	Species not identified 4
Aller and Aller (1986)	Arthropoda	Genus not identified 5	Species not identified 5
Aller and Aller (1986)	Arthropoda	Genus not identified 6	Species not identified 6
Aller and Aller (1986)	Arthropoda	Genus not identified 7	Species not identified 7
Aller and Aller (1986)	Arthropoda	Genus not identified 8	Species not identified 8
Aller and Aller (1986)	Arthropoda	Genus not identified 9	Species not identified 9
Aller and Aller (1986)	Arthropoda	Genus not identified 10	Species not identified 10
Aller and Aller (1986)	Arthropoda	Genus not identified 11	Species not identified 11
Silva et al. (2003)	Arthropoda	<i>Acanthacaris</i>	<i>Turbinella laevigata</i> Anton, 1838
Silva et al. (2003)	Arthropoda	<i>Nephropsis</i>	<i>Nephropsis aculeata</i> Smith, 1881
Silva et al. (2003)	Arthropoda	<i>Nephropsis</i>	<i>Nephropsis rosea</i> Spence Bate, 1888
Silva et al. (2003)	Arthropoda	<i>Palinustus</i>	<i>Palinustus truncatus</i> A. Milne-Edwards, 1880
Silva et al. (2003)	Arthropoda	<i>Panulirus</i>	<i>Panulirus argus</i> (Latreille, 1804)
Silva et al. (2003)	Arthropoda	<i>Parribacus</i>	<i>Parribacus antarcticus</i> (Lund, 1793)



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Study	Phylum	Genus	Species
Silva et al. (2003)	Arthropoda	<i>Polycheles</i>	<i>Polycheles typhlops</i> Heller, 1862
Silva et al. (2003)	Arthropoda	<i>Scyllarides</i>	<i>Polycheles typhlops</i> Heller, 1862
Silva et al. (2003)	Arthropoda	<i>Stereomastis</i>	<i>Stereomastis</i> sp.
Porto et al. (2005)	Arthropoda	<i>Panulirus</i>	<i>Panulirus argus</i> (Latreille, 1804)
Porto et al. (2005)	Arthropoda	<i>Panulirus</i>	<i>Panulirus laevicauda</i> (Latreille, 1817)
Porto et al. (2005)	Arthropoda	<i>Scyllarides</i>	<i>Scyllarides delfosi</i> Holthuis, 1960
R. L. Moura et al. (2016)	Arthropoda	<i>Palinurus</i>	Species not identified 1
Francini-Filho et al. (2018)	Arthropoda	<i>Lysmata</i>	<i>Lysmata grabhami</i> (Gordon, 1935)
Nóbrega et al. (2021)	Arthropoda	<i>Acanthilia</i>	<i>Acanthilia intermedia</i> (Miers, 1886)
Nóbrega et al. (2021)	Arthropoda	<i>Achelous</i>	<i>Achelous gibbesii</i> (Stimpson, 1859)
Nóbrega et al. (2021)	Arthropoda	<i>Achelous</i>	<i>Achelous rufiremus</i> (Holthuis, 1959)
Nóbrega et al. (2021)	Arthropoda	<i>Achelous</i>	<i>Achelous spinicarpus</i> Stimpson, 1871
Nóbrega et al. (2021)	Arthropoda	<i>Agolambrus</i>	<i>Agolambrus agonus</i> (Stimpson, 1871)
Nóbrega et al. (2021)	Arthropoda	<i>Alpheus</i>	<i>Alpheus macrocheles</i> (Hailstone, 1835)
Nóbrega et al. (2021)	Arthropoda	<i>Alpheus</i>	Species not identified 1
Nóbrega et al. (2021)	Arthropoda	<i>Amboplax</i>	<i>Amboplax peresi</i> (Rodrigues da Costa, 1968)
Nóbrega et al. (2021)	Arthropoda	<i>Anasimus</i>	<i>Anasimus latus</i> Rathbun, 1894
Nóbrega et al. (2021)	Arthropoda	<i>Calappa</i>	<i>Calappa ocellata</i> Holthuis, 1958
Nóbrega et al. (2021)	Arthropoda	<i>Calappa</i>	<i>Calappa sulcata</i> Rathbun, 1898
Nóbrega et al. (2021)	Arthropoda	<i>Callinectes</i>	<i>Callinectes bocourti</i> A. Milne-Edwards, 1879
Nóbrega et al. (2021)	Arthropoda	<i>Callinectes</i>	<i>Callinectes ornatus</i> Ordway, 1863
Nóbrega et al. (2021)	Arthropoda	<i>Charybdis</i>	<i>Charybdis (Charybdis) hellerii</i> (A. Milne-Edwards, 1867)
Nóbrega et al. (2021)	Arthropoda	<i>Clibanarius</i>	<i>Clibanarius foresti</i> Holthuis, 1959
Nóbrega et al. (2021)	Arthropoda	<i>Collodes</i>	<i>Collodes inermis</i> A. Milne-Edwards, 1878
Nóbrega et al. (2021)	Arthropoda	<i>Cronius</i>	<i>Cronius ruber</i> (Lamarck, 1818)
Nóbrega et al. (2021)	Arthropoda	<i>Dardanus</i>	<i>Dardanus fucosus</i> Biffar & Provenzano, 1972
Nóbrega et al. (2021)	Arthropoda	<i>Dardanus</i>	<i>Dardanus venosus</i> (H. Milne Edwards, 1848)
Nóbrega et al. (2021)	Arthropoda	<i>Dromia</i>	<i>Dromia erythropus</i> (Edwards in Catesby & Edwards, 1771)
Nóbrega et al. (2021)	Arthropoda	<i>Ericerodes</i>	<i>Ericerodes gracilipes</i> (Stimpson, 1871)
Nóbrega et al. (2021)	Arthropoda	<i>Exhippolysmata</i>	<i>Exhippolysmata oplophoroides</i> (Holthuis, 1948)
Nóbrega et al. (2021)	Arthropoda	<i>Farfantepenaeus</i>	<i>Farfantepenaeus subtilis</i> (Pérez Farfante, 1967)
Nóbrega et al. (2021)	Arthropoda	<i>Hepatus</i>	<i>Hepatus gronovii</i> Holthuis, 1959
Nóbrega et al. (2021)	Arthropoda	<i>Hepatus</i>	<i>Hepatus pudibundus</i> (Herbst, 1785)
Nóbrega et al. (2021)	Arthropoda	<i>Hepatus</i>	<i>Hepatus scaber</i> Holthuis, 1959
Nóbrega et al. (2021)	Arthropoda	<i>Leiolambrus</i>	<i>Leiolambrus nitidus</i> Rathbun, 1901
Nóbrega et al. (2021)	Arthropoda	<i>Leptochela</i>	<i>Leptochela serratorbita</i> Spence Bate, 1888
Nóbrega et al. (2021)	Arthropoda	<i>Libinia</i>	<i>Libinia ferreirae</i> de Brito Capello, 1871



Appendix 1.

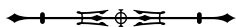
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Study	Phylum	Genus	Species
Nóbrega et al. (2021)	Arthropoda	<i>Litopenaeus</i>	<i>Litopenaeus schmitti</i> (Burkenroad, 1936)
Nóbrega et al. (2021)	Arthropoda	<i>Lysiosquilla</i>	<i>Lysiosquilla scabricauda</i> (Lamarck, 1818)
Nóbrega et al. (2021)	Arthropoda	<i>Menippe</i>	<i>Menippe nodifrons</i> Stimpson, 1859
Nóbrega et al. (2021)	Arthropoda	<i>Mithrax</i>	<i>Mithrax tortugae</i> Rathbun, 1920
Nóbrega et al. (2021)	Arthropoda	<i>Moreiradromia</i>	<i>Moreiradromia antillensis</i> (Stimpson, 1859)
Nóbrega et al. (2021)	Arthropoda	<i>Nematopalaemon</i>	<i>Nematopalaemon schmitti</i> (Holthuis, 1950)
Nóbrega et al. (2021)	Arthropoda	<i>Panopeus</i>	<i>Panopeus occidentalis</i> de Saussure, 1857
Nóbrega et al. (2021)	Arthropoda	<i>Parasquilla</i>	<i>Parasquilla meridionalis</i> Manning, 1961
Nóbrega et al. (2021)	Arthropoda	<i>Paulita</i>	<i>Paulita tuberculata</i> (Lemos de Castro, 1949)
Nóbrega et al. (2021)	Arthropoda	<i>Penaeus</i>	Species not identified 1
Nóbrega et al. (2021)	Arthropoda	<i>Persephona</i>	<i>Persephona lichtensteinii</i> Leach, 1817
Nóbrega et al. (2021)	Arthropoda	<i>Persephona</i>	<i>Persephona mediterranea</i> (Herbst, 1794)
Nóbrega et al. (2021)	Arthropoda	<i>Persephona</i>	<i>Persephona punctata</i> (Linnaeus, 1758)
Nóbrega et al. (2021)	Arthropoda	<i>Petrochirus</i>	<i>Petrochirus diogenes</i> (Linnaeus, 1758)
Nóbrega et al. (2021)	Arthropoda	<i>Pilumnus</i>	<i>Pilumnus diomedea</i> Rathbun, 1894
Nóbrega et al. (2021)	Arthropoda	<i>Platylambrus</i>	<i>Platylambrus serratus</i> (H. Milne Edwards, 1834)
Nóbrega et al. (2021)	Arthropoda	<i>Plesionika</i>	<i>Plesionika ensis</i> (A. Milne-Edwards, 1881)
Nóbrega et al. (2021)	Arthropoda	<i>Porcellana</i>	<i>Porcellana sayana</i> (Leach, 1821)
Nóbrega et al. (2021)	Arthropoda	<i>Rimapenaeus</i>	<i>Rimapenaeus similis</i> (Smith, 1885)
Nóbrega et al. (2021)	Arthropoda	Genus not identified 1	Species not identified 1
Nóbrega et al. (2021)	Arthropoda	Genus not identified 2	Species not identified 2
Nóbrega et al. (2021)	Arthropoda	Genus not identified 3	Species not identified 3
Nóbrega et al. (2021)	Arthropoda	<i>Sicyonia</i>	<i>Sicyonia burkenroadi</i> Cobb, 1971
Nóbrega et al. (2021)	Arthropoda	<i>Sicyonia</i>	<i>Sicyonia dorsalis</i> Kingsley, 1878
Nóbrega et al. (2021)	Arthropoda	<i>Sicyonia</i>	<i>Sicyonia stimpsoni</i> Bouvier, 1905
Nóbrega et al. (2021)	Arthropoda	<i>Stenocionops</i>	<i>Stenocionops furcatus</i> (Olivier, 1791)
Nóbrega et al. (2021)	Arthropoda	<i>Stenorhynchus</i>	<i>Stenorhynchus seticornis</i> (Herbst, 1788)
Nóbrega et al. (2021)	Arthropoda	<i>Xiphopenaeus</i>	<i>Xiphopenaeus kroyeri</i> (Heller, 1862)
Jovane et al. (2024)	Arthropoda	Genus not identified 1	Species not identified 1
Jovane et al. (2024)	Arthropoda	Genus not identified 2	Species not identified 2
Jovane et al. (2024)	Arthropoda	Genus not identified 3	Species not identified 3
Jovane et al. (2024)	Arthropoda	Genus not identified 4	Species not identified 4
Jovane et al. (2024)	Arthropoda	Genus not identified 5	Species not identified 5
Jovane et al. (2024)	Arthropoda	Genus not identified 6	Species not identified 6
Jovane et al. (2024)	Arthropoda	Genus not identified 7	Species not identified 7
Aller and Aller (1986)	Echinodermata	Genus not identified 1	Species not identified 1
R. L. Moura et al. (2016)	Echinodermata	<i>Ophiothela</i>	<i>Ophiothela mirabilis</i> (Verrill, 1867)



Appendix 1. (Conclusion)

Study	Phylum	Genus	Species
Francini-Filho et al. (2018)	Echinodermata	Genus not identified 1	Species not identified 1
Nóbrega et al. (2021)	Echinodermata	Genus not identified 2	Species not identified 1
Jovane et al. (2024)	Echinodermata	<i>Coronaster</i>	<i>Coronaster</i> sp.
Jovane et al. (2024)	Echinodermata	<i>Nymphaster</i>	<i>Nymphaster</i> sp.
Jovane et al. (2024)	Echinodermata	Genus not identified 1	Species not identified 1
Jovane et al. (2024)	Echinodermata	Genus not identified 2	Species not identified 2
Jovane et al. (2024)	Echinodermata	Genus not identified 3	Species not identified 3
Aller and Aller (1986)	Chordata	Genus not identified 1	Species not identified 1
Jovane et al. (2024)	Chordata	<i>Ariosoma</i>	<i>Ariosoma</i> sp.
Jovane et al. (2024)	Chordata	<i>Chaunax</i>	<i>Chaunax</i> sp.
Jovane et al. (2024)	Chordata	<i>Saurida</i>	<i>Saurida</i> sp.
Jovane et al. (2024)	Chordata	<i>Antigonia</i>	<i>Antigonia</i> sp.
Jovane et al. (2024)	Chordata	<i>Coelorinchus</i>	<i>Coelorinchus</i> sp.
Jovane et al. (2024)	Chordata	<i>Lutjanus</i>	<i>Lutjanus</i> sp.
Jovane et al. (2024)	Chordata	<i>Symphurus</i>	<i>Symphurus</i> sp.
Jovane et al. (2024)	Chordata	Genus not identified 1	Species not identified 1
Jovane et al. (2024)	Chordata	Genus not identified 2	Species not identified 2
Jovane et al. (2024)	Chordata	Genus not identified 3	Species not identified 3
Jovane et al. (2024)	Chordata	Genus not identified 4	Species not identified 4



From roots to burrows: how *Spartina alterniflora* (Poaceae) structure modulates brachyuran diversity in Amazonian saltmarshes

Das raízes às tocas: como a estrutura de *Spartina alterniflora* (Poaceae) modula a diversidade de Brachyura em marismas amazônicas

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Abstract: Saltmarshes dominated by *Spartina alterniflora* are highly productive coastal ecosystems that play key roles in sediment stabilization, organic matter accumulation, and the maintenance of benthic communities. While the ecological influence of *S. alterniflora* on macrofauna is well documented in temperate and subtropical regions, however, few studies about these interactions in the Amazon coast are reported. Based on that, this study evaluated the effects of *S. alterniflora* vegetation structure on the abundance, richness, and composition of Brachyuran crabs in saltmarshes at Maçarico Beach, Salinópolis, Pará, Northern Brazil. Fieldwork was conducted in June 2019 comparing two transects with contrasting vegetation zones. Vegetation attributes (above- and belowground biomass, height, organic matter content) and crab assemblage metrics (abundance, species richness, burrow density) were analyzed using ANOVA, PERMANOVA, and multivariate ordinations. Structurally complex areas with taller stems, higher root biomass, and greater organic matter content supported significantly higher crab abundance, richness, and burrow density. Community composition also varied between zones, with *Uca maracoani* and *Minuca* sp. dominating vegetated areas, while *Callinectes bocourti* was associated with less vegetated zones. These findings indicate that crab distribution in Amazonian saltmarshes is strongly associated with vegetation complexity, underscoring the ecological relevance of conserving *S. alterniflora* habitats under increasing coastal pressures.

Keywords: Wetlands. Decapoda. Macroinvertebrates. Amazon coast. Benthic ecology.

Resumo: Marismas dominadas por *Spartina alterniflora* são ecossistemas costeiros altamente produtivos que desempenham papéis fundamentais na estabilização de sedimentos, acúmulo de matéria orgânica e manutenção de comunidades bentônicas. Embora a influência ecológica de *S. alterniflora* sobre a macrofauna seja bem documentada em regiões temperadas e subtropicais, poucos estudos sobre essas interações são reportados na costa amazônica. Nesse contexto, este estudo avaliou os efeitos da estrutura da vegetação de *S. alterniflora* sobre a abundância, a riqueza e a composição de caranguejos braquiúros em marismas da praia do Maçarico, em Salinópolis, Pará, Norte do Brasil. O trabalho de campo foi realizado em junho de 2019, comparando dois transectos com zonas de vegetação contrastantes. Atributos da vegetação (biomassa aérea e subterrânea, altura e teor de matéria orgânica) e métricas da assembleia de caranguejos (abundância, riqueza de espécies e densidade de tocas) foram analisados por meio de ANOVA, PERMANOVA e ordenações multivariadas. Áreas estruturalmente mais complexas, com maior altura de caules, maior biomassa radicular e maior teor de matéria orgânica, apresentaram valores significativamente mais elevados de abundância, riqueza e densidade de tocas. A composição da comunidade também variou entre as zonas, com *Uca maracoani* e *Minuca* sp. dominando áreas vegetadas, enquanto *Callinectes bocourti* esteve associado a zonas menos vegetadas. Esses resultados indicam que a distribuição de caranguejos em marismas amazônicas está fortemente associada à complexidade da vegetação, destacando a relevância ecológica da conservação de habitats de *S. alterniflora* diante do aumento das pressões costeiras.

Palavras-chave: Planícies alagadas. Decapoda. Macroinvertebrados. Costa amazônica. Ecologia bentônica.

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INTRODUCTION

In tropical and subtropical estuaries, saltmarshes often occur in association with mangroves, typically occupying intertidal flats with low hydrodynamic energy (Braga et al., 2011). These environments form structurally complex habitats that sustain diverse faunal communities (Davy & Costa, 1992; Schaeffer-Novelli et al., 2023). The cordgrass *Spartina alterniflora* Loiseleur, 1807 is a pioneer species commonly established at the seaward edge of several Brazilian estuaries (Braga et al., 2009, 2011). Its extensive belowground root system enhances sediment retention and promotes organic matter accumulation, thereby modifying the physical and chemical properties of marsh substrates (Flynn et al., 1996; Netto & Lana, 1997). Such structural attributes are not only essential for the physical stability of the marsh but also exert profound ecological influences on associated macrofaunal assemblages (Lana & Guiss, 1992). Vegetation complexity shapes faunal spatial distribution by creating microhabitats, increasing habitat heterogeneity, and providing both food resources and refuge from predators (Whitcraft & Levin, 2007; Ferreira-Ramos et al., 2026).

Numerous studies have shown that vegetation characteristics (e.g. biomass, height, and root structure) are positively correlated with benthic macrofauna abundance and diversity (Rader, 1984; Lana & Guiss, 1992; Reis et al., 2019; Santos et al., 2025). In particular, the belowground biomass of *S. alterniflora* promotes the formation of burrows and shelters for crustaceans, while the accumulation of detritus from decomposing plant matter serves as a food source for deposit feeders and omnivores (Lillebø et al., 1999; Silliman & Bortholus, 2003). The result is a suite of direct and indirect interactions that link plant traits to faunal community composition and ecosystem functioning (Schaeffer-Novelli et al., 2023).

Crustaceans, particularly Brachyura, are key components of saltmarsh ecosystems (Bertness, 1985; Schaeffer-Novelli et al., 2023). Species from genera such as *Uca* Latreille, 1804, *Minuca* Bott, 1954, *Leptuca*

Bott, 1973, and *Panopeus* H. Milne Edwards, 1834 are commonly associated with marsh environments worldwide (Bertness, 1985; Schaeffer-Novelli et al., 2023). These crabs are important bioturbators and often act as ecosystem engineers by modifying sediment properties, influencing vegetation growth, and contributing to nutrient cycling (Bortolus & Iribarne, 1999; Posey et al., 2003). In North America and Europe, the relationship between brachyuran crabs and *Spartina* vegetation is well established. Studies have shown that fiddler crabs (e.g. *Minuca pugnax* Smith, 1870 and *Minuca rapax* Smith, 1870) enhance plant productivity through their burrowing activity, which increases oxygenation and nitrogen availability in sediments (Szura et al., 2017).

Although saltmarsh fauna is well documented in the Northern Hemisphere (Santos et al., 2020) and along the southern and southeastern Brazilian coast (e.g. Lana & Guiss, 1991, 1992; Netto & Lana, 1996, 1997, 1999; Pagliosa & Lana, 2005), studies on Amazonian saltmarshes remain scarce. Research conducted in this region (Braga et al., 2009, 2011, 2013, 2024; Santos et al., 2020, 2025) has revealed important faunal differences across *Spartina alterniflora* vegetation gradients, but investigations specifically addressing brachyuran crabs and their functional roles are still limited. Consequently, the relationships between vegetation structure and crab assemblages in Amazonian saltmarshes remain poorly understood.

Therefore, this study evaluates how variation in the structural attributes of *S. alterniflora* (above- and belowground biomass, stem height, and organic matter content) shapes the abundance, richness, and composition of brachyuran crabs in Amazonian saltmarshes by comparing two intertidal zones with contrasting vegetation density and complexity. We hypothesize that areas with higher vegetation complexity (denser stands, taller stems, and greater root biomass) support greater crab abundance, species richness, and burrow density, and that community composition differs between areas according to vegetation structure.



within a 0.25 m² quadrat, stored in double plastic bags and fixed in 70% ethanol.

Additionally, Burrow counts were conducted within each 0.25 m² quadrat using a standardized search effort of five minutes per station. Counts were performed by two trained observers to minimize detection bias and ensure consistency across sampling points. All sampling occurred during spring low tide and under calm weather conditions, ensuring that burrows were fully exposed and detectability was maximized. Only burrows showing clear structural integrity (= recently maintained) were recorded to avoid including collapsed or inactive structures.

Because no direct capture–recapture validation or correlation between burrow counts and actual crab abundance was performed during fieldwork, burrow density is used here strictly as a proxy for crab activity and site occupancy, as commonly adopted in saltmarsh and mangrove studies.

Using a similar sampling design, a single plot (0.25 m²) was randomly selected from each sampling station for the sampling of vegetation. Mean vegetation height (cm) was obtained by measuring all stems, and vegetation density was obtained by counting the number of saltmarsh stems inside each plot (Braga et al., 2011). The area in each plot was dug to a depth of 20 cm and all plant material, aboveground biomass (stems and leaves) and belowground biomass (roots and rhizomes), were removed to estimate vegetation H₂O content and organic matter (OM) (Santos et al., 2025). These samples were kept cool in the field and later frozen in the laboratory to prevent decomposition and loss of biomass until final processing in the laboratory (Santos et al., 2025).

Field activities were carried out under authorization from the Brazilian Ministry of the Environment through the Sistema de Autorização e Informação em Biodiversidade (SISBIO) (permit no. 58198-1). All sampling procedures complied with Brazilian environmental legislation and followed the guidelines established by Normative Instruction n°. 003/2014 (SEMAS-PA, 2014).

LABORATORY ANALYSIS

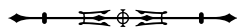
The biological samples were examined using a stereoscopic microscope, and the Brachyuran crabs were counted and identified to the lowest possible taxonomic level using the Identification Manual of the Brachyura (Crabs and Swimming Crabs) from the Brazilian Coast by Melo (1996) and literature review on the taxonomic classification of the group by Lima and Martinelli-Lemos (2019).

For vegetation, the aerial parts (stem, leaves, flowers, shoots) and underground parts (roots) were separated to determine the OM and H₂O contents. Saltmarsh H₂O content was estimated as water loss after drying the vegetation at 60 °C until constant weight. The saltmarsh OM content was estimated by burning 2 g of dry vegetation at 500 °C for 4 h (Braga et al., 2011).

DATA ANALYSIS

The Relative Abundance (RA) (the number of individuals of the species divided by the total number of individuals captured), density (ind/m²), and the Frequency of Occurrence (FO) (the number of samples containing the species divided by the total number of samples) were calculated for each crab species. Crab species richness was expressed as the total number of species present in a given sample. In order to test the assumption of normality and the homoscedasticity of variance, the Shapiro–Wilk and Cochran's tests were applied, respectively. Whenever required, the values were fourth-root transformed. Differences in the crab richness and density and vegetation (area, H₂O content, OM, density, and height) were evaluated using a one-factor Analysis of Variance (ANOVA) where F represents the F-statistic and p the probability value. ANOVA was also applied to test for differences between the species densities and crab burrows between the intertidal areas.

To evaluate the effects of saltmarshes on Brachyuran crabs and validate our a priori clustering (upper and lower intertidal areas), a one-way Permutational ANOVA (PERMANOVA) based on Bray–Curtis dissimilarities of fourth root transformed abundance data, with 9,999 permutations



designed with the same layout as the ANOVA. The P-values were adjusted using Monte Carlo random draws from the asymptotic permutation distribution, as the number of possible unique permutations was insufficient to generate a fully exhaustive permutation test (Anderson & Robinson, 2003). Ordination of community patterns was performed using Principal Coordinate Analysis (PCO). To identify the species that characterized each intertidal area, species that were correlated (Spearman's coefficient) with one of the first two axes by more than 60% were plotted in each PCO. This threshold follows standard practices in multivariate ecological analyses (Clarke & Gorley, 2015), as it highlights species with meaningful contributions to the ordination structure while avoiding excessive graphical clutter. The contribution of each taxon to the similarity and dissimilarity found among the groups was assessed using the similarity percentage (SIMPER) routine. The relationships between biological (crab species richness, density and burrow density) and vegetation parameters (biomass, height, OM) were evaluated using Spearman's rank correlation coefficient.

RESULTS

VEGETATION STRUCTURE

Marsh density showed no significant differences between areas (Table 1). In general, the vegetation structure varied significantly between the Upper and Lower transects (Table 1). Mean aboveground dry biomass was significantly higher (ANOVA: $F = 4.31$; $p = 0.02$) in the Upper transect ($547.3 \pm 62.1 \text{ g/m}^2$) than in the Lower ($289.6 \pm 41.5 \text{ g/m}^2$), and the same pattern was observed for belowground biomass ($673.8 \pm 78.4 \text{ g/m}^2$ versus $382.7 \pm 56.2 \text{ g/m}^2$; ANOVA: $F = 11.27$; $p = 0.03$).

Stem height was significantly higher in the Upper area than in the Lower. Conversely, root length was greater in the Lower area compared to the Upper (Table 1). Overall, the H₂O content was consistently higher in the Lower area, both in stems and roots. In contrast, stem organic matter content was higher in the Upper area than in the Lower, while root organic matter did not differ significantly between areas (Table 1).

Table 1. Vegetation structural parameters (mean \pm SD) of *Spartina alterniflora* in the saltmarsh intertidal areas (Upper and Lower) at Maçarico beach (Pará, northern Brazil). Results of one-way ANOVA are shown; significant differences ($p < 0.05$) are indicated with an asterisk.

Factors	Area	Mean (\pm SD)	Upper x Lower	
			F	p
Stem height (cm)	Upper	43.51 \pm 1.09	14.85	0.00*
	Lower	35.55 \pm 1.14		
Root size (cm)	Upper	21.91 \pm 1.2	6.78	0.01*
	Lower	27.32 \pm 1.17		
Marsh density (ind/m ²)	Upper	4.88 \pm 1.38	0.38	0.55
	Lower	4.44 \pm 1.36		
Stem H ₂ O content	Upper	22 \pm 1.34	16.42	0.00*
	Lower	40.37 \pm 1.31		
Root H ₂ O content	Upper	26.41 \pm 1.68	4.85	0.04*
	Lower	39.2 \pm 1.3		
Stem OM	Upper	0.47 \pm 0.05	6.09	0.02*
	Lower	0.50 \pm 0.13		
Root OM	Upper	0.83 \pm 0.18	0.86	0.63
	Lower	0.8 \pm 0.17		



CRAB ASSEMBLAGES: COMPOSITION AND SPATIAL DISTRIBUTION

In general, burrow density was significantly higher in the Upper area (mean 36.3 ± 5.1 burrows/m²) than in the Lower area (22.1 ± 4.8 burrows/m²). Similarly, higher crab density and richness were found in the Upper area (Figure 2).

A total 519 crab specimens were collected during this study (Table 2), corresponding to six species and distributed into three families: Ocypodidae (three species), Grapsidae (two species) and Panopeidae (one species). Among the species, *Uca maracoani* (Latreille, 1802) was the most abundant and frequent species overall (RA = 35.26%; FO = 100%), followed by *Minuca* sp. (RA = 29.47%; FO = 72%) and *Leptuca cumulanta* (Crane, 1943) (RA = 27.93%; FO = 65%). All the other species had low abundances and were infrequently recorded on the saltmarsh.

Overall, significant differences in the density were found between the areas for *U. maracoani* ($F_{(1,17)} = 129.73$; $p < 0.05$), *Minuca* sp. ($F_{(1,17)} = 71.32$; $p < 0.05$) and *Acantholobulus bermudensis* (Benedict & Rathbun, 1891) ($F_{(1,17)} = 4.00$, $p < 0.05$) with higher density was found in the Upper area, and for *Callinectes bocourtes* (A. Milne-Edwards, 1879) ($F_{(1,17)} = 12.46$, $P < 0.05$) with higher density was found in the Lower area (Figure 2). Although no significant differences in the density of *L. cumulanta* ($F_{(1,17)} = 1.60$; $P > 0.05$) and *Pachygrapsus gracilis* (Saussure, 1857) ($F_{(1,17)} = 2.43$; $P > 0.05$), higher values were found in the Upper area for *L. cumulanta* and for *P. gracilis* in the Lower area (Figure 3).

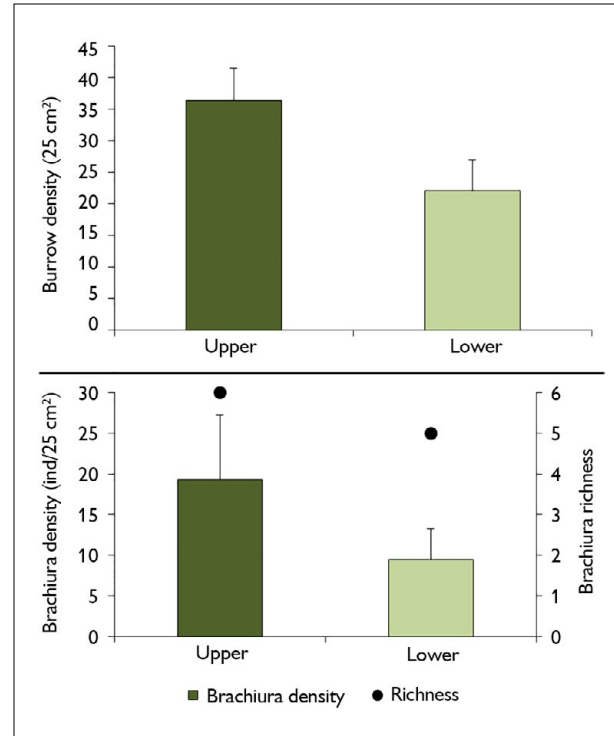


Figure 2. Burrow density (A), mean (\pm SD) density and richness (B) of brachyuran crab across the upper and lower intertidal areas in the Amazonian saltmarshes.

The PCO plot clearly distinguished the Brachyura samples between the study areas (Figure 4). Axis 1 explained 68.3% of the variation in the data and was responsible for separating the areas. On the positive side of this axis, crab species such as *U. maracoani*, *Minuca* sp., *P. gracilis*, and *A. bermudensis* were best correlated with the Upper area, while *L. cumulanta* and *C. bocourti* were associated with the Lower transect (Figure 4).

Table 2. Mean abundance (\pm SD) of crab species in the upper and lower intertidal zones of the Amazonian salt marshes.

Species	Upper	Lower
<i>Uca maracoani</i>	16.11 \pm 1.17	7.33 \pm 1.66
<i>Leptuca cumulanta</i>	7.33 \pm 1.66	8.77 \pm 1.2
<i>Minuca</i> sp.	12.88 \pm 1.23	4.11 \pm 1.57
<i>Pachygrapsus gracilis</i> (Saussure, 1858)	1.88 \pm 1.87	0.77 \pm 1.32
<i>Callinectes bocourti</i> A. Milne-Edwards, 1879	0.11 \pm 1	1.11 \pm 1.44
<i>Acantholobulus bermudensis</i> (Benedict & Rathbun, 1891)	0.33 \pm 1	0

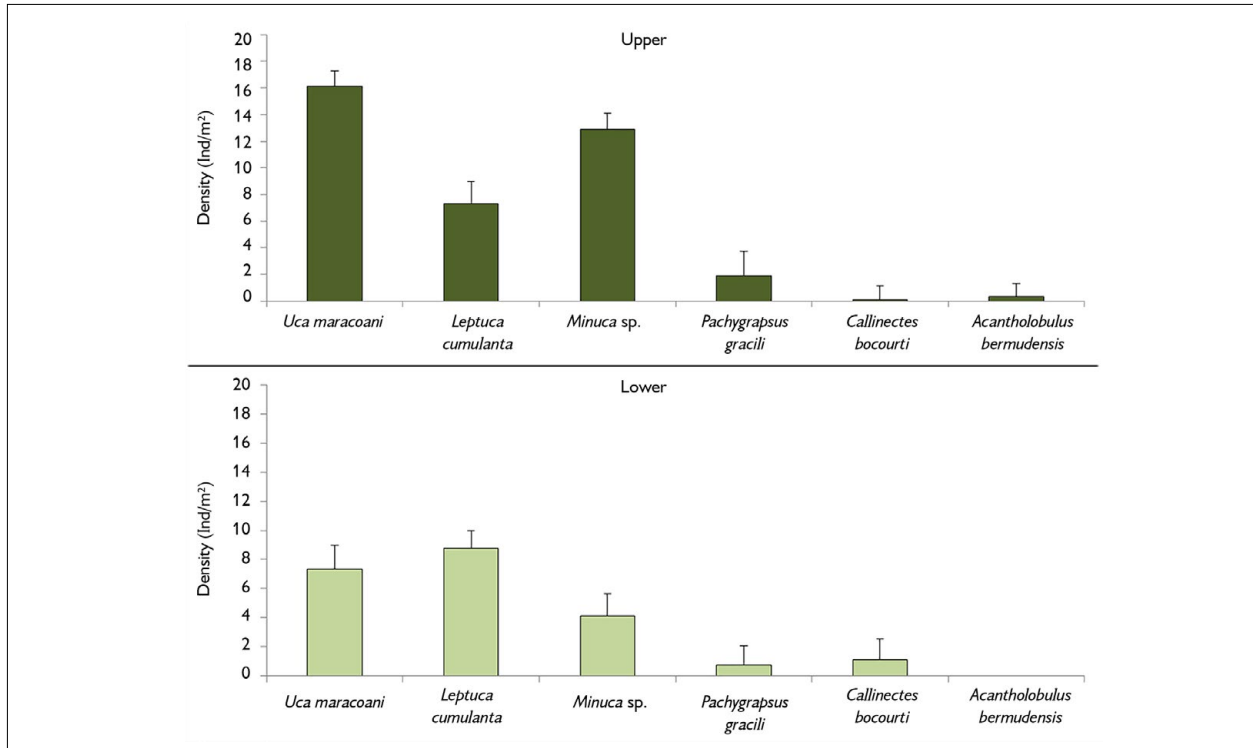


Figure 3. Density (ind/25 cm²) of the most abundant crab species across Upper and Lower intertidal areas at Maçarico beach (Pará, northern Brazil).

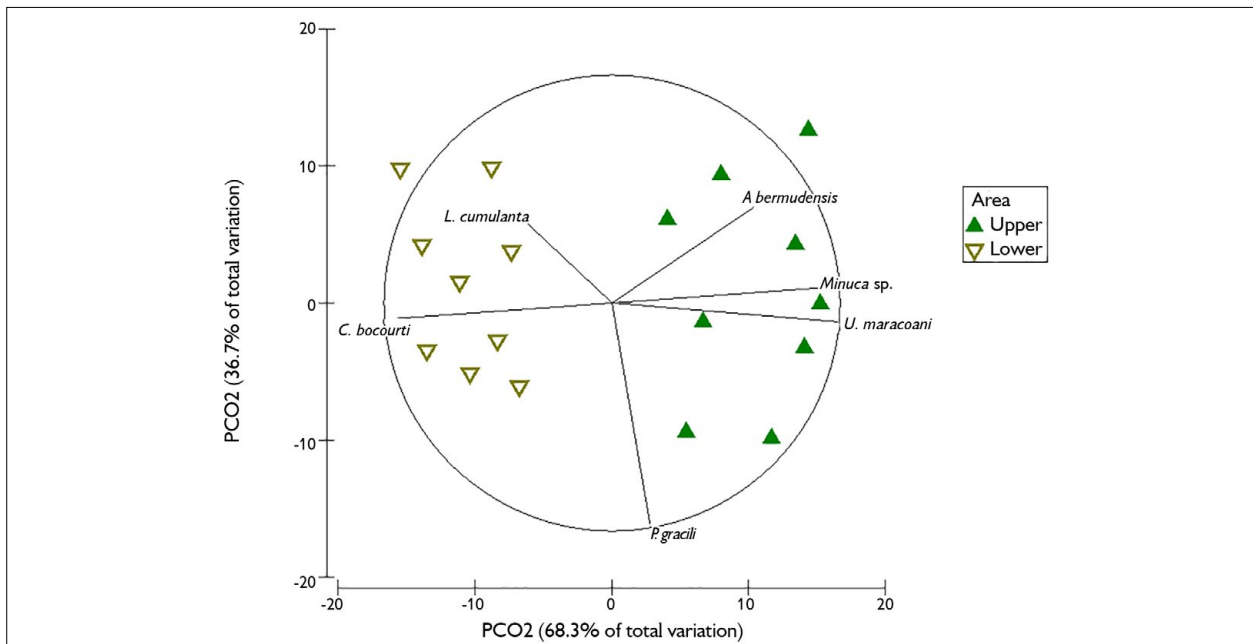


Figure 4. Principal Coordinates Analysis (PCO) of brachyuran assemblages in Upper and Lower intertidal areas based on Bray-Curtis similarity of square-root transformed data.

PERMANOVA results showed significant differences in spatial between study areas ($pseudo-F = 3.76$; $p_{(perm)} = 0.01$; $p_{(Monte Carlo)} = 0.001$). SIMPER analysis indicated a mean dissimilarity of 94.36% between areas, with *C. bocourti* and *A. bermudensis* being the main contributors to this dissimilarity. Within each area, similarity was largely explained by the dominance of *U. maracoani*, *Minuca* sp., *A. bermudensis* and *P. gracilis* in the Upper area (90.95% cumulative contribution), and by *C. bocourti* and *L. cumulanta* in the Lower area (92.5%).

BIO-ENV analysis indicated that the root length, above- and belowground biomass, and organic matter content were the best match with the structure of the brachyuran community ($r = 0.586$; $p < 0.05$). Linear regression analyses revealed significant positive correlations between crab abundance and several vegetation parameters, particularly belowground biomass ($R^2 = 0.68$, $p < 0.01$), aboveground organic matter ($R^2 = 0.62$, $p < 0.05$), and stem height ($R^2 = 0.55$, $p < 0.05$). Burrow density was also strongly correlated with

root biomass ($R^2 = 0.73$, $p < 0.01$). Species-specific analyses further indicated that *C. bocourti*, *P. gracilis*, *A. bermudensis*, *L. cumulanta*, *U. maracoani*, and *Minuca* sp. all exhibited significant relationships with vegetation variables such as stem height and aboveground organic matter content (Table 3).

DISCUSSION

The results of this study demonstrate that the structural attributes of *Spartina alterniflora* vegetation exert a strong influence on the abundance, richness, and spatial distribution of brachyuran assemblages in Amazonian saltmarshes. Structurally complex areas, characterized by taller stems, greater above- and belowground biomass, and higher organic matter content, supported more abundant and diverse crab communities, as well as higher burrow density. These findings reinforce the role of vegetation complexity as a primary ecological filter in intertidal systems, shaping faunal communities through modifications of sediment stability, hydrodynamics, and microhabitat availability.

Table 3. Pearson correlation coefficients (r values) for linear regression between marsh variables and crab species between the intertidal areas (upper and Lower) (X = absence of specimen; * $p < 0.05$).

Plant variable	Area	<i>Uca maracoani</i>	<i>Leptuca cumulanta</i>	<i>Minuca</i> sp.	<i>Pachygrapsus gracilis</i>	<i>Callinectes bocourti</i>	<i>Acantholobulus bermudensis</i>
Stem length	Upper	-0.1107	-0.0195*	-0.0351*	-0.1414	0.0636	-0.1427
	Lower	0.1342	0.0519	0.3523	-0.0105*	0.0445*	X
Root length	Upper	-0.1411	0.0027*	0.2326	-0.1396	-0.1342	0.0513
	Lower	0.1647	0.0083*	0.2543	0.1532	0.0680	X
Marsh density	Upper	-0.1260	-0.1132	0.0290*	0.1431	0.0767	-0.1307
	Lower	0.1753	-0.0568	0.0594	0.2061	-0.0487*	X
Stem H ₂ O content	Upper	-0.0975	-0.1420	0.0664	-0.0737	-0.1379	-0.0944
	Lower	-0.0434*	0.4958	0.0739	0.0983	0.3240	X
Root H ₂ O content	Upper	0.3095	-0.1002	-0.1184	-0.1199	0.5502	0.1355
	Lower	0.3142	0.3368	0.0804	-0.1356	-0.0671	X
Stem OM	Upper	0.0350*	-0.1426	0.0290*	-0.0979	0.0148*	-0.1034
	Lower	-0.1257	-0.1396	0.0729	0.1848	0.1478	X
Root OM	Upper	-0.1023	0.1016	0.1752	-0.0136*	0.1627	-0.1405
	Lower	0.4143	-0.1375	0.1353	0.1687	0.0221*	X



Amazonian coastal environments are highly dynamic due to macrotidal regimes, strong hydrodynamic forcing, and intense seasonal freshwater inputs (Dittmar & Lara, 2001; Souza-Filho et al., 2009; Santos et al., 2026). As a result, saltmarshes along this coastline are subjected to marked variability in environmental drivers such as sediment moisture, organic matter accumulation, inundation frequency, and oxygen penetration into porewaters (Levin & Talley, 2000). These abiotic factors play a major role in shaping benthic invertebrate communities, modulating habitat suitability for both burrowing and mobile crab species.

In the present study, the environmental contrasts between the Upper and Lower intertidal zones reflect the influence of key abiotic gradients that characterize Amazonian macrotidal systems (Dittmar & Lara, 2001; Souza-Filho et al., 2009). The Lower zone, positioned near the tidal edge, exhibited higher stem and root water content, indicating prolonged inundation and reduced sediment drainage, conditions typical of more exposed environments that result in softer and more saturated substrates (Levin & Talley, 2000). In contrast, the Upper zone, subjected to shorter inundation periods, displayed greater above- and belowground biomass, taller stems, and higher aboveground organic matter content, characteristics consistent with more stable and better-drained sediments that favor detritus retention and accumulation (Braga et al., 2009, 2011, 2013, 2024).

Although vegetation density did not differ significantly between zones, the higher organic matter content in stems and the greater biomass recorded in the Upper zone suggest that differences in sediment stability and hydrodynamic energy, rather than density alone, drive the spatial distribution of organic matter. This interpretation aligns with the well-established influence of hydrodynamic conditions on the deposition and retention of fine sediments and detrital material in saltmarsh systems (Adam, 1990; Davy & Costa, 1992). In more energetic areas, such as the Lower zone, stronger currents

and wave action likely limit long-term organic matter accumulation despite the presence of *Spartina* (Santos et al., 2020). Conversely, the relatively sheltered conditions of the Upper zone favor detritus deposition, a pattern similarly documented in other Amazonian estuarine environments (Braga et al., 2011; Santos et al., 2025).

Overall, these findings indicate that the environmental heterogeneity observed between Upper and Lower intertidal marshes at Maçarico is shaped principally by hydrodynamic exposure, inundation regime, and sediment moisture, factors that in turn influence vegetation structure and the spatial distribution of brachyuran crabs. As reported for other regions, saltmarshes act as plastic coastal features whose sediment and vegetation characteristics are tightly linked to local hydrodynamics (Isacch et al., 2006; Braga et al., 2011, 2013). In our system, these abiotic gradients mediate habitat suitability and contribute directly to the observed patterns of species distribution, abundance, and burrow density.

The crab assemblage recorded included representatives of Ocypodidae (*U. maracoani*, *Minuca* sp., *L. cumulanta*), Grapsidae (*P. gracilis*), Panopeidae (*A. bermudensis*), and Portunidae (*C. bocourti*). This composition is common in Brazilian saltmarshes (Checon et al., 2023) and this taxonomic diversity illustrates the functional mosaic of Amazonian saltmarshes. Ocypodids dominated the community, as expected, since they are recognized as ecosystem engineers whose burrowing activity directly affects sediment structure and nutrient cycling (Bertness, 1985; Bortolus & Iribarne, 1999). The predominance of *U. maracoani*, a large-bodied fiddler crab, has also been reported in other regional studies (Braga et al., 2009, 2011; Santos et al., 2020), and is related to its strong burrowing capacity and tolerance to tidal inundation (Szura et al., 2017). Their dominance in vegetated areas suggests positive feedback between vegetation and crab activity: denser *Spartina* stands provide food and shelter, while crab burrows improve sediment conditions and organic matter turnover,

ultimately favoring plant productivity (Bertness, 1991; Raposa et al., 2018).

Smaller-bodied fiddler crabs species such as *Minuca* sp. and *L. cumulanta* also reached high abundances, reflecting their ecological plasticity and ability to exploit both vegetated and more exposed intertidal zones (Iribarne et al., 1997). Similar patterns have been observed in subtropical saltmarshes of southern Brazil (Bonnet et al., 1994; Netto & Lana, 1997) and in South Atlantic marshes (Iribarne et al., 1997). Less abundant species, including *A. bermudensis* and *P. gracilis*, add to the functional heterogeneity of saltmarsh assemblages, with the former associated with fine, organic-rich sediments and the latter showing generalist habits and mobility across substrates (Melo, 1996). The presence of *C. bocourti* in higher densities in the lower area is particularly relevant, as portunid crabs are usually associated with sandy/muddy or open substrates (Wolff et al., 2000). Their occurrence in saltmarshes suggests the use of these habitats as feeding or nursery grounds, as also reported in Amazonian estuaries (Braga et al., 2009).

Patterns of species distribution across areas provide evidence of niche partitioning mediated by vegetation structure. While *U. maracoani* and *Minuca* sp. were more abundant in densely vegetated zones (upper area), *C. bocourti* and *P. gracilis* showed a stronger association with less vegetated areas (lower area). Such spatial segregation is consistent with global studies reflecting the ability of vegetation to regulate crab assemblages by altering food availability, predation risk, and sediment properties (Bertness, 1985; Whitcraft & Levin, 2007).

The positive relationship observed between belowground biomass and burrow density confirms the central role of root systems in modifying sediment properties and providing suitable microhabitats for burrowing (Levin & Talley, 2000). Similar trends have been described in temperate marshes of the United States, where fiddler crab activity enhances sediment aeration and nitrogen availability, increasing *Spartina* productivity (Bertness, 1991). In European marshes

dominated by *Spartina. maritima* (Curtis) Fernald, 1916 and *Spartina anglica* C.E. Hubbard, 1968, higher vegetation complexity promoted organic matter retention and favored macrofaunal assemblages (Lillebø et al., 1999). In South American marshes, particularly in Argentina and Uruguay, studies with *Leptuca uruguayensis* (Nobili, 1901) revealed reciprocal effects, where crab burrows influenced sediment drainage and plant growth (Iribarne et al., 1997; Bortolus & Iribarne, 1999). These global comparisons reinforce that the plant–crab relationship is an ecological pattern consistently observed across biogeographic regions.

Despite these similarities, Amazonian saltmarshes present unique features that distinguish them from temperate and subtropical systems (Braga et al., 2011; Santos et al., 2020, 2025). Macrotidal influence, marked rainfall seasonality, and close interaction with extensive mangroves shape local sediment and vegetation dynamics (Santos et al., 2025). While temperature seasonality regulates benthic patterns in southern Brazil and in the North Atlantic (Netto & Lana, 1997; Flynn et al., 1996), rainfall and fluvial input appear to be more determinant in Amazonian marshes (Santos et al., 2025). These regional singularities highlight the need for local studies to complement global frameworks.

Overall, our findings demonstrate that Amazonian saltmarshes support diverse and functionally important crab assemblages, strongly mediated by vegetation complexity. By integrating local results with and global studies, we reinforce that conserving *Spartina alterniflora* marshes is crucial not only for maintaining brachyuran biodiversity, but also for sustaining ecological processes such as sediment bioturbation, nutrient cycling, reproduction, and nursery functions that are vital at local and global scales.

Limitations of the present study must be acknowledged. Because sampling was conducted only once and under a single set of tidal and meteorological conditions, our dataset represents a snapshot of a highly dynamic saltmarsh system. As such, temporal variability in crab activity, vegetation structure, and sediment properties could not be assessed,



and causality cannot be inferred from the patterns observed. In addition, several potentially important environmental drivers were not measured in this study, including microtopography, sediment granulometry, salinity gradients, human disturbance, and predator presence. These factors may also influence crab assemblages and could contribute to the spatial patterns observed here.

Nevertheless, the spatially structured sampling design and the integration of multiple vegetation metrics with faunal data provide a robust basis for identifying consistent associations within the study area. We recommend that future studies incorporate temporal replication across seasons and tidal phases to strengthen the generality and mechanistic interpretation of vegetation–faunal interactions in Amazonian saltmarshes.

CONCLUSIONS

This study provides an exploratory evaluation of spatial patterns linking vegetation structure and brachyuran assemblages within an Amazonian saltmarsh. Although based on a single sampling event, the results reveal consistent associations between inundation gradients, sediment conditions, and *Spartina alterniflora* attributes, particularly belowground biomass and organic matter content which correspond to differences in crab abundance, species richness, and burrow density. These patterns suggest that local vegetation architecture and environmental conditions may act as important correlates of crab habitat use, supporting the idea that structurally complex saltmarsh zones can serve as favorable areas for foraging, refuge, and occupation by multiple brachyuran species.

Because the study relies on a single-time survey, the relationships identified here should be interpreted as indicative rather than mechanistic. Nevertheless, the dataset contributes valuable baseline information for a region where saltmarshes remain severely understudied and highlights the potential role of *S. alterniflora* marshes in supporting faunal assemblages and sediment-related processes in tropical estuarine environments. Future research

incorporating temporal replication, expanded environmental measurements, and experimental approaches will be essential to clarify underlying mechanisms and to strengthen ecological inferences regarding vegetation–faunal interactions in Amazonian saltmarshes.

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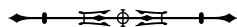
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AUTHORS' CONTRIBUTION

S. de B. Neves Neto contributed with formal analysis, methodology, investigation, and writing (original draft); C. F. Braga contributed with project administration, conceptualization, data curation, supervision, and writing (review and editing); and T. M. T. dos Santos contributed with supervision, validation, visualization, and writing (review and editing).



**Benthic meiofauna response to mangrove oyster farming
(*Crassostrea gasar*) in an Amazonian estuary**
Resposta da meiofauna bentônica à criação de ostras-do-mangue
(*Crassostrea gasar*) em um estuário amazônico

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Abstract: Mariculture is expanding rapidly in northern Brazil, where oyster farming is a key economic activity. However, little is known about its effects on estuarine communities. This study assessed the influence of oyster farming (*Crassostrea gasar*) on the structure of the meiofauna community in the Curuçá Estuary (Pará, Amazon region). Sampling was conducted at two sites: an area beneath the oyster farming tables and a control area located 100 m away. Both areas had fine, well-sorted sediments, with higher organic matter content in the farming area. Twelve meiofauna groups were recorded, dominated by Nematoda and Oligochaeta. Density was lower in the cultivation area, while species richness did not differ between the sites. Gastropoda and Bivalvia were found beneath the cultivation tables, indicating enrichment. Multivariate analyses revealed differences in community structure associated with grain size and organic matter content. Overall, oyster cultivation induced moderate and limited changes, without exceeding ecological limits. The selective responses of meiofauna taxa highlight their potential as early indicators of aquaculture impacts in tropical estuaries and underscore the need for continuous environmental monitoring.

Keywords: Meiofauna. Bioindicator. Aquaculture. Amazon coast. *Crassostrea gasar*. Benthic ecology.

Resumo: A maricultura está expandindo rapidamente no Norte do Brasil, onde o cultivo de ostras representa uma atividade econômica essencial. No entanto, pouco se sabe sobre seus efeitos nas comunidades de estuários. Este estudo avaliou a influência do cultivo de ostras (*Crassostrea gasar*) sobre a estrutura da comunidade de meiofauna no estuário de Curuçá (Pará, Amazônia). As amostragens foram realizadas em dois locais: uma área sob as mesas de cultivo de ostras e uma área-controle, situada a 100 m de distância. Ambas as áreas apresentaram sedimentos finos e bem selecionados, com teor de matéria orgânica maior na área de cultivo. Foram registrados doze grupos de meiofauna, dominados por Nematoda e Oligochaeta. A densidade foi menor na área de cultivo, a riqueza não diferiu entre os locais. Gastropoda e Bivalvia ocorreram sob as mesas de cultivo, indicando enriquecimento. As análises multivariadas revelaram diferenças na estrutura da comunidade associadas ao tamanho dos grãos e ao teor de matéria orgânica. De modo geral, o cultivo de ostras induziu mudanças moderadas e restritas, sem ultrapassar limites ecológicos. As respostas seletivas dos táxons de meiofauna ressaltam seu potencial como indicadores precoces dos impactos da aquicultura em estuários tropicais e destacam a necessidade de monitoramento ambiental contínuo.

Palavras-chave: Meiofauna. Bioindicador. Aquicultura. Costa amazônica. *Crassostrea gasar*. Ecologia bentônica.

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INTRODUCTION

Mangrove ecosystems constitute highly productive and dynamic transitional environments that connect terrestrial and marine systems in tropical and subtropical regions (Alongi, 2020). Although they occupy less than 1% of global coastal areas (Bunting et al., 2022), these forests rank among the planet's most efficient natural systems in terms of primary productivity and ecological functioning (Bouillon et al., 2008; Pinheiro et al., 2025). Brazil holds the second-largest mangrove area in the world, covering roughly 11,400 km², with more than two-thirds situated along the Amazonian coast (Bunting et al., 2022). The Amazonian mangroves are notable for their extensive and mature forests, which hold ecosystem carbon stocks two to ten times higher than those of adjacent upland forests (Kauffman et al., 2018). Mangroves deliver a wide range of essential ecosystem services (Tasneem & Ahsan, 2024) that sustain the livelihoods of countless traditional coastal populations who depend on these habitats for subsistence (Maneschy, 1993, 1995; Fernandes et al., 2018; Owuor et al., 2024; Otieno et al., 2026).

Despite their critical importance, mangroves are globally recognized as one of the most threatened ecosystems, due to rapid coastal development and continuous population growth (Goldberg et al., 2020). Among the main drivers of mangrove degradation is aquaculture, which, over the past century, has profoundly altered the structure and functioning of coastal ecosystems by modifying nutrient fluxes and food webs (Price et al., 2015; Ferriss et al., 2016; Van der Linden et al., 2016; Lacoste et al., 2020). Bivalve cultivation, a key component of marine aquaculture, is often considered to have a lower environmental impact compared to finfish or shrimp farming, as it typically requires no external feed inputs (Dumbauld et al., 2009; Cranford et al., 2012). However, intensive farming can act as a localized stressor.

Cultured bivalves can also enhance ecosystem complexity by providing substrates for settlement of other species (Tallman & Forrester, 2007), generating novel energy

pathways (Kluger et al., 2017), and supporting meiofaunal communities through biodeposition (Huang et al., 2018). In addition, the accumulation of organic wastes, in estuarine sediments promotes organic enrichment, which can lead to reduced interstitial dissolved oxygen, eutrophication, and negative impacts on local benthic fauna (Diaz & Rosenberg, 2008). Understanding the complex interactions between aquaculture practices and mangrove ecosystems is therefore essential for promoting sustainable production and effective coastal management (Figueira et al., 2016).

Benthic fauna, particularly meiofauna, are widely used as bioindicators to assess environmental stress due to their ecological roles and sensitivity to pollutants. Benthic meiofauna (the assemblage of microscopic organisms inhabiting the sediment interstices) is widely employed to diagnose environmental stress due to their strong dependence on the sedimentary environment and its central role in nutrient cycling and energy transfer (Coull & Chandler, 1992; Giere, 2009). Meiofauna is particularly suitable for monitoring because of its high diversity, widespread distribution, and rapid, localized response to anthropogenic disturbances (Giere, 2009; Schratzberger & Ingels, 2018; T. M. T. Santos et al., 2025a).

In Brazil, oyster farming (ostreiculture) has expanded since the 1970s (Valenti et al., 2021), and in Pará State, production focuses on the cultivation of the native oyster species, *Crassostrea gasar* (Adanson, 1757), using fixed-table and long-line systems in intertidal areas characterized by a macrotidal regime (Hoshino, 2009; Lopes et al., 2013). This species naturally forms dense beds on rocky or muddy substrates along riverbeds (Nascimento, 1991; Rios, 1994). In mangrove environments, oysters represent an important fishery resource for coastal communities (Galvão et al., 2012) and the key municipalities involved in oyster cultivation in the Pará state include Augusto Corrêa, Curuçá, Maracanã, Salinópolis, and São Caetano de Odivelas (Hoshino, 2009).

In the northern region of Brazil, oyster farming systems are predominantly fixed-table types installed in macrotidal mangrove areas, which are daily subjected to

tidal emersion and submersion. When cultivated, they often exhibit faster growth rates than in natural environments due to seed selection and management practices (Pereira et al., 2003). In this context, *C. gasar* has been successfully farmed in the Amazon region (Lopes et al., 2013), and well-regulated oyster farming can help mitigate the environmental pressure caused by extractive harvesting on natural populations (Gardunho et al., 2012). Therefore, by understanding the interactions among oyster farming practices, benthic communities, and mangrove ecosystem functioning, sustainable management strategies can be developed to balance production with conservation of these highly valuable coastal habitats.

While the cultivation of *C. gasar* provides an important income source for communities and helps mitigate pressure on natural populations (Gardunho et al., 2012), information on its specific environmental impacts in the Amazonian region remains scarce. Given the imminent expansion of ostreiculture along the Pará coast, this study aimed to identify and assess the effects of the cultivation of mangrove oysters (*C. gasar*) in the meiofauna community in the Curuçá estuary. The following hypothesis was tested: Oyster farming of *C. gasar* alters the composition and abundance of meiofaunal communities, such that cultivated areas exhibit significant differences in density, species richness, and diversity compared to non-cultivated areas.

MATERIAL AND METHODS

STUDY AREA

This study was carried out in Curuçá city (00° 43' 48" S, 47° 51' 06" W) located on the Northern Amazon coast of Brazil (Figure 1). It is a humid equatorial region (Amazon Rainforest equatorial climate-type Am), characterized by high temperatures (27 °C annual average), low thermal amplitude, and high precipitation of over 2,000 mm per year (Martorano et al., 1993). Curuçá city has over 40,000 residents and its economy is based on fishing, agriculture, and tourism in mangroves (IBGE, 2018). Salinity varies

from < 7 ‰ during rainy season to > 22 ‰ in the dry season (Pará, 2005).

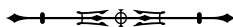
The city is within a coastal extractive reserve (Lauro Sodré Community), which holds one of the largest protected areas on the Amazon coast with rich mangrove ecosystems so there is good representation for other reserves in the country. The reserve has nearly 60 traditional community settlements with approximately 3,000 families living on estuarine islands, tidal creeks, rivers, beaches, and mangroves (Figueiredo et al., 2009). The Curuçá estuary is formed by the confluence of the Curuçá and Muriá rivers (Paula et al., 2006).

FIELD PROCEDURES

Sampling was carried out in April 2019 within a cultivation area of *Crassostrea gasar* in the São João da Ponta village (00° 50' 59" S, 47° 55' 12" W). Two distinct areas were selected for sample collection: (I) the cultivation area, located directly beneath the oyster tables, and (II) the control area, positioned approximately 100 m away from the cultivation area. In each area, ten biological samples were collected using a 3 cm diameter corer inserted to a depth of 10 cm into the sediment (Figure 1C). Immediately after sampling, the material was fixed in 4% formaldehyde. Additionally, sediment samples were taken from each site for the analysis of grain size and organic matter content. Samples intended for organic matter determination were kept refrigerated during fieldwork and subsequently frozen in the laboratory until further processing. Seawater salinity was also determined in the water column with a manual refractometer.

LABORATORY PROCEDURES

Meiofauna was extracted from the sediment using colloidal silica at a specific density of 1.18 g/cm³ (Somerfield et al., 2005). The supernatant was washed through 0.3 and 0.045 mm meshes, and the organisms retained in the 0.045 mm mesh were placed on Dollfus plates and identified to the major taxonomic groups (phylum, class, or order, depending on the group) following Giere (2009) and Danovaro (2010).



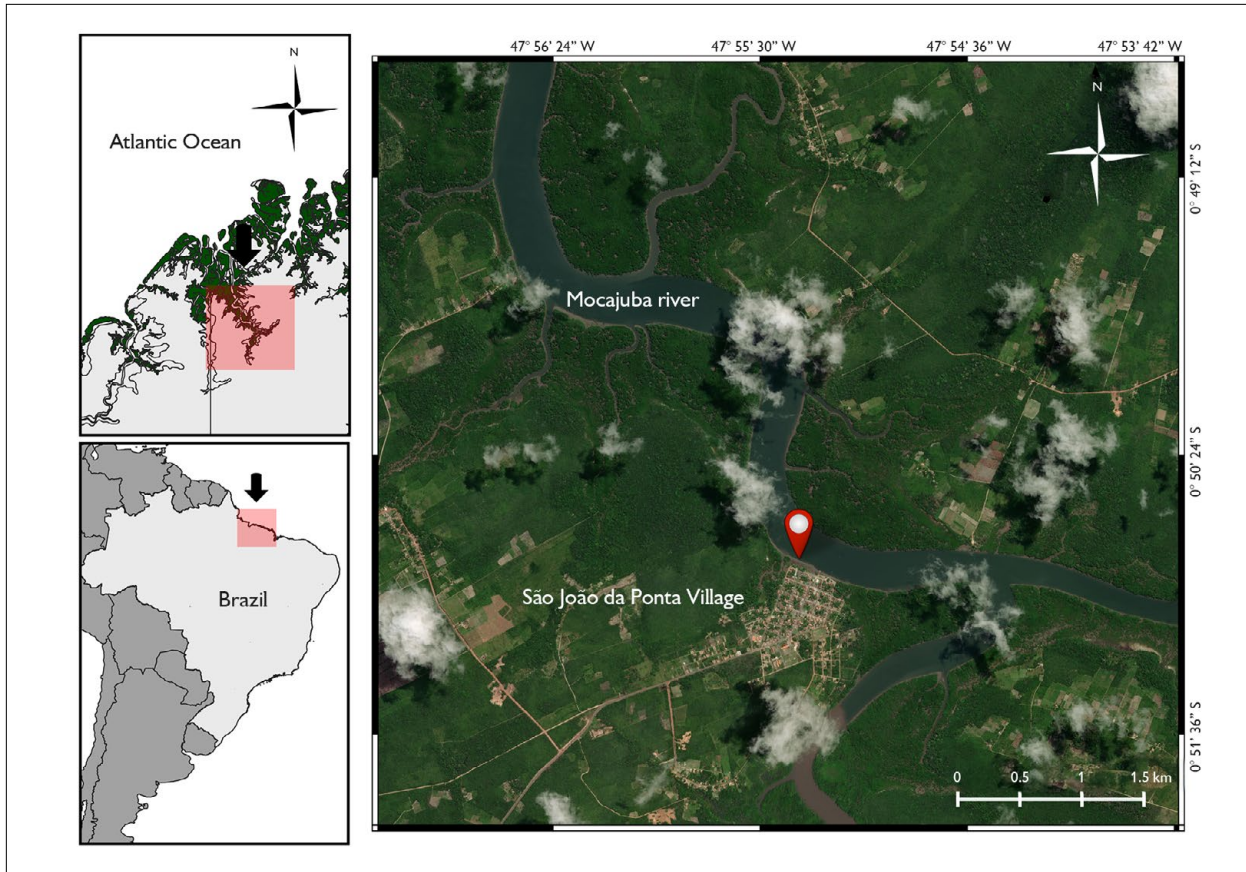


Figure 1. Map of the study area showing the location of the study areas. Map: Thuareg Monteiro Trindade dos Santos (2025).

The granulometric analysis was conducted by sieving out coarse sediments and pipetting fine sediments, as proposed by Suguio (1973). Textural parameters (mean grain size, sorting, % sand, and gravel) were calculated using the equations of Folk and Ward (1957). Grain sizes were determined by sieving the sediment in an automatic shaker and classifying the grains according to the Wentworth scale (Buchanan, 1984). Water content was determined as the percentage of mass loss after drying the sediment samples at 60 °C until constant weight and calculated according to the formula: water content (%) = $[(\text{wet mass} - \text{dry mass})/\text{wet mass}] \times 100$. Organic matter content was determined by loss on ignition (Dean, 1974). Sediment samples were dried at 60 °C until constant weight to obtain dry mass and then combusted at 550 °C for 4 h.

Organic matter was calculated as the percentage of mass loss relative to the initial dry mass, using the formula: %LOI = $[(\text{dry mass} - \text{ash mass})/\text{dry mass}] \times 100$.

STATISTICAL ANALYSIS

Meiofauna density (ind./10 cm²) and major taxonomic group richness were calculated for each biological sample; density was standardized to the corer surface area (10 cm²), and all samples were analyzed considering the entire sediment column (0–10 cm). Differences between study areas (*Crassostrea gasar* tables × control area) were tested using one-way analysis of variance (ANOVA) after verifying normality and homogeneity of variances with the Kolmogorov–Smirnov and Levene tests, respectively. When necessary, data were fourth-root transformed.

A Principal Coordinates Analysis (PCO) was run on a Bray-Curtis similarity matrix of the fourth root-transformed species to visualize the similarity between samples across areas. To identify the species that characterized each area, species that correlated (Spearman's coefficient) more than 60% with one of the first two axes were plotted in each PCO. Simultaneously, the same density matrices used for the PCO were analyzed using a one-way permutational ANOVA (PERMANOVA) designed using the same layout as the ANOVA. The contribution of each taxon to the dissimilarity found among the groups was assessed using the SIMPER (similarity percentage) routine.

For linking the meiofauna community biological descriptors with the sediment variables, a distance-based linear model (DistLM; Anderson, 2001) was performed. This technique analyzes and models the relationship between a multivariate data cloud, as described by a resemblance matrix and predictor variables. Resemblance matrices were calculated using Euclidean distance ($\log_{(x+1)}$ transformed data). The best models in DistLM were chosen using a forward routine with 9999 permutations based on AIC selection criteria (Anderson et al., 2008). A 5% significance level was considered in all analyses.

RESULTS

ENVIRONMENTAL VARIABLES

In the study area, seawater salinity was 11 ± 2 ‰. Overall, sediment temperature presented higher values in the control area in comparison with the *Crassostrea gasar* table (Table 1). The sediment H₂O content presented higher values in the Control area (Table 1). Organic matter (OM) did not varied between areas ($F_{(1,8)} = 7.03$, $p > 0.05$), however higher value was found in the *Crassostrea gasar* table (Table 1). The sediments were mostly very-well sorted muddy (silt + clay) however, some differences were found between the areas. In the *C. gasar* table the sediment varied from well-sorted coarse

silt to moderated-sorted medium sand, with presence of gravel, while in the Control area, the sediment was predominantly muddy (Table 1).

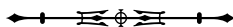
MEIOFAUNA COMMUNITY

Overall, ANOVA showed significant differences in density between areas ($F_{(1,18)} = 8.41$; $p < 0.01$), with higher values found at Control area (38.65 ± 29.16 ind/10 cm²) than in the *Crassostrea gasar* table (32.04 ± 22.05 ind/10cm²) (Figure 2A). On the other hand, richness did not varied significantly between areas ($F_{(1,18)} = 3.21$; $p > 0.05$), however, higher values were found in the control area (Figure 2B).

Meiofauna was comprised of 12 major groups and composition was similar in the study areas, however gastropods and bivalves were exclusively found at *C. gasar* table area (Table 2). Overall, Nematoda (77.5%) and Oligochaeta (15.8%) were the dominant groups; however, their contribution varied among areas. In the *C. gasar* table area, Nematoda (74.6%) and Oligochaeta (19.5%) were the dominant groups, in addition, the contribution of other major groups were higher. In the Area 2, a decrease in

Table 1. Mean values (\pm SD) of the sediment variables in the study areas.

Variable	Study areas	
	<i>Crassostrea gasar</i> table	Control area
Temperature (°C)	28.13 \pm 0.32	29.53 \pm 0.50
Organic matter (%)	5.08 \pm 1.44	4.67 \pm 1.02
H ₂ O content (%)	49.81 \pm 1.07	47.25 \pm 1.21
Mean grain size (Φ)	3.85 \pm 0.24	4.61 \pm 0.31
Sorting (Φ)	0.89 \pm 0.84	0.48 \pm 0.28
% Gravel	0.37 \pm 0.64	0
% Sand	27.29 \pm 21.06	0.99 \pm 0.32
% Mud (Silt + Clay)	72.34 \pm 21.4	99.01 \pm 0.24
Grain size classification	Coarse silt	Coarse silt
Sorting classification	Well sorted to Moderate sorted	Very-well sorted



the Oligochaeta (12%) contribution, with a proportional increase in Nematoda (80.2%) and of other major groups occurred dominance (Figure 3C).

The structure of the meiofauna community varied significantly between areas ($pseudo-F_{(1,18)} = 8.15$; $p_{(perm)} = 0.001$; $p_{(Monte Carlo)} = 0.001$), and the spatial configuration distinguished the meiofauna samples between the two study areas (Figure 3). Regarding major groups,

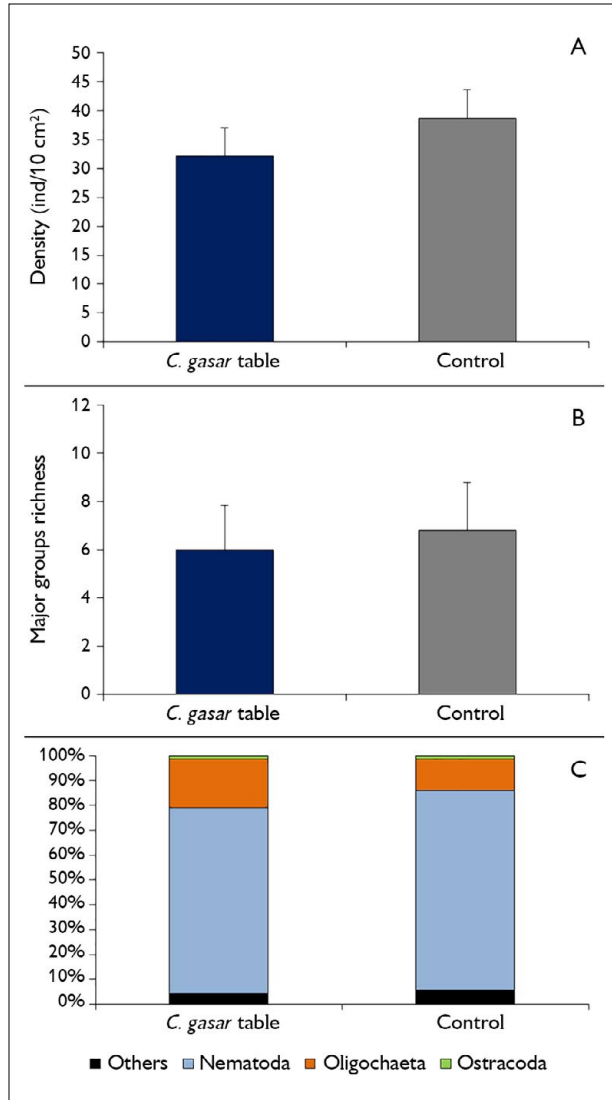


Figure 2. Mean density (\pm SE) (A), mean major groups richness (\pm SE) (B), and relative abundance (%) (C) of the meiobenthic major groups of the study areas.

Table 2. Mean density (\pm SE) of the meiofauna major groups found in the study areas.

Major groups	<i>Crassostrea gasar</i> table	Control area
Nematoda	28.7 \pm 2.9	34.1 \pm 4.65
Ostracoda	0.5 \pm 0.3	0.6 \pm 0.2
Oligochaeta	7.5 \pm 1.4	5.36 \pm 1.34
Acari	0.1 \pm 0.07	0.14 \pm 0.05
Kinorhyncha	0	0.35 \pm 0.06
Copepoda	0.3 \pm 0.1	0.53 \pm 0.16
Simpunculla	0.5 \pm 0.2	0.48 \pm 0.21
Tubertlaria	0.14 \pm 0.07	0.22 \pm 0.07
Gastthropoda	0.16 \pm 0.06	0
Bivalve	0.22 \pm 0.08	0
Polychaeta	0.05 \pm 0.05	0.63 \pm 0.14
Gastrothicha	0	0.02 \pm 0.01
Peracarida	0.02 \pm 0.01	0.05 \pm 0.01

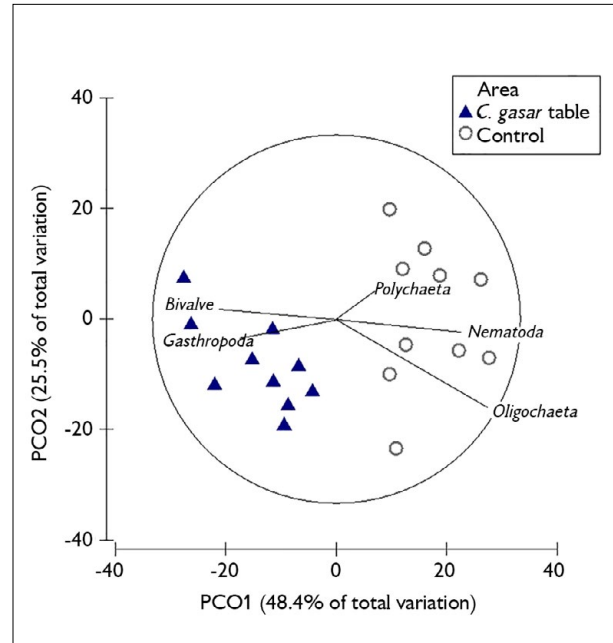


Figure 3. Principal Coordinates Analysis (PCO) of the samples of the meiobenthic major groups considering the taxonomic composition. The vectors represent species/groups correlating more than 60% (based on Spearman correlation coefficients) with one of the first two PCO axes.



axis 1 explained 48.4% of the variation in the data and was responsible for separating the two areas. The major groups most correlated with *C. gasar* tables samples were Gastropoda and Bivalve, whereas Nematoda, Oligochaeta and Polychaeta were most correlated with Control area. The SIMPER analysis indicated a mean dissimilarity of more than 80% between the study areas (Table 3). Comparing areas, most of the species indicated by SIMPER were more abundant in *C. gasar* tables, in particular Gastropoda and Bivalve (Table 3).

The best distance-based linear model (DistLM) explained 45% for density and 56% for richness variation of meiofauna community in the study areas. Sediment grain size, organic matter and % sandy were the principal environmental variables correlated with both descriptors, while H₂O content and % muddy were related principally with density and richness, respectively (Table 4).

DISCUSSION

Overall, the granulometric composition on both areas was characterized by predominantly muddy sediments (silt + clay). This sediment composition is typical of low-energy Amazonian estuaries (Silva et al., 2011; Mendes, 2023; Braga

et al., 2024; T. M. T. Santos et al., 2024, 2025b, 2026; Rocha et al., 2026) where fine fractions enhance organic matter retention and provide a food-rich microhabitat for benthic fauna (Giere, 2009). In contrast, the occurrence of coarser and poorly sorted particles in the *C. gasar* table indicates local hydrodynamic influence associated with the oyster-table structures and the deposition of fragmented shells. Fixed installations can modify near-bottom flow, generating micro-zones of turbulence, erosion, and selective deposition (Heery et al., 2017; T. M. T. Santos & Aviz, 2020). Similar patterns were reported by Chamberlain et al. (2001), who observed increased sand and gravel fractions beneath *Mytilus edulis* long-lines, and by Mendes (2023) in the Muriá Channel (Curuçá, Pará), where intermittent currents and microtopographic variations promoted heterogeneous accumulation of fine and coarse sediments around fixed structures.

Organic matter content was slightly higher in the *C. gasar* table, although the difference was not statistically significant. This pattern agrees with previous studies showing that the accumulation of bivalve biodeposits is the main source of organic enrichment beneath aquaculture structures (Dahlbäck & Gunnarsson, 1981; Chamberlain et al., 2001; Nizzoli et al., 2006; Zhao et al., 2022). Oyster biodeposits have high settling velocities

Table 3. Average dissimilarities between the samples from *Crassostrea gasar* table and control area, with the contribution from taxonomical groups.

Average dissimilarity = 82.64			
Major groups	Average dissimilarity	Dissimilarity/Standard deviation	Contribution %
Gastropoda	6.32	1.46	23.72
Bivalve	3.94	0.7	22.8
Oligochaeta	3.01	1.11	11.29
Nematoda	2.68	0.95	10.06

Table 4. Best distance-based linear models (DistLM) fitted for meiobenthic community descriptors against sediment variables in the study areas. Values in brackets: proportion of variability explained by each variable; * = significant differences (p < 0.05).

Descriptors	AIC	R ²	Variable included	p
Density	25.7	0.86	Grain size (15%), organic matter (12%), H ₂ O content (10%), % sand (8%)	< 0.05* (all)
Richness	19.4	0.81	Grain size (22%), organic matter (17%), % sand (10%), % muddy (7%)	< 0.05* (all)



and tend to accumulate directly beneath culture tables, locally increasing particulate organic carbon and altering decomposition dynamics (Callier et al., 2006). However, the magnitude of this accumulation depends strongly on hydrodynamic conditions. In macrotidal environments such as the Amazon coast, strong currents and tidal flushing disperse fine particles, mitigating excessive organic buildup (Sutherland et al., 2018). Therefore, the moderate increase in OM observed in the Curuçá estuary likely reflects a balance between organic input and dispersive forces, a condition typical of high-energy estuarine systems where hydrodynamics prevent anoxia but do not entirely remove deposited material (Souza-Filho et al., 2009; Asp et al., 2013).

The community descriptors (density and richness) differed between conditions, with lower density and richness at *C. gasar* table, as expected from previous studies (Mirto et al., 2000; Christensen et al., 2003; Callier et al., 2008). Overall, in organically enriched areas, meiofaunal density generally tends to decrease due to oxygen depletion and sediment compaction (La Rosa et al., 2001). In the Curuçá estuary, this pattern was consistent with those observations, as lower densities were recorded in the *C. gasar* table area, while higher values occurred in the Control area.

Overall, the composition of the meiofauna on the study areas was similar. Furthermore, the taxonomic composition of these areas was similar to that of other soft bottom habitats on the Amazon coast (Paula et al., 2006; Gomes & Rosa Filho, 2009; Rosa Filho et al., 2011; Baia & Venekey, 2019; T. M. T. Santos et al., 2021, 2025a; Baia et al., 2021; T. B. Santos et al., 2023; Melo et al., 2024; Ferreira-Ramos et al., 2026; T. M. T. Santos & Aviz, 2026), as well as other estuarine areas worldwide, with Nematoda as the dominant group (see Giere, 2009 for review). This dominance of nematodes is associated with three main factors: i) their body shape (long, thin, and fusiform), which facilitates burrowing activities; ii) their high tolerance to environmental stress; and iii) their diversity of feeding habits, allowing them to utilize all

available food resources (Bouwman, 1983; Giere, 2009; T. M. T. Santos & Venekey, 2017). In addition, Nematodes are known bioindicators of anthropic impact (T. M. T. Santos et al., 2021, 2025a) and are highly tolerant to environmental variations, often dominating areas with organic enrichment (Schratzberger & Ingels, 2018).

Species richness is generally expected to decline in impacted areas, leading to increased dominance by opportunistic taxa (Clarke & Warwick, 2001), while more sensitive species decrease (Pearce et al., 1981). In this study, the high abundance of Oligochaeta beneath *C. gasar* tables indicates that oyster bio-deposition strongly shapes the benthic environment. It is well known that Oligochaeta is favored under organically enriched conditions (Pearson & Rosenberg, 1978; Giere, 2009). This bio-stimulatory effect is reinforced by the exclusive presence of Gastropoda and Bivalvia in the farming area, likely benefiting from increased detrital food and calcareous particles from shell fragments (Dahlbäck & Gunnarsson, 1981; Zhao et al., 2022). In contrast, the absence or reduction of the sensitive Gastrotricha highlights its susceptibility to micro-environmental changes such as sediment compaction and oxygen fluctuations (Kieneke & Schmidt-Rhaesa, 2015). The low abundance of Copepoda is consistent with the low-salinity conditions of the inner estuarine zone, where freshwater-associated copepod taxa are commonly recorded (Boxshall & Defaye, 2008). These selective shifts in meiofaunal composition underscore their value as early-warning indicators of low-level environmental impacts (Paula et al., 2006).

In the study region, the oyster production system that covers both juvenile and growth phases until the market-size adults (Funo et al., 2019). Therefore, the presence of adults tends to be lower in comparison to other cultivation areas, since the adults are collected regularly. The organic enrichment due to the presence of juvenile oysters is likely low compared with that of adult oysters, but the continuous exploitation of the area for farming may have modified community characteristics

compared with outside areas (Lacoste et al., 2020). However, despite the reduction in the *C. gasar* table, the densities remained within the range reported for other unpolluted tropical estuaries (Vasconcelos et al., 2004), suggesting that the level of organic enrichment in Curuçá has not yet reached a critical threshold capable of causing severe ecological degradation (Paula et al., 2006).

Aquaculture has become the primary solution for meeting the continuously rising global demand for aquatic products, in light of plateauing wild-capture fisheries. A major milestone was recently reached: according to the FAO's SOFIA 2024 report (FAO, 2024), aquaculture surpassed capture fisheries in 2022, contributing 51% of the total global production of aquatic animals for human consumption. This rapid and sustained growth underscores the sector's crucial role in global food security. However, this expansion demands a strict commitment to sustainability, particularly given the intense competition for resources (land, water, energy) and the imperative to minimize environmental impact.

In vulnerable ecosystems, such as Amazonian estuaries where aquaculture is often nascent, assessing environmental impacts from the outset is essential for adaptive management. We recommend that impact assessments move beyond isolated physical and chemical analyses and integrate farming-related factors (e.g., establishment time, occupied area, and production yield) with biological indicators. In this context, the meiofauna community is proposed as a highly effective monitoring tool (Giere, 2009).

Among meiofaunal groups, Nematoda deserve particular emphasis, as they are typically the most abundant and taxonomically diverse group and often respond to environmental changes before shifts become evident at broader taxonomic levels (Bongers & Ferris, 1999). Analyses at finer taxonomic resolution (e.g., family or genus level) can therefore provide a more sensitive and precise assessment of mariculture impacts (Mirto et al., 2014).

CONCLUSION

In conclusion, the sediment and meiofaunal patterns observed in the Curuçá estuary indicate that oyster farming induces moderate, localized environmental changes without exceeding ecological thresholds. The selective responses of meiofaunal taxa, particularly the dominance of tolerant groups and the reduction of sensitive taxa, underscore their utility as sensitive bioindicators. Nematoda, the most abundant meiofaunal group, comprises a high diversity of species whose abundance and composition are strongly influenced by environmental conditions, reinforcing the potential of finer taxonomic resolution to improve impact detection. Ongoing and future analyses at the genus level will provide additional insights into community responses to oyster farming. These findings highlight the importance of continuous monitoring and adaptive management to ensure sustainable oyster cultivation while preserving benthic ecosystem integrity in tropical estuaries.

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AUTHORS' CONTRIBUTION

A. B. M. Ferreira-Ramos contributed to formal analysis, methodology, investigation and writing (original draft); E. F. S. de Souza contributed to formal analysis and investigation; J. T. Lee contributed to project administration, methodology and visualization; and T. M. T. dos Santos contributed to supervision, conceptualization, data curation, validation and writing (review and editing).

Zooplankton diversity in freshwater environments of Parintins, Amazonas, Brazil

Diversidade do zooplâncton em ambientes de água doce de Parintins, Amazonas, Brasil

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Abstract: This study presents a taxonomic survey of the zooplankton community in Parintins, located on the right bank of the Amazon River, Amazonas State, Brazil. Sampling was carried out at ten sites encompassing lentic and lotic environments during the rainy (June–July 2022) and dry (October–November 2022) seasons. Zooplankton samples were collected through horizontal subsurface tows using a 64 μm plankton net and analyzed under light microscopy. A total of 118 taxa were identified, belonging to eight main groups: rotifera, protozoa, chromista, branchiopoda, copepoda, diptera, gastrotricha, and nematoda. Taxonomic richness was higher in lentic environments (99 taxa) and during the dry season (93 taxa). Rotifera and protozoa were the most representative groups, followed by chromista and branchiopoda. Seventy-nine taxa represent first records for the lower Amazonas region, highlighting the importance of taxonomic inventories in underexplored Amazonian areas and contributing to biodiversity knowledge and environmental monitoring in the context of urbanization and hydrological variability.

Keywords: Amazon Basin. Black water. Inventories. Plankton.

Resumo: Este estudo apresenta um levantamento taxonômico da comunidade zooplânctônica de Parintins, localizada na margem direita do rio Amazonas, estado do Amazonas, Brasil. As coletas foram realizadas em dez pontos abrangendo ambientes lênticos e lóticos, durante as estações chuvosa (junho–julho de 2022) e seca (outubro–novembro de 2022). As amostras foram obtidas por meio de arrastos horizontais em subsuperfície, utilizando uma rede de plâncton com malha de 64 μm , e analisadas em microscópio óptico. Foi identificado um total de 118 táxons pertencentes a oito grupos principais: rotifera, protozoa, chromista, branchiopoda, copepoda, diptera, gastrotricha e nematoda. Ambientes lênticos apresentaram maior riqueza de táxons (99 táxons) e durante o período seco (93 táxons). Os rotifera e protozoa foram os grupos mais representativos, seguidos por chromista e branchiopoda. Setenta e nove táxons representam registros inéditos para a região do baixo Amazonas, destacando a importância dos inventários taxonômicos em áreas amazônicas pouco exploradas e contribuindo para o conhecimento da biodiversidade e para o monitoramento ambiental associado à urbanização e à variação hidrológica.

Palavras-chave: Bacia amazônica. Águas pretas. Inventários. Plâncton.

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INTRODUCTION

Freshwater ecosystems hold highly diverse, endemic, and sensitive biota that provide and sustain a wide range of ecosystem services (Strayer & Dudgeon, 2010). Among freshwater fauna, zooplankton occur abundantly in virtually all types of aquatic habitats and play a key role in energy transfer, occupying an intermediate trophic level (Melo et al., 2006). Many zooplankton species feed on bacteria and algae and, in turn, serve as prey for numerous invertebrates, fish, and birds (Simões et al., 2008; Panpatil & Deshmukh, 2021).

Limnetic zooplankton communities are mainly composed of protozoa, rotifera, copepoda, and branchiopoda, whose distribution is regulated by environmental factors such as food availability, water flow, and turbidity (Simões et al., 2013). Studies on zooplankton diversity and ecology contribute to a better understanding of aquatic ecosystem functioning and have increasingly been used as indicators of water quality and hydrological fluctuations (Medeiros et al., 2011; Panpatil & Deshmukh, 2021).

Globally, freshwater ecosystems are estimated to harbor the following number of known species: 257 genera and 2,814 species of copepoda (Boxshall & Defaye, 2008), 128 genera and 1,949 species of rotifera (Segers, 2008), 95 genera and 620 species of branchiopoda (Forró et al., 2008). In Brazil, between 1900 and 2021, a total of 1,014 studies on freshwater zooplankton were published, most of them focusing on the ecology and taxonomy of branchiopoda, followed by copepoda and rotifera, whereas protozooplankton remain the least investigated group (Castilho-Noll et al., 2023). Despite this growing body of research, the freshwater zooplankton fauna of Brazil is still poorly known (Elmoor-Loureiro et al., 2022).

Although the Amazon Basin represents the world's largest river system in terms of both drainage area and freshwater discharge (Calléde et al., 2000), there is a gap of nearly four decades in zooplankton research for the region, particularly for the state of Amazonas (Brandorff et al., 1982; Hardy et al., 1984; Robertson & Hardy, 1984; Koste et al., 1984; Brito et al., 2015; Arrieira et al., 2016;

Souza et al., 2021; Elmoor-Loureiro et al., 2022). Consequently, knowledge of zooplankton diversity in Amazonian ecosystems remains incomplete, with many areas still lacking adequate survey and taxonomic documentation (Souza et al., 2019; L. Santos et al., 2022).

Increasing anthropogenic pressures and land use changes throughout the Amazon Basin (Pacheco et al., 2015; Kimura et al., 2017) threaten species that have not yet been recorded, disrupting biological processes and altering zooplankton species distribution patterns, colonization dynamics, and life cycles (Simões et al., 2008; K. Santos et al., 2022). These impacts may ultimately lead to species loss and functional homogenization (Gadelha et al., 2022).

In this study, we present a taxonomic inventory of zooplankton species from lentic and lotic environments of white and black water systems in the Amazon basin and its tributaries in Parintins, lower Amazon region. This study contributes with new data on regional biodiversity and improves knowledge of the occurrence and distribution of zooplankton communities in Amazonian freshwater ecosystems.

MATERIAL AND METHODS

STUDY AREA

The study was conducted in the Parintins region (02° 37' 40" S; 56° 44' 09" W), the second most populous municipality in the state of Amazonas, Brazil, with approximately 110,000 inhabitants (Silva et al., 2016; IBGE, 2023). Parintins is a fluvial island located on the right bank of the Amazon River and comprises aquatic ecosystems influenced by both white-water and black-water systems.

White waters, originating mainly from Andean and sub-Andean drainages, are characterized by high loads of suspended sediments, neutral to slightly acidic pH, higher electrical conductivity, and relatively elevated concentrations of dissolved nutrients. These characteristics result in high primary and secondary productivity. In contrast, black waters drain highly weathered terrains and are characterized by low sediment loads, acidic pH, low ionic content, and high



concentrations of dissolved humic substances, which impart a dark coloration to the water and are associated with low nutrient availability and reduced productivity (Sioli, 1984; Junk et al., 2011).

The region has a humid tropical climate (Köppen, 1936), with four distinct phases in the regional hydrological cycle: an intense rainy season from December to April, a period of high water levels in May and June, a dry season from June to October, and the lowest water levels in November (Coelho et al., 2024; Silva-Lehmkuhl et al., 2024).

Ten sampling sites were selected within and around Parintins Island and classified as lentic (P1–P6) and lotic (P7–P10) environments (Figure 1).

SAMPLING

Sampling was conducted during the high-water (June–July 2022) and low-water periods (October–November 2022). Water temperature ($^{\circ}\text{C}$) and pH were measured *in situ* using a multiparameter probe (HANNA HI98194) (Table 1).

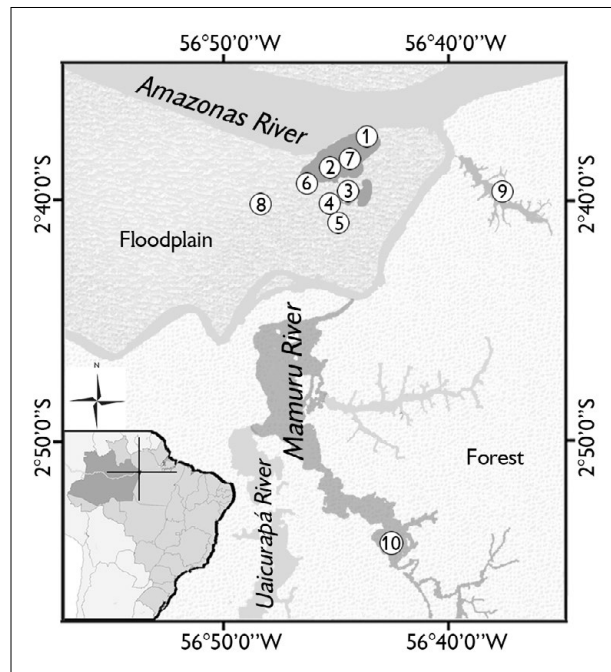


Figure 1. Location of the sampling sites in Parintins, Amazonas, Brazil. Site codes correspond to those listed in Table 1. Source: Author (2026).

Zooplankton samples were collected through horizontal subsurface tows (Anyanwu et al., 2020) using a conical plankton net with a $64\ \mu\text{m}$ mesh size and 60 cm mouth diameter, towed for three minutes. The material retained in the net was transferred to 200 mL polyethylene bottles, properly labeled, and preserved in 70% ethanol (CETESB, 2014).

SPECIES ANALYSIS

Samples were homogenized, and 1.5 mL subsamples were withdrawn using a Hansen–Stempel pipette, following Bottrell et al. (1976). Analyses were performed in a Sedgewick–Rafter counting chamber (Koste, 1978) under a light microscope (Opton TNB-40T model) at $100\times$ and $400\times$ magnifications, equipped with a digital camera. Subsamples were examined following a species rarefaction criterion, whereby consecutive microscopic fields were analyzed until no additional taxa were observed. Whenever possible, organisms were identified to the species level based on Montú and Gloeden (1986), Loureiro (1996), Dahms et al. (2006), Tenebaum (2006), and Ezz et al. (2014). Taxa representing first record for Parintins are indicated by an asterisk (*) in Table 2.

RESULTS

A total of 118 taxa were recorded in the study area, comprising 48 rotifera (40.6%) (Figure 3), 38 protozoa (32.2%) (Figure 4), 16 chromista (13.5%), 10 branchiopoda (8.7%) (Figure 5), three copepoda (2.6%), and one taxon (0.8%) each of diptera, gastrotricha, and nematoda (Table 2). Of these, 79 taxa represent the first records for the lower Amazonas region.

Taxonomic richness ranged from 67 taxa in lotic environments to 99 in lentic environments. Species richness was also higher during the dry season (93 taxa) than during the rainy season (46 taxa) (Table 2, Figure 2). All zooplankton groups exhibited greater richness during the dry period and in lentic environments (Figure 2).

Table 1. Description of zooplankton sampling sites in Parintins, Amazonas, Brazil, including geographic coordinates, environment type, and mean temperature (T °C) and pH values during flood and drought periods. Sites P3–P6 are associated with groundwater discharge.

CODE	Sampling sites	Geographic coordinates	Environment type	T (°C)	pH
P1	Francesa Lagoon	2° 37' 31.8" S 56° 43' 22.2" W	Floodplain area with lentic conditions and white water, influenced by seasonal inundation pulses	33.4	6.8
P2	Lake Lagoa Azul	2° 38' 51" S 56° 44' 52" W	An urban lentic black-water lake	32.6	9.3
P3	Paraíso Resort Spring	2° 40' 11.9" S 56° 44' 52.5" W	Lentic black-water spring located in a recreational area	26.8	3.4
P4	Regaço Resort Spring	2° 39' 46" S 56° 44' 18" W	Lentic black-water spring located in a recreational area	26.5	4.6
P5	Luiz Viana Farm Spring	2° 40' 52.4" S 56° 44' 39.2" W	Lentic black-water spring located on a farm	30	6.3
P6	Areial Springs	2° 39' 32.2" S 56° 45' 50.4" W	Lentic black-water spring complex in a sandy area	31	5.2
P7	Amazonas-Macurany várzea	2° 38' 29" S 56° 44' 04" W	Floodplain area with lentic conditions and white water, influenced by seasonal inundation pulses	32	7
P8	Canta Galo	2° 40' 16" S 56° 47' 47" W	Floodplain area with lentic conditions and white water, influenced by seasonal inundation pulses	30.7	6.4
P9	Lake Lago do Zé Açu	2° 40' 12.7" S 56° 37' 36" W	Lake influenced by lotic black-water from tributaries	31.4	5.7
P10	Mamuru River	2° 55' 9.88" S 56° 42' 13.06" W	Lotic black-water	32	5.2

Table 2. Occurrence and distribution of zooplankton taxa across sampling sites in Parintins, Amazonas, Brazil. Taxa marked with an asterisk (*) indicate new records for Parintins. Site locations correspond to the codes presented in Table 1. (Continue)

Taxa	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10
COPEPODA										
Order: Calanoida										
Family: Diaptomidae										
<i>Diaptomus</i> Westwood, 1836									X	
Order: Cyclopoida										
Family: Cyclopidae										
<i>Microcyclops</i> Claus, 1893		X				X			X	X
* <i>Microcyclops varicans</i> (Sars G.O., 1863)	X	X							X	X
BRANCHIOPODA										
Order: Anomopoda										
Family: Chydoridae										
<i>Alonella</i> G.O. Sars, 1862						X	X			
<i>Chydorus</i> Leach, 1816			X							
* <i>Chydorus sphaericus</i> (O.F. Müller, 1776)			X			X				
<i>Leydigia</i> Kurz, 1875				X						

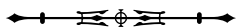


Table 2.	Taxa	P1	P2	P3	P4	P5	P6	P7	P8	(Continued)
	<i>*Monospilus dispar</i> G.O. Sars, 1862						X			
	Family: Bosminidae									
	<i>Bosmina longirostris</i> (O.F. Müller, 1785)	X							X	X
	<i>Bosminopsis deitersi</i> Richard, 1895	X						X		X
	Family: Macrothricidae									
	<i>*Macrothrix laticornis</i> (Jurine, 1820)						X			
	Family: Moinidae									
	<i>*Moina micrura</i> Kurz, 1875	X	X				X	X	X	X
	Order: Ctenopoda									
	Family: Sididae									
	<i>Diaphanosoma</i> Fischer, 1850							X		
	ROTIFERA									
	Subclass: Bdelloida									
	Order: Adinetida									
	Family: Adinetidae									
	<i>*Adineta vaga</i> (Davis, 1873)	X	X			X	X			
	Family: Philodinidae									
	<i>Philodina</i> Ehrenberg, 1830								X	
	Subclass: Monogononta									
	Order: Flosculariaceae									
	Family: Conochilidae									
	<i>Conochilus</i> Ehrenberg, 1834								X	
	Family: Hexarthridae									
	<i>*Hexarthra mira</i> (Hudson, 1871)						X			
	Family: Testudinellidae									
	<i>Testudinella patina</i> (Hermann, 1783)	X					X	X		
	Family: Trochosphaeridae									
	<i>Filinia opoliensis</i> (Zacharias, 1898)							X		X
	<i>*Filinia terminalis</i> (Plate, 1886)							X	X	
	Order: Ploima									
	Family: Asplanchnidae									
	<i>Asplanchna priodonta</i> Gosse, 1850						X	X		X
	Family: Brachionidae									
	<i>Anuraeopsis fissa</i> Gosse, 1851		X				X	X	X	X
	<i>*Brachionus angularis</i> Gosse, 1851		X							X
	<i>*Brachionus bidentatus</i> Anderson, 1889	X							X	
	<i>*Brachionus budapestinensis</i> Daday, 1885	X	X					X		
	<i>*Brachionus caudatus</i> Barrois & Daday, 1894							X		
	<i>*Brachionus diversicornis</i> (Daday, 1883)		X							

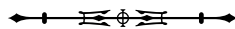


Table 2.	Taxa	P1	P2	P3	P4	P5	P6	P7	P8	(P9)	(P10)
	<i>Brachionus falcatus</i> Zacharias, 1898		X								
	* <i>Brachionus forficula</i> Wierzejski, 1891		X					X			
	<i>Brachionus gessneri</i> Hauer, 1956						X		X	X	
	* <i>Brachionus havanaensis</i> Rousselet, 1911		X					X			X
	* <i>Brachionus plicatilis</i> Müller, 1786		X								X
	<i>Brachionus zahniseri</i> Ahlstrom, 1934		X								
	<i>Keratella americana</i> Carlin, 1943										X
	<i>Keratella cochlearis</i> (Gosse, 1851)			X					X	X	
	* <i>Keratella tropica</i> (Apstein, 1907)							X			
	<i>Plationus patulus</i> var. <i>macracanthus</i> (Daday, 1905)							X			
	Family: Euchlanidae										
	* <i>Euchlanis dilatata</i> Ehrenberg, 1830							X			
	Family: Gastropidae										
	<i>Ascomorpha ovalis</i> (Bergendal, 1892)						X				X
	* <i>Ascomorpha saltans</i> Bartsch, 1870		X				X		X	X	
	<i>Gastropus</i> Imhof, 1888		X				X		X		
	Family: Lecanidae										
	<i>Lecane bulla</i> (Gosse, 1851)	X	X	X			X	X			
	<i>Lecane closterocerca</i> (Schmarda, 1859)						X				
	<i>Lecane luna</i> (Müller, 1776)			X	X	X	X				
	* <i>Lecane mira</i> (Murray, 1913)						X		X		
	<i>Lecane papuana</i> (Murray, 1913)	X						X			
	* <i>Lecane undulata</i> Hauer, 1938.	X									
	Family: Lepadellidae										
	<i>Colurella adriatica</i> Ehrenberg, 1831			X	X						
	Family: Mytilinidae										
	* <i>Mytilina mucronata</i> (Müller, 1773)	X	X					X	X	X	
	Family: Notommatidae										
	<i>Cephalodella</i> Bory de St. Vincent, 1826	X					X				X
	<i>Eosphora</i> Ehrenberg, 1830							X			
	* <i>Monommata longiseta</i> (Müller, 1786)			X		X					X
	Family: Proalidae										
	* <i>Proales daphnicola</i> Thompson, 1892		X								
	Family: Trichocercidae										
	* <i>Trichocerca cylindrica</i> (Imhof, 1891)									X	X
	* <i>Trichocerca multicrinis</i> (Kellcott, 1897)		X				X				
	<i>Trichocerca pusilla</i> (Jennings, 1903)		X				X	X	X	X	
	Family: Trichotriidae										
	* <i>Macrochaetus subquadratus</i> (Perty, 1850)										X
	Family: Synchaetidae										

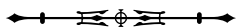


Table 2. Taxa	P1	P2	P3	P4	P5	P6	P7	P8	(Continued)
<i>Ploesoma lenticulare</i> Herrick, 1885									X
* <i>Polyarthra dolichoptera</i> Idelson, 1925	X					X	X		X
<i>Polyarthra vulgaris</i> Carlin, 1943	X	X					X		X
<i>Synchaeta stylata</i> Wierzejski, 1893							X		X
PROTOZOA									
AMEBOZOA									
Order: Arcellinida									
Family: Arcellidae									
* <i>Arcella brasiliensis</i> A.M.Cunha, 1913		X			X				X
* <i>Arcella conica</i> (Playfair, 1918)				X	X	X		X	
* <i>Arcella costata</i> Ehrenberg, 1847						X			
* <i>Arcella crenulata</i> Deflandre, 1928			X		X	X	X		X
* <i>Arcella gandalfi</i> Féres, Porfirio-Sousa, Ribeiro, Rocha, Sterza, Souza, Soares and Lahr, 2016				X					
* <i>Arcella gibbosa</i> Penard, 1890								X	X
* <i>Arcella hemisphaerica</i> Perty, 1852		X	X	X	X		X		
* <i>Arcella hemisphaerica</i> forma <i>undulata</i> Deflandre, 1928						X			
* <i>Arcella mitrata</i> Leidy, 1876						X			
* <i>Arcella vulgaris</i> Ehrenberg, 1830	X	X	X	X	X	X	X	X	X
* <i>Galeripora discoides</i> (Ehrenberg, 1871) González-Miguéns et al. 2021						X			
* <i>Galeripora megastoma</i> (Penard, 1902)				X					
Family: Centropyxidae									
* <i>Centropyxis aculeata</i> (Ehrenberg, 1832) Stein, 1859	X		X	X	X	X			
* <i>Centropyxis constricta</i> (Ehrenberg, 1841) Deflandre, 1929	X								
* <i>Centropyxis sylvatica</i> (Deflandre, 1929) Bonnet and Thomas, 1955	X								
Family: Cylindriflugidae									
* <i>Cylindriflugia acuminata</i> (Ehrenberg, 1838)	X				X				
* <i>Cylindriflugia elegans</i> (Penard, 1890)	X					X	X		
* <i>Cylindriflugia oblonga</i> (Ehrenberg, 1838)	X		X	X	X	X	X		
Family: Diffugiidae									
* <i>Diffugia brevicolla</i> Cash & Hopkinson, 1909	X		X	X	X	X			
* <i>Diffugia limnetica</i> (Levander, 1900) Penard, 1902	X								
* <i>Diffugia lobostoma</i> (Leidy, 1879)			X					X	
* <i>Diffugia nodosa</i> (Leidy, 1879)				X					
* <i>Diffugia papillomata</i> Gauthier-Lièvre et Thomas, 1958						X			
* <i>Lagenodiffugia vas</i> (Leidy, 1874) Medioli e Scott, 1983			X		X				
<i>Lamtopyxis</i> Bonnet, 1974						X			
* <i>Protocucurbitella coroniformis</i> Gauthier-Lièvre & Thomas, 1960	X								
Family: Heleoperidae									
* <i>Heleopera petricola</i> Leidy, 1879									X



Table 2.	Taxa	P1	P2	P3	P4	P5	P6	P7	P8	(P9)	(P10)
	Family: Hyalospheniidae										
	* <i>Hyalosphenia nobilis</i> Cash, 1909			X							
	* <i>Hyalosphenia subflava</i> Cash, 1909	X		X	X						X
	Family: Lesquereusiidae										
	* <i>Lesquereusia spiralis</i> Ehrenberg, 1840	X					X				
	Family: Netzeiliidae										
	* <i>Netzelia corona</i> (Wallich, 1864)						X				
	* <i>Netzelia oviformis</i> (Cash, 1909) Ogden, 1979	X	X	X			X	X			X
	Family: Plagiopyxidae										
	<i>Bullinularia</i> Penard, 1911	X		X	X	X					X
	* <i>Plagiopyxis declivis</i> Bonnet, 1955	X									
	Family: Trigonopyxidae										
	* <i>Cyclopyxis arcelloides</i> (Penard, 1902) Deflandre, 1929						X		X		
	* <i>Cyclopyxis impressa</i> (Daday, 1905) Da Cunha, 1913		X	X	X						
	CHROMISTA										
	CERCOZOA										
	Order: Euglyphida										
	Family: Euglyphidae										
	* <i>Euglypha filifera</i> Penard, 1890					X					
	* <i>Euglypha rotunda</i> Wailes & Penard, 1911	X						X			X
	Family: Trinematidae										
	* <i>Trinema complanatum</i> Penard, 1890							X			
	* <i>Trinema enchelys</i> (Ehrenberg, 1838) Leidy, 1878	X								X	
	CILIOPHORA										
	Order: Choreotrichida										
	Family: Codonellidae										
	<i>Codonaria</i> Kofoid & Campbell, 1939					X					
	<i>Codonella</i> Haeckel, 1873	X									
	* <i>Codonella nationalis</i> Brandt, 1906										X
	* <i>Tintinnopsis acuminata</i> Daday, 1887	X						X	X	X	X
	* <i>Tintinnopsis beroidea</i> Stein, 1867	X				X					
	* <i>Tintinnopsis campanula</i> (Ehrenberg, 1840)	X									
	* <i>Tintinnopsis fimbriata</i> Meunier, 1919									X	
	* <i>Tintinnopsis lobiancoi</i> Daday, 1887	X									
	* <i>Tintinnopsis radix</i> (Imhof, 1886)								X		
	* <i>Tintinnopsis rotundata</i> Kofoid & Campbell, 1929					X		X			
	Family: Codonellopsidae										
	* <i>Codonellopsis morchella</i> (Cleve) Jörgensen, 1924	X									
	Family: Tintinnidiidae										
	* <i>Leprotintinnus simplex</i> Schmidt, 1902	X				X					

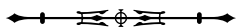


Table 2.

(Conclusion)

Taxa	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10
* <i>Tintinnidium fluviatile</i> Stein, 1863	X									
GASTROTRICHA										
Order: Chaetonotida										
Family: Chaetonotidae										
<i>Chaetonotus</i> Ehrenberg, 1830										X
Others (aloc-tone)										
NEMATODA										
Order: Dorylaimida										
Family: Dorylaimidae										
<i>Prodorylaimus</i> Andrassy, 1959			X			X				
INSECTA										
Order: Diptera										
Family: Dixidae										
<i>Dixa</i> Meigen, 1818				X						

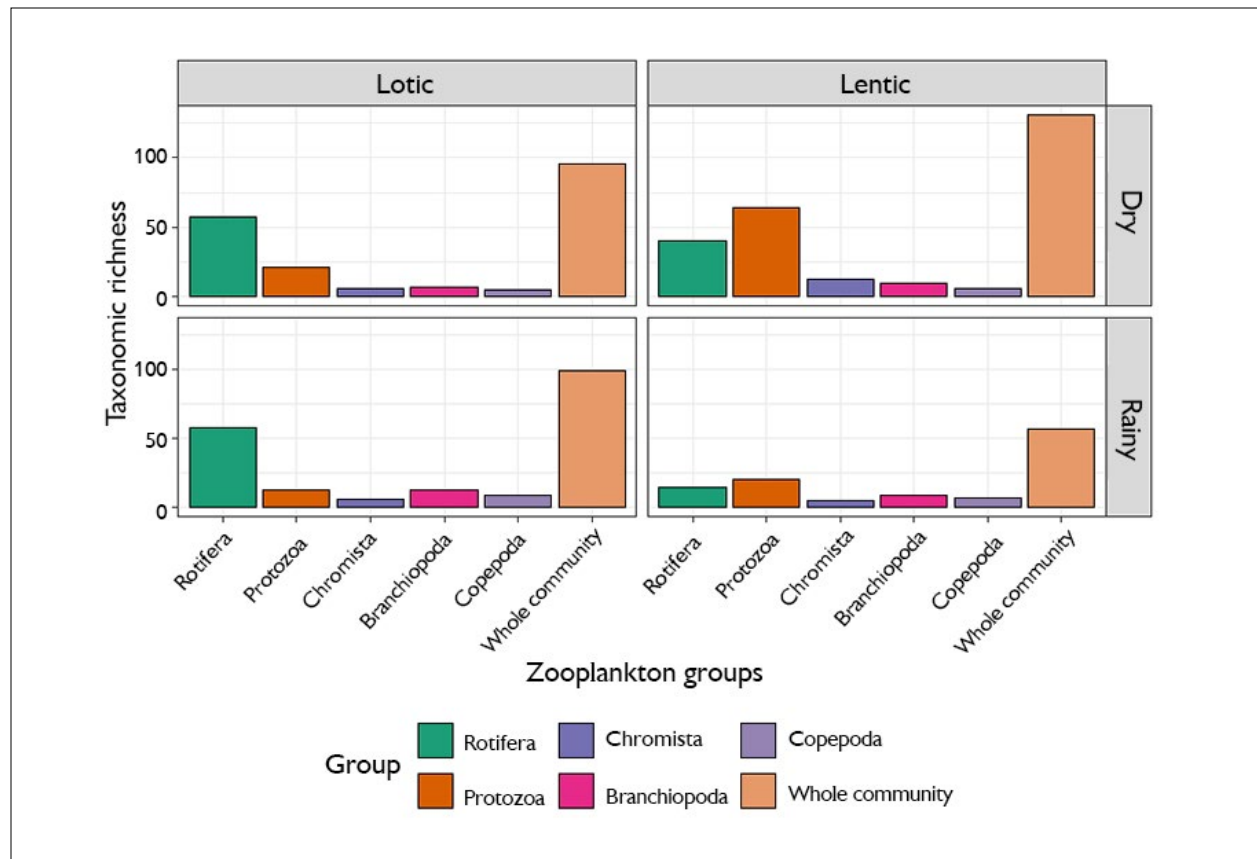
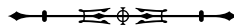


Figure 2. Difference in zooplankton group richness between lotic and lentic environments and between rainy and dry periods. On the X-axis, from left to right: Rotifera, Protozoa, Chromista, Branchiopoda, Copepoda and the whole community. Source: Author (2026).



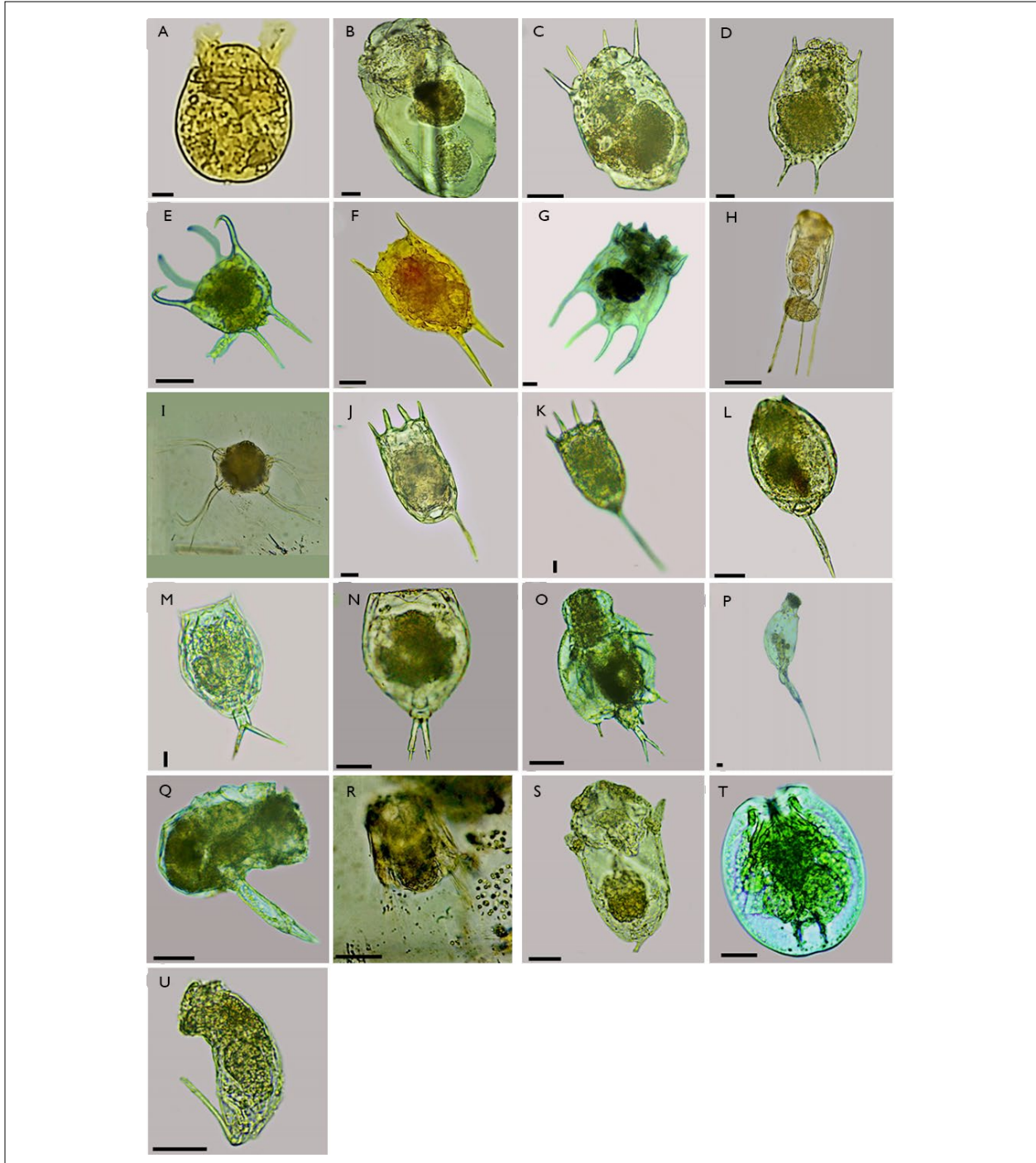


Figure 3. Rotifer taxa recorded in freshwater environments of Parintins, Amazonas, Brazil: A) *Ascomorpha saltans*, B) *Asplanchna priodonta*, C) *Brachionus budapestinensis*, D) *Brachionus forficula*, E) *Brachionus gessneri*, F) *Brachionus havanaensis*, G) *Plationus patulus* var. *macracanthus*, H) *Filinia opoliensis*, I) *Hexarthra mira*, J) *Keratella tropica*, K) *Keratella cochleares*, L) *Lecane bulla*, M) *Lecane mira*, N) *Lecane papuana*, O) *Macrochaetus subquadratus*, P) *Monommata longiseta*, Q) *Ploesoma lenticulare*, R) *Polyarthra dolichoptera*, S) *Synchaeta stylata*, T) *Testudinella patina*, U) *Trichocerca pusilla*. Scale bar: 2 μ m. Source: Author (2026).

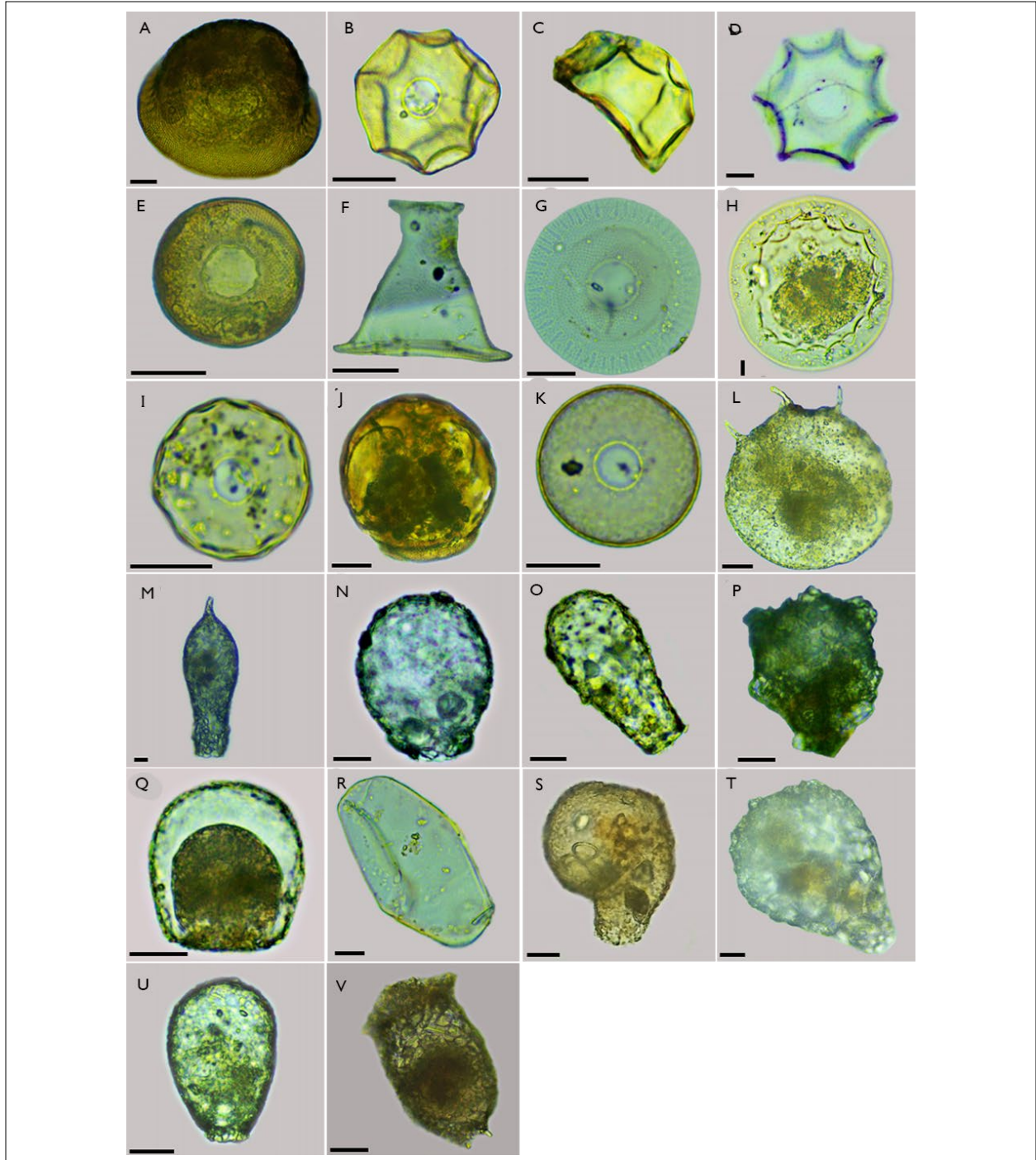


Figure 4. Protozoa taxa recorded in freshwater environments of Parintins, Amazonas, Brazil: A) *Arcella brasiliensis*, B) *Arcella conica* (basal view), C) *Arcella conica* (lateral view), D) *Arcella costata*, E) *Arcella crenulata*, F) *Arcella gandalfi*, G) *Arcella gandalfi* (basal view), H) *Arcella gibbosa*, I) *Arcella hemisphaerica*, J) *Arcella mitrata*, K) *Arcella vulgaris*, L) *Centropyxis aculeata*, M) *Cylindriflugia acuminata*, N) *Diffflugia brevicolla*, O) *Cylindriflugia oblonga*, P) *Diffflugia nodosa*, Q) *Heleopera petricola*, R) *Hyalosphenia subflava*, S) *Lesquereusia spiralis*, T) *Nebela*, U) *Netzelia oviformis*, V) *Protocucurbitella coroniformis*. Scale bar: 2 μ m. Source: Author (2026).

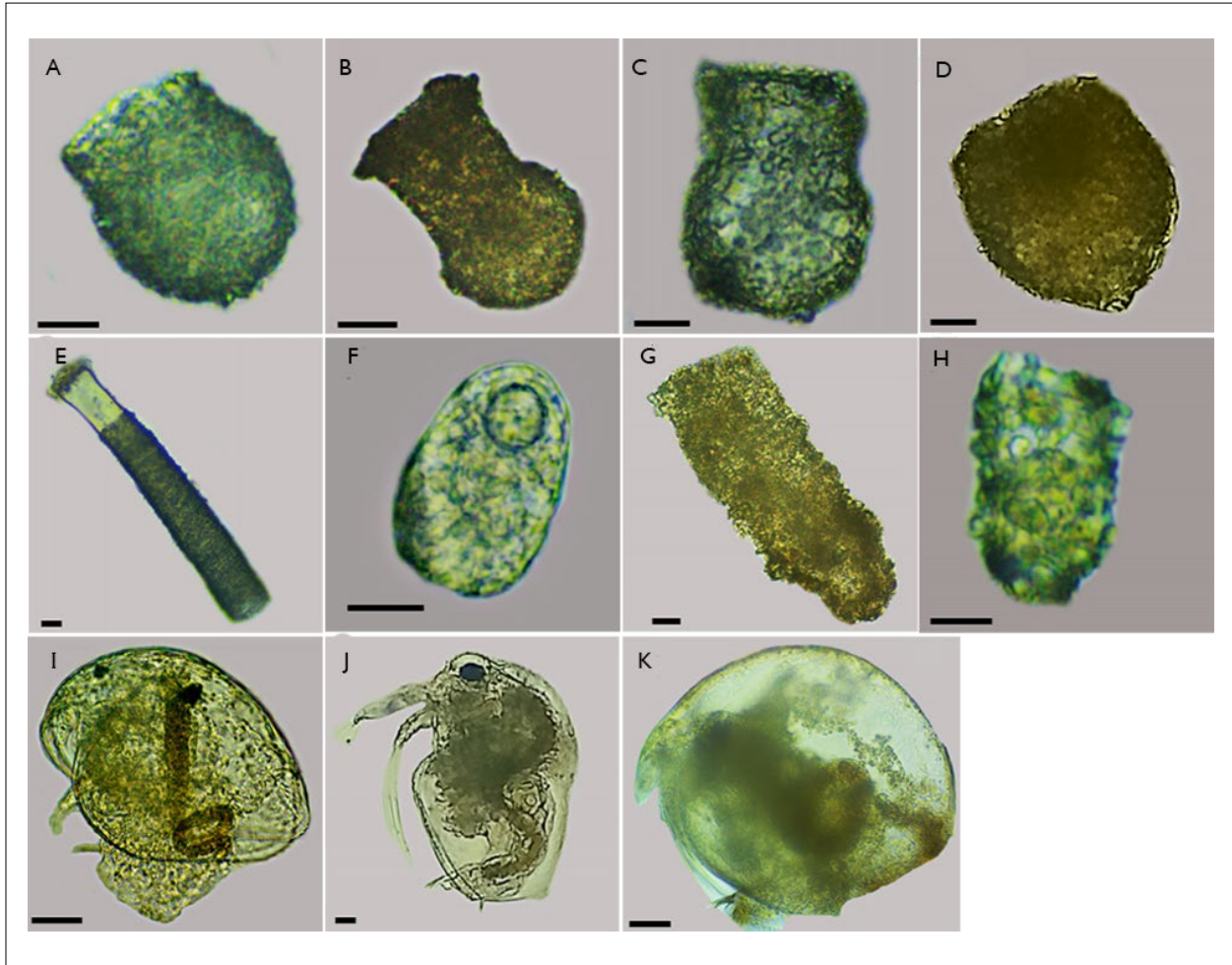


Figure 5. Chromista (A-H) and Diplostraca (I-K) taxa recorded in freshwater environments of Parintins, Amazonas, Brazil: A) *Codonaria*, B) *Codonella*, C) *Codonella nationalis*, D) *Codonellopsis morchella*, E) *Leprotintinnus simplex*, F) *Trinema complanatum*, G) *Tintinnopsis acuminata*, H) *Tintinnopsis beroidea*, I) *Alonella*, J) *Bosmina longirostris*, K) *Chydorus sphaericus*. Scale bar: 2 μm . Source: Author (2026).

Rotifera, protozoa, chromista, and branchiopoda accounted for 26, 27, nine, and six species, respectively, occurring exclusively in lentic environments. In contrast, lotic environments harbored 13 rotifera, two protozoa, two chromista, and one branchiopoda species. With respect to seasonality, 11 rotifer taxa, two protozoan taxa, five chromista taxa, and three branchiopoda taxa were recorded exclusively during the rainy period, whereas 27 rotifer taxa, 49 protozoa taxa, 10 chromista taxa, and six branchiopoda taxa occurred only during the dry period (Appendix 1). *Arcella vulgaris* was the most frequent species in the samples.

DISCUSSION

Our study revealed a higher richness of rotifera, followed by protozoa, chromista, and branchiopoda, a pattern commonly reported for inland water environments in the Amazon Basin (Table 3; Robertson & Hardy, 1984; Keppeler, 2003; L. Santos et al., 2022; Brito et al., 2015; Costa et al., 2016a). The prevalence of rotifera is closely associated with their high reproductive rates, short life cycles, and efficient conversion of primary production into biomass, with this group accounting for up to 30% of total plankton biomass in some freshwater systems.

In addition, rotifera exhibit a broad feeding spectrum and in environments subject to elevated organic pollution high ecological resilience, allowing them to persist even (Oliveira et al., 2015; Gadelha et al., 2022).

Table 3. Occurrence of the main zooplankton groups in different Amazonian aquatic environments, indicating water type and supporting literature. Hydrographic basins and main river systems are indicated in bold. (Continue)

Environment	Water category	Rotifera	Branchiopoda	Copepoda	Protozoa	Chromista	Main source
Amazon-Solimões River System	White	110		17			Robertson and Hardy (1984)
Calado Lake	White		8				Robertson and Hardy (1984)
Camaleão Lake	White	175					Koste et al. (1984)
Castanho Lake	White		16				Robertson and Hardy (1984)
Jacaretinga Lake	White		12				Robertson and Hardy (1984)
Redondo Lake	White		5				Robertson and Hardy (1984)
Manacuri Lake	White		16				Robertson and Hardy (1984)
Branco River	White	11	1				Robertson and Hardy (1984)
Madeira River	White	60		7			Robertson and Hardy (1984)
		130	55	28	105		Souza et al. (2021)
Maracá-Roraima Island	White	159					Koste and Robertson (1990)
Cuiabá River marginal lakes	White	79	30	6			Neves et al. (2003)
Acre river							
Amapá Lake, Pirapora Lake	White	38	6	2			Keppeler (2003)
Amapá Lake	White	30	5	3			Keppeler and Hardy (2004)
Guamá River	White	30					Gadelha et al. (2022)
Juruá River							
Cigana Lake	White	37	2				L. Santos et al. (2022)
Novo Lake	White	49	2				L. Santos et al. (2022)
Verde Lake	White	48	3				L. Santos et al. (2022)
Moju Lake	White	41	2				L. Santos et al. (2022)



Table 3.

(Continue)

Environment	Water category	Rotifera	Branchiopoda	Copepoda	Protozoa	Chromista	Main source
Santo Elias Lake	White	36	3				L. Santos et al. (2022)
Curupêrê-Dendê River	White	37	8	8	27	11	Costa et al. (2016a)
Pará River	White	30	7	4	8	4	Costa et al. (2016b)
Amazonian floodplain lakes (Solimões and Amazon Rivers)	White				70	1	Arrieira et al. (2016)
Amazon Basin							
Pacu Lake	White	13	5	3			Ghidini et al. (2018)
Sucuriju Lake	White	6	4	7			Ghidini et al. (2018)
Itapaíuna Lake	White	3	2	7			Ghidini et al. (2018)
Araçazinho Lake	White	6	7	11			Ghidini et al. (2018)
Lagoa da Francesa	White	11	3	1	15	10	This is study
Lagoa Azul Lake	Black	18	1	2	5		This is study
Lago do Zé Açú Lake	Black	14	2	3	3	3	This is study
Amazonas-Macurany várzea	White	20	4		6	4	This is study
Canta Galo Springs	Black	27	8		53	5	This is study
Mamuru River	Black	21	3	2	8	3	This is study
Negro River	Black	50	7	18			Robertson and Hardy (1984)
Cristalino Lake	Black		6				Robertson and Hardy (1984)
Tarumã-Mirim Lake	Black		12				Robertson and Hardy (1984)
Guedes Lake	Black		7				Robertson and Hardy (1984)
Caju Lake	Black		5				Robertson and Hardy (1984)
Prato Lake	Black		3				Robertson and Hardy (1984)
Utinga-Pará system Bolonha Lake	Black	30	19	7			Melo et al. (2006)
Tapajós River	Clear	127		8			Robertson and Hardy (1984)
Paroni Lake	Clear	76					Koste (1974)

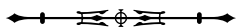


Table 3.

(Conclusion)

Environment	Water category	Rotifera	Branchiopoda	Copepoda	Protozoa	Chromista	Main source
Tocantins River	Clear	34	15	8			Espíndola et al. (2000)
Tocantins River	Clear	21	5-7	14			Robertson and Hardy (1984)
Tauá Lake	Clear	6					Robertson and Hardy (1984)
Paulo Pool	Clear	3					Robertson and Hardy (1984)
Lower Nhamundá River	Clear	145					Brandorff et al. (1982)
Trombetas River							
Macaco Lake	Clear	48					Koste (1989)
Batata Lake (impacted by bauxite waste)	Clear	98	10	7			Bozelli et al. (2000)
Xingu River (lentic/lotic)	Clear	55-87	10-16	1-2			Brito et al. (2015)
Ilha Grande Lake	Clear	56	6	3			Brito et al. (2015)
Pimental Lake	Clear	97	5	4			Brito et al. (2015)
Curuá-Una River (Reservoir)	Clear				51		Lansac-Tôha et al. (2008)
Amazon Region		397	107	88	159		Elmoor-Loureiro et al. (2022)

All zooplankton groups exhibited greater taxonomic richness in lentic environments and during the dry period. In lentic environments, increased richness during the dry period can be attributed to hydrological changes associated with water-level drawdown. As water levels decrease, lakes become shallower, leading to the concentration of organisms and increased availability of nutrients and seston in the water column, either through sediment resuspension or enhanced local inputs of organic matter (Roberto et al., 2009; Arrieira et al., 2016). These conditions promote higher primary productivity and favor the development of zooplankton communities (Bonecker et al., 2013). Furthermore, the greater hydrodynamic stability typically observed in lentic environments during the dry season provides favorable conditions for the establishment and persistence of planktonic species.

Lake margins, in particular, tend to support higher species richness than central areas due to increased

environmental heterogeneity associated with aquatic macrophytes. Macrophyte stands enhance food availability, increase structural complexity, and provide refuge from predators, allowing the coexistence of planktonic and periphytic species (Buosi et al., 2011). During the rainy season, rising water levels and increased connectivity with flooded areas expand available habitats but promote organism dispersal and population dilution. As a result, local richness may decrease despite higher regional connectivity, in accordance with predictions of the flood pulse concept (Junk et al., 2011).

In lotic environments, the lower richness observed compared to lentic systems primarily reflects less stable hydrodynamic conditions, characterized by higher current velocity and shorter water residence time. These conditions limit the development and persistence of typically planktonic organisms (Park et al., 2023). Increased current



velocity and turbulence shift environmental conditions from lentic to lotic, directly impairing zooplankton reproductive and feeding activities, such as predation and filtration (Ning et al., 2013; Park et al., 2023).

During the dry season, reduced river discharge may locally favor zooplankton accumulation in marginal zones and low-flow areas, allowing the occurrence of taxa exclusive to this period. In contrast, during the rainy season, increase discharge intensifies longitudinal transport and organism dilution, reducing local richness and favoring species with greater tolerance to hydraulic drift (Bonecker et al., 2013; Arrieira et al., 2016). In this context, the seasonal flood pulse of the Amazon plays a central role in structuring zooplankton communities by regulating the alternation between phases of concentration, dispersion, and connectivity among rivers, lakes, and floodplains, thereby shaping spatial and temporal patterns of diversity in both lotic and lentic environments (Melack & Forsberg, 2001; K. Santos et al., 2022).

Protozooplankton groups, including Chromista and Protozoa, remain among the least studied component of tropical freshwater ecosystems. In these environments, testate amoebae (Arcellinida and Diffugiidae) generally prevail, followed by ciliates, flagellates, and naked amoebae (Castilho-Noll et al., 2023). In the present study, species of the family Codonellidae (Ciliophora) were recorded, a group more commonly associated with brackish and marine environments. The occurrence of ciliates across diverse habitats reflects their high tolerance and adaptability to a wide range of physical and chemical conditions (Vilas-Boas et al., 2020). Studies conducted in the Guamá River, a tidal system under oceanic influence, indicate that such species can be transported from estuarine areas and persist in environments with very low salinity (Gadelha et al., 2023).

The order Arcellinida was the most diverse protozoan group in the studied environments, consistent with findings from other tropical freshwater systems. This order represents the most species-rich assemblage of testate amoebae, currently comprising approximately

687 described species (Castilho-Noll et al., 2023). Within Arcellinida, *Arcella* is one of the most extensively studied genera, exhibiting high morphological plasticity and a wide geographic distribution, particularly in tropical and subtropical regions (Zapata-Muñoz et al., 2021).

This study documents the first record of *Arcella gandalfi* Féres et al., for Parintins and for the state of Amazonas. This species was recently described and has so far been recorded in South America, where it may serve as a flagship species for the continent (Féres et al., 2016). Previous records have been identified in Brazil, specifically Minas Gerais (Gameleira River), Tocantins (*Vereda Bomfim*), Paraná (Paraná River), Amapá (Araguaia River), and Rio de Janeiro (Veiga Lagoon; Féres et al., 2016), and in Colombia (Caño Siete Vueltas and Caño Grande, Acacias River; Zapata-Muñoz et al., 2021).

Arcella gandalfi has been reported from freshwater systems and coastal lagoons, typically occurring in waters with temperatures above 21 °C and pH ranging from acid (4.4) to neutral (7.38), and showing tolerance to wide ranges of conductivity (16.1–941 $\mu\text{S}/\text{cm}$), total phosphorus ($< 0.030\text{--}4.700 \mu\text{g}/\text{L}$), and dissolved oxygen (0.37–9.31 mg/L) (Féres et al., 2016; Zapata-Muñoz et al., 2021). In this study, the species was recorded in lentic environments characterized black, warm and acidic waters, in agreement with previous reports.

Although this record expands the known geographic distribution of *A. gandalfi* into the lower Amazonas region, its broader distribution along the Amazon River and its tributaries cannot be ruled out. The presence of this species suggests a broad ecological tolerance and potential connectivity among Amazonian aquatic habitats and other Neotropical regions. This finding represents an important contribution to the knowledge of testate amoebae diversity and biogeography in the Amazon Basin. Future studies should investigate whether *A. gandalfi* forms stable populations in the region or represents a sporadic occurrence associated with passive dispersal processes.



CONCLUSION

This study expands current knowledge of the composition and spatial distribution of zooplankton communities in Parintins, in the lower Amazonas region, by documenting 118 taxa across lentic and lotic environments. The identification of 79 taxa recorded for the first time in Parintins highlights the still-limited knowledge of zooplankton diversity in Amazonian freshwater ecosystems and emphasizes the importance of local-scale taxonomic inventories in underexplored areas. The observed patterns of richness, with higher diversity in lentic environments and during the dry season, reinforce the role of hydrological dynamics and habitat heterogeneity in structuring zooplankton communities in the Amazon Basin. In addition, the occurrence of taxa with broad ecological tolerances, including species typically associated with other aquatic systems, underscores the potential for dispersal, adaptability, and connectivity among the Amazonian freshwater habitats. Finally, our findings highlight the need to strengthen biodiversity research initiatives and to promote graduate-level training focused on the taxonomy and ecology of zooplankton in tropical regions.

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AUTHOR'S CONTRIBUTION

E. S. Gadelha contributed to conceptualization, methodology, data curation, data analysis and writing (original draft, revision and editing); J. M. S. Coêlho contributed to research and writing (revision and editing); M. R. Casartelli contributed to research and writing (revision and editing); E. A. Lehmkuhl contributed to research, formal analysis and writing (revision and editing); A. M. da Silva-Lehmkuhl contributed to methodology, research, project management, funding acquisition, supervision and writing (original draft, revision and editing).

Appendix 1. List of zooplankton species found on Parintins Island by seasonal period.

(Continue)

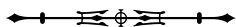
Groups	Season	
	Rainy	Dry
Copepode		
Order: Cyclopoida		
Family: Cyclopidae		
<i>Microcyclops varicans varicans</i> (Sars G.O., 1863)		X
<i>Microcyclops rubellus</i> (Lilljeborg, 1901)	X	X
Cladocera		
Order: Anomopoda		
Family: Chydoridae		
<i>Alonella</i> G.O. Sars, 1862		X
<i>Chydorus</i> Leach, 1816		X
<i>Chydorus sphaericus</i> (O.F. Müller, 1776)		X
<i>Leydigia</i> Kurz, 1875		X
<i>Monospilus dispar</i> G.O. Sars, 1862		X
Family: Bosminidae		
<i>Bosmina (Bosmina) longirostris</i> (O.F. Müller, 1785)	X	
<i>Bosminopsis deitersi</i> Richard, 1895	X	
Family: Macrothricidae		
<i>Macrothrix laticornis</i> (Jurine, 1820)		X
Family: Moinidae		
<i>Moina micrura</i> Kurz, 1875	X	X
Order: Ctenopoda		
Family: Sididae		
<i>Diaphanosoma</i> Fischer, 1850	X	
Nematoda		
Order: Dorylaimida		
Family: Dorylaimidae		
<i>Prodorylaimus</i> Andrassy, 1959		X
Gastrotricha		
Order: Chaetonotida		
Family: Chaetonotidae		
<i>Chaetonotus</i> Ehrenberg, 1830		X
Insecta		
Order: Diptera		
Family: Dixidae		
<i>Dixa</i> Meigen, 1818		X



Appendix 1.

(Continue)

Groups	Season	
	Rainy	Dry
Rotifera		
Order: Adinetida		
Family: Adinetidae		
<i>Adineta vaga</i> (Davis, 1873)	X	X
Order: Flosculariaceae		
Family: Hexarthridae		
<i>Hexarthra mira</i> (Hudson, 1871)		X
Family: Testudinellidae		
<i>Testudinella patina</i> (Hermann, 1783)	X	X
Family: Trochosphaeridae		
<i>Filinia opoliensis</i> (Zacharias, 1898)	X	
<i>Filinia terminalis</i> (Plate, 1886)	X	
Order: Ploima		
Family: Asplanchnidae		
<i>Asplanchna priodonta</i> Gosse, 1850		X
Family: Brachionidae		
<i>Anuraeopsis fissa</i> Gosse, 1851		X
<i>Brachionus angularis</i> Gosse, 1851	X	
<i>Brachionus bidentata</i> Anderson, 1889		X
<i>Brachionus budapestinensis</i> Daday, 1885	X	
<i>Brachionus caudatus</i> Barrois & Daday, 1894		X
<i>Brachionus diversicornis</i> (Daday, 1883)	X	
<i>Brachionus falcatus</i> Zacharias, 1898		X
<i>Brachionus forficula</i> var. <i>inegalis</i> Rodewald, 1940	X	
<i>Brachionus gessneri</i> Hauer, 1956		X
<i>Brachionus havanaensis</i> Rousselet, 1911		X
<i>Brachionus patulus</i> var. <i>macracanthus</i> (Daday, 1905)		X
<i>Brachionus plicatilis</i> Müller, 1786	X	
<i>Brachionus zahniseri</i> Ahlstrom, 1934		X
<i>Keratella americana</i> Carlin, 1943		X
<i>Keratella cochlearis</i> (Gosse, 1851)		X
<i>Keratella tropica</i> (Apstein, 1907)	X	
Family: Euchlanidae		
<i>Euchlanis dilatata</i> Ehrenberg, 1832		X
Family: Gastropidae		
<i>Ascomorpha ovalis</i> (Bergendal, 1892)		X
<i>Ascomorpha saltans</i> Bartsch, 1870		X
<i>Gastropus</i> Imhof, 1898		X
Family: Lecanidae		



Appendix 1.

(Continue)

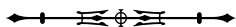
Groups	Season	
	Rainy	Dry
<i>Lecane bulla</i> (Gosse, 1851)	X	X
<i>Lecane luna</i> (Müller, 1776)		X
<i>Lecane mira</i> (Murray, 1913)		X
<i>Lecane papuana</i> (Murray, 1913)		X
<i>Lecane undulata</i> Hauer, 1938.	X	
<i>Monostyla closteroerca</i> Schmarida, 1859		X
Family: Lepadellidae		
<i>Colurella adriatica</i> Ehrenberg, 1831		X
Family: Mytilinidae		
<i>Mytilina mucronata</i> (Müller, 1773)	X	
Family: Notommatidae		
<i>Cephalodella</i> Bory de St. Vincent, 1826		X
<i>Eosphora</i> Weber, 1918		X
<i>Monommata</i> Bartsch, 1870		X
Family: Proalidae		
<i>Proales daphnicola</i> Thompson, 1892	X	
Family: Trichocercidae		
<i>Trichocerca cylindrica</i> (Imhof, 1891)		X
<i>Trichocerca multicrinis</i> (Kellicott, 1897)	X	X
<i>Trichocerca pusilla</i> (Jennings, 1903)	X	X
Family: Trichotriidae		
<i>Macrochaetus subquadratus</i> (Perty, 1850)		X
Family: Synchaetidae		
<i>Ploesoma lenticulare</i> Herrick, 1885		X
<i>Polyarthra dolichoptera</i> Idelson, 1925	X	X
<i>Polyarthra vulgaris</i> Carlin, 1943	X	
<i>Synchaeta stylata</i> Wierzejski, 1893	X	X
Protozoa		
Order: Arcellinida		
Family: Arcellidae		
<i>Arcella brasiliensis</i> Cunha, 1913	X	X
<i>Arcella conica</i> (Playfair, 1918)	X	X
<i>Arcella costata</i> Ehrenberg, 1847		X
<i>Arcella crenulata</i> Deflandre, 1928		X
<i>Arcella gandalfi</i> Féres, Porfírio-Sousa, Ribeiro, Rocha, Sterza, Souza, Soares and Lahr, 2016		X
<i>Arcella gibbosa</i> Penard, 1890		X
<i>Arcella hemisphaerica</i> Perty, 1852		X
<i>Arcella hemisphaerica undulata</i> Deflandre, 1928		X
<i>Arcella mitrata</i> Leidy, 1876		X
<i>Arcella vulgaris</i> Ehrenberg, 1832	X	X



Appendix 1.

(Continue)

Groups	Season	
	Rainy	Dry
<i>Galeripora discoides</i> (Ehrenberg, 1871) González-Miguéns et al., 2021		X
<i>Galeripora megastoma</i> (Penard, 1902)		X
Family: Centropxyidae		
<i>Centropyxis aculeata</i> (Ehrenberg, 1832) Stein, 1859		X
<i>Centropyxis constricta</i> (Ehrenberg, 1841) Deflandre, 1929		X
<i>Centropyxis sylvatica</i> (Deflandre, 1929 var.) Bonnet and Thomas, 1955	X	
<i>Trigonopyxis arcuata</i> Penard, 1912		X
Family: Diffugiidae		
<i>Diffugia acuminata</i> Ehrenberg, 1838		X
<i>Diffugia brevicollis</i> Cash & Hopkinson, 1909		X
<i>Diffugia elegans</i> Penard, 1890		X
<i>Diffugia limnetica</i> (Levander, 1900) Penard, 1902		X
<i>Diffugia lobostoma</i> (Leidy, 1879)		X
<i>Diffugia nodosa</i> (Leidy, 1879)		X
<i>Diffugia oblonga</i> Ehrenberg, 1838	X	X
<i>Diffugia papillomata</i> Gauthier-Lièvre et Thomas, 1958		X
<i>Lagenodiffugia vas</i> (Leidy, 1874) Medioli and Scott, 1983	X	X
<i>Protocucurbitella coroniformis</i> Gauthier-Lièvre & Thomas, 1960		X
Family: Heleoperidae		
<i>Heleopera petricola</i> Leidy, 1879		X
Family: Hyalospheniidae		
<i>Hyalosphenia nobilis</i> Cash & Hopkinson, 1909		X
<i>Hyalosphenia subflava</i> Cash and Hopkinson, 1909	X	X
Family: Lamtopyxidae		
<i>Lamtopyxis</i> Bonnet, 1974		X
Family: Lesquereusiidae		
<i>Lesquereusia spiralis</i> Ehrenberg, 1840	X	X
Family: Nebelidae		
<i>Nebela</i> (Leidy, 1874)		X
Family: Netzelidae		
<i>Netzelia corona</i> (Wallich, 1864)		X
<i>Netzelia oviformis</i> (Cash, 1909) Ogden, 1979		X
Family: Plagiopyxidae		
<i>Bullinularia</i> Penard, 1911	X	X
<i>Plagiopyxis declivis</i> Bonnet, 1955	X	
Family: Trigonopyxidae		
<i>Cyclopyxis arcelloides</i> (Penard, 1902)		X
<i>Cyclopyxis impressa</i> (Daday, 1905) Da Cunha, 1913	X	X



Appendix 1.

(Conclusion)

Groups	Season	
	Rainy	Dry
Kingdom: Chromista		
Cercozoa		
Order: Euglyphida		
Family: Euglyphidae		
<i>Euglypha filifera</i> Penard, 1890		X
<i>Euglypha rotunda</i> Wailes & Penard, 1911	X	
Family: Trinematidae		
<i>Trinema enchelys</i> (Ehrenberg, 1938) Leidy, 1878	X	
<i>Trinema complanatum</i> Penard, 1890		X
Ciliophora		
Order: Choreotrichida		
Family: Codonellidae		
<i>Codonaria</i> Kofoid & Campbell, 1939	X	X
<i>Codonella</i> Haeckel, 1873		X
<i>Codonella nationalis</i> Brandt, 1906		X
<i>Tintinnopsis acuminata</i> Daday, 1887	X	
<i>Tintinnopsis beroidea</i> Stein, 1867	X	X
<i>Tintinnopsis campanula</i> Ehrenberg, 1840	X	
<i>Tintinnopsis lobiancoi</i> Daday, 1887		X
<i>Tintinnopsis radix</i> (Imhof, 1886)		X
<i>Tintinnopsis rotundata</i> Kofoid & Campbell, 1929		X
Family: Codonellopsidae		
<i>Codonellopsis morchella</i> (Cleve) Jörgensen, 1924		X
Family: Tintinnidiidae		
<i>Leprotintinnus simplex</i> Schmidt, 1902	X	X
<i>Tintinnidium fluviatile</i> Stein, 1863	X	



BOLETIM DO MUSEU PARAENSE EMÍLIO GOELDI. CIÊNCIAS NATURAIS

INSTRUÇÕES AOS AUTORES

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O **Boletim do Museu Paraense Emílio Goeldi. Ciências Naturais** tem como missão publicar trabalhos originais em biologia (zoologia, botânica, biogeografia, ecologia, taxonomia, anatomia, biodiversidade, vegetação, conservação da natureza) e geologia. A revista aceita colaborações em português, espanhol e inglês (Inglaterra) para as seguintes seções:

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Notas de Pesquisa – relato preliminar sobre observações de campo, dificuldades e progressos de pesquisa em andamento, ou em fase inicial, enfatizando hipóteses, comentando fontes, resultados parciais, métodos e técnicas utilizados.

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Resenhas Bibliográficas – texto descritivo e/ou crítico de obras publicadas na forma impressa ou eletrônica.

Ética na publicação

As submissões devem atender as diretrizes do Committee on Publication Ethics (COPE), cujo texto original em inglês pode ser consultado em https://publicationethics.org/files/Code_of_conduct_for_journal_editors_1.pdf e a versão traduzida para o português em <http://www.periodicos.letras.ufmg.br/CCBP-COPE.pdf>. Essas diretrizes devem nortear editores, avaliadores e autores quanto a questões éticas concernentes ao processo editorial e de avaliação por pares, a fim de prevenir com relação à má conduta na publicação. Aos Editores, ao Conselho Científico e aos consultores científicos ad hoc cabe a responsabilidade ética do sigilo e da colaboração voluntária para garantir a qualidade científica das publicações e da revista. Aos autores cabe a responsabilidade da veracidade das informações prestadas, do depósito dos materiais estudados em instituições legais, quando couber, e o cumprimento das leis locais que regem a coleta, o estudo e a publicação dos dados. Recomendamos a leitura do “Código de boas práticas científicas”, elaborado pela Fundação de Amparo à Pesquisa do Estado de São Paulo (FAPESP), disponível em https://fapesp.br/boaspraticas/FAPESP-Codigo_de_Boas_Praticas_Cientificas_2014.pdf. A revista passou a adotar nas submissões o sistema de detecção de plágio Similarity Check, da Crossref. Títulos que forem verificados como similares a publicações anteriores serão rejeitados. Caso necessário, serão publicadas retratações e correções, baseadas nos procedimentos recomendados no “Retraction Guidelines”, do COPE, disponível em <https://publicationethics.org/files/cope-retraction-guidelines-v2.pdf>.

Apresentação de originais

O Boletim recebe contribuições somente em formato digital. Os arquivos digitais dos artigos devem ser submetidos online na plataforma via o site da revista (<https://boletimcn.museu-goeldi.br/ojs/?journal=bcnaturais&page=login>), fornecendo obrigatoriamente as informações solicitadas pela plataforma.

Cadastramento

O(s) autor(es) deve(m) realizar o cadastro, criando uma conta pessoal na plataforma online, na seção “Cadastro” (<https://boletimcn>).

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Encaminhamento

1. Faça seu cadastro como Autor ou, caso já possua cadastro, clique em Acesso (<https://boletimcn.museu-goeldi.br/ojs/?journal=bcnaturais&page=login>), para iniciar a Submissão de seu trabalho;
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5. Na opção “Carregar arquivo de submissão”, selecione os itens “Folha de Rosto”, “Texto do artigo” e “Lista de avaliadores” e faça o upload dos respectivos arquivos. Caso haja imagens, elas devem ser carregadas também neste momento. Em seguida, em “Metadados”, o autor deve editar o nome do arquivo, a fim de garantir o sigilo necessário à etapa de avaliação por pares. Após isso, clique em “Concluir”;
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8. Insira o título nos idiomas solicitados – o símbolo do planeta Terra ficará verde após a inserção do título nos idiomas selecionados. O resumo também deverá constar nos idiomas solicitados;
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A revista possui um Conselho Científico. Os trabalhos submetidos são primeiramente avaliados pelo Editor ou por um dos Editores Associados. O Editor reserva-se o direito de sugerir alterações nos trabalhos recebidos ou devolvê-los, caso não estejam de acordo com os critérios exigidos para publicação.

Uma vez aceitos, os artigos seguem para avaliação por pares (peer-review). Os artigos são analisados por dois especialistas, no mínimo, que não integram a Comissão Editorial. Caso haja discordância entre os pareceres, o trabalho é submetido a outro(s) especialista(s). Caso mudanças ou correções sejam recomendadas, o trabalho é devolvido ao(s) autor(es), que terá(ão) um prazo de trinta dias para elaborar nova versão.

A publicação implica cessão integral dos direitos autorais do trabalho à revista. A declaração para a cessão de direitos autorais é enviada juntamente com a notificação de aceite do artigo. Deve ser devolvida assinada via e-mail. Todos os autores devem assinar uma declaração.

Preparação de originais

Todas as submissões devem ser enviadas por meio da plataforma de submissão online. Os originais devem ser enviados em Word, com fonte Times New Roman, tamanho 12, entrelinha 1,5, em laudas sequencialmente numeradas.

No momento da submissão, os arquivos mencionados abaixo devem ser carregados na plataforma de submissão:

O primeiro arquivo (Folha de rosto) deve conter: título (no idioma do texto e em inglês); resumo; abstract; palavras-chave e keywords. Além disso, este arquivo deve conter um parágrafo com informações sobre a contribuição de cada um dos autores, que deve ser descrito usando as seguintes categorias: 1) Administração de projeto; 2) Análise formal; 3) Aquisição de financiamento; 4) Conceituação; 5) Curadoria de dados; 6) Escrita - rascunho original; 7) Escrita - revisão e edição; 8) Investigação; 9) Metodologia; 10) Recursos; 11) Software; 12) Supervisão; 13) Validação; 14) Visualização. Cada um dos autores deve ter contribuído em pelo menos duas

destas categorias. Para mais informações sobre as contribuições dos autores, consulte: <https://www.elsevier.com/authors/policies-and-guidelines/credit-author-statement>. Este arquivo deve ser carregado como arquivo do Word.

O segundo arquivo (Texto do artigo) deve conter: título (no idioma do texto e em inglês), resumo, abstract, palavras-chave e keywords, introdução, material e métodos, resultados, discussão (a qual pode ser apresentada junto com os resultados), conclusão, agradecimentos, referências, legendas no idioma do texto e em inglês das figuras e tabelas (se for o caso). Tabelas devem ser digitadas em Word, sequencialmente numeradas, com claro enunciado. Este arquivo deve ser enviado como arquivo do Word.

Um terceiro arquivo (Lista de avaliadores), contendo o nome, titulação e e-mail de seis possíveis revisores deve ser enviado como arquivo do Word. Nesse arquivo, também podem ser especificados os revisores que devem ser evitados.

Todas as figuras (ilustrações, gráficos, imagens, diagramas etc.) (PDF com imagens) devem ser apresentadas em páginas separadas e numeradas, com as respectivas legendas no idioma do texto e em inglês, e submetidas na plataforma online como PDF. As imagens também devem ser submetidas separadamente (em arquivos individuais) e ter resolução mínima de 300 dpi e tamanho mínimo de 1.500 pixels, em formato JPEG ou TIFF, obedecendo, se possível, as proporções do formato de página do Boletim, nos limites de 16,5 cm de largura e 20 cm de altura (para uso em duas colunas) ou 8 cm de largura e 20 cm de altura (para uso em uma coluna). As informações de texto presentes nas figuras, caso possuam, devem estar em fonte Arial, com tamanho entre 7 e 10 pts. O texto deve, obrigatoriamente, fazer referência a todas as tabelas, gráficos e ilustrações.

Chaves devem ser apresentadas no seguinte formato:

1. Lagarto com 4 patas minúsculas 2
Lagarto com 4 patas bem desenvolvidas 3
2. Dígitos geralmente sem unhas, dorsais lisas..... *Bachia flavescens*
Dígitos com unhas, dorsais quilhadas.....*Bachia panoplia*
3. Mãos com apenas 4 dedos 4
Mãos com 5 dedos 5
4. Escamas dorsais lisas*Gymnophthalmus underwoodii*
Escamas dorsais quilhadas *Amapasaurus tetradactylus*
5. Cabeça com grandes placas 6
Cabeça com escamas pequenas 7
6. Placas posteriores da cabeça formam uma linha redonda.....*Alopoglossus angulatus*
Placas posteriores da cabeça formam uma linha reta *Arthrosaura kockii*
7. Etc.
Etc.

Pede-se destacar termos ou expressões por meio de aspas simples. Apenas termos científicos latinizados ou em língua estrangeira devem constar em itálico. Observar cuidadosamente as regras de nomenclatura científica, assim como abreviaturas e convenções adotadas em disciplinas especializadas. Os artigos deverão seguir as recomendações da APA 7th Edition - Citation Guide (<https://apastyle.apa.org/style-grammar-guidelines/references/examples>) para uso e apresentação de citações e de referências. Todas as obras citadas ao longo do texto devem estar corretamente referenciadas ao final do artigo.

Estrutura básica dos trabalhos

Título – No idioma do texto e em inglês (quando este não for o idioma do texto). Deve ser escrito em caixa baixa, em negrito, centralizado na página.

Resumo e Abstract – Texto em um único parágrafo, ressaltando os objetivos, métodos e conclusões do trabalho, com, no máximo, duzentas palavras, no idioma do texto (Resumo) e em inglês (Abstract). A versão para o inglês é de responsabilidade do(s) autor(es).

Palavras-chave e Keywords – Três a seis palavras que identifiquem os temas do trabalho, para fins de indexação em bases de dados.

Introdução – Deve conter uma visão clara e concisa de conhecimentos atualizados sobre o tema do artigo, oferecendo citações pertinentes e declarando o objetivo do estudo.

Material e métodos – Exposição clara dos métodos e procedimentos de pesquisa e de análise de dados. Técnicas já publicadas devem ser apenas citadas e não descritas. Termos científicos, incluindo espécies animais e vegetais, devem ser indicados de maneira correta e completa (nome, autor e ano de descrição).

Resultados e discussão – Podem ser comparativos ou analíticos, ou enfatizar novos e importantes aspectos do estudo. Podem ser apresentados em um mesmo item ou em separado, em sequência lógica no texto, usando tabelas, gráficos e figuras, dependendo da estrutura do trabalho.

Conclusão – Deve ser clara, concisa e responder aos objetivos do estudo.

Agradecimentos – Devem ser sucintos: créditos de financiamento; vinculação do artigo a programas de pós-graduação e/ou projetos de pesquisa; agradecimentos pessoais e institucionais. Nomes de instituições devem ser por extenso, de pessoas pelas iniciais e sobrenome, explicando o motivo do agradecimento.

Referências – Devem ser listadas ao final do trabalho, em ordem alfabética, de acordo com o sobrenome do primeiro autor. No caso de mais de uma referência de um mesmo autor, usar ordem cronológica, do trabalho mais antigo ao mais recente. No caso de mais de uma publicação do mesmo autor com o mesmo ano, utilizar letras após o ano para diferenciá-las. Nomes de periódicos devem ser por extenso. Teses e dissertações acadêmicas devem preferencialmente estar publicadas. Todas as referências devem seguir as recomendações da APA 7th Edition - Citation Guide:

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Capítulo de livro: Aranha, L. G., Lima, H. P., Makino, R. K., & Souza, J. M. (1990). Origem e evolução das bacias de Bragança - Viseu, S. Luís e Ilha Nova. In E. J. Milani & G. P. Raja-Gabaglia (Eds.), *Origem e evolução das bacias sedimentares* (pp. 221-234). Petrobras.

Artigo de periódico: Gans, C. (1974). New records of small amphisbaenians from northern South America. *Journal of Herpetology*, 8(3), 273-276. <http://dx.doi.org/10.2307/1563187>.

Série/Coleção: Camargo, C. E. D. (1987). *Mandioca, o "pão caboclo": de alimento a combustível* (Coleção Brasil Agrícola). Ícone.

Documento eletrônico: Instituto Brasileiro de Geografia e Estatística (IBGE) (2011). *Censo Demográfico 2010*. <https://censo2010.ibge.gov.br/>

Provas

Os trabalhos, depois de formatados, são encaminhados em PDF para a revisão final dos autores, que devem devolvê-los com a maior brevidade possível. Os pedidos de alterações ou ajustes no texto devem ser feitos por escrito. Nessa etapa, não serão aceitas modificações no conteúdo do trabalho ou que impliquem alteração na paginação. Caso o autor não responda ao prazo, a versão formatada será considerada aprovada. Os artigos são divulgados integralmente no formato PDF na página eletrônica do Boletim do Museu Paraense Emílio Goeldi. Ciências Naturais (<https://boletimcn.museu-goeldi.br/>), com acesso aberto.

Endereço para correspondência

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3 - É de responsabilidade do(s) autor(es) o conteúdo científico do artigo, o cuidado com o idioma em que ele foi concebido, bem como a coerência da versão para o inglês do título, do resumo (abstract) e das palavras-chave (keywords). Quando o idioma não estiver corretamente utilizado, o trabalho pode ser recusado.

BOLETIM DO MUSEU PARAENSE EMÍLIO GOELDI. CIÊNCIAS NATURAIS

INSTRUCTIONS FOR AUTHORS

Goals and editorial policy

The mission of the **Boletim do Museu Paraense Emílio Goeldi. Ciências Naturais** is to publish original works on Biology (zoology, botany, biogeography, ecology, taxonomy, anatomy, biodiversity, vegetation, nature conservation) and Geology. The journal accepts contributions in Portuguese, Spanish, and English (UK) for the following sections:

Articles – Scientific and original analytical papers stemming from studies and research, which effectively contribute to building knowledge in the field. Maximum length: 50 pages.

Short Communications – Preliminary reports on field observations, problems and progress of current research, emphasizing hypotheses, mentioning sources, partial results, methods and techniques used. Maximum length: 15 pages.

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Book Reviews – Text discussing recently published books in the field of natural sciences, in print or electronically. Maximum length: 5 pages.

Publication ethics

Submissions must comply with the guidelines of the Committee on Publication Ethics (COPE), the English text of which can be consulted at https://publicationethics.org/files/Code_of_conduct_for_journal_editors_1.pdf and the Portuguese version at <http://www.periodicos.letras.ufmg.br/CCBP-COPE.pdf>. These guidelines should orientate editors, reviewers, and authors with regard to ethical issues that concern the editorial and peer-review processes, in order to prevent improper publishing practices. The ethical responsibility for confidentiality during the publication process and for voluntary collaboration to ensure the scientific quality of the journal rests with the editors, the scientific board, and the ad hoc scientific consultants. The authors are responsible for the veracity of the information provided, for the deposit of the studied materials in legal institutions, when applicable, and for compliance with local laws that govern the collection, study and publication of the results. We recommend reading the "Code of Good Scientific Practice", prepared by the São Paulo Research Foundation (FAPESP) (https://fapesp.br/boaspraticas/FAPESP-Codigo_de_Boas_Praticas_Cientificas_2014.pdf). Submissions to the journal are checked with software plagiarism detection Similarity Check, by Crossref. Submissions found to be similar to previous publications will be rejected. If necessary, retractions and corrections will be published, based on the procedures recommended in the "Retraction Guidelines" of the COPE, available at: <https://publicationethics.org/files/cope-retraction-guidelines-v2.pdf>.

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Authors must register in order to create a password-protected personal account on the online platform in the section "Register"

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2. To access your profile, click "Login" at the top of the screen.
3. To submit your manuscript, click "New Submission" in the left corner of the screen. This will open a screen with norms and conditions for submission to the journal. Remember to include the required items that are marked with an asterisk.
4. Choose the section and confirm all the requirements for submission. If you have comments for the Editor (possible conflicts of interest or other relevant issues), you can communicate them at this stage. After that, click "Save and continue".
5. In the "Upload Submission File" option, select "Title Page", "Article Text" and "Referee List" and upload the respective files. Images should be uploaded at this time. In "Review Details", the author should edit the file name in order to guarantee privacy for peer review of the manuscript. Then click "Complete".
6. Each file will appear in "Submission Files". Click "Save and continue".
7. In "Enter Metadata", all author information should be included. To enter data on co-authors, click "Add Contributor". Do not forget to assign the role of each author. Click "Save and continue" to continue the submission process.
8. Enter the manuscript title in the requested languages. The Planet Earth symbol will turn green after the title is inserted in the selected language. The manuscript's abstract should also appear in the requested languages.
9. In the final step, the system will confirm that your file is ready to be sent. If everything is correct, click "OK".

The journal has a Scientific Board. The manuscripts are first examined by the Editor or by one of the Associate Editors. The Editor has the right to recommend alterations be made to the papers submitted or to return them when they fail to comply with the journal's editorial policy. The magazine adopts plagiarism detection systems for submissions available on free platforms. Titles found to be similar to previous publications will be rejected.

Upon acceptance, the manuscripts are submitted to peer-review and are reviewed by two specialists who are not members of the Editorial Commission. In the event of disagreement, the manuscript is submitted to other(s) referee(s). If changes or corrections need to be made, the manuscript is returned to the authors who will have thirty days to send a new version.

Publication means fully assigning and transferring all copyrights of the manuscript to the journal. The Liability Statement and Assignment of Copyrights will be enclosed with the notice of acceptance. All the authors must sign the document and return it to the journal.

Preparing manuscripts

The manuscripts should be sent in Word for Windows formats, in Times New Roman, font 12, 1.5 spacing between lines, and pages must be sequentially numbered.

At the time of manuscript submission, the three files specified below must be uploaded to the submission platform:

The first file (Title page) should contain: title (in the language of the text and in English), abstract, resumo, keywords, and palavras-chave. This file should be uploaded as Word file. In addition, add a paragraph with information about the authors contributions, which should be described using the following categories: 1) Conceptualization; 2) Data curation; 3) Formal analysis; 4) Funding acquisition; 5) Investigation; 6) Methodology; 7) Project administration; 8) Resources; 9) Software; 10) Supervision; 11) Validation; 12) Visualization; 13) Writing-original draft;

14) Writing-review & editing. Each author should have contributed in at least two of them. For more information on the author's contributions, please check: <https://www.elsevier.com/authors/policies-and-guidelines/credit-author-statement>. This file should be uploaded as Word file.

The second file (Article Text) should contain: title (in the language of the text and in English), abstract, *resumo* (abstract in Portuguese), keywords, and *palavras-chave* (keywords in Portuguese), introduction, material and methods, results, discussion (discussion and results can be presented together), conclusions, acknowledgments, references, figure legends in the language of the text and in English, and tables. Tables should be in Word format, sequentially numbered, and with clear captions. This file should be uploaded as Word file.

A third file (Referee list) containing the name, title and e-mail of six possible reviewers should be submitted as Word file. In this file you can also specify reviewers who should be avoided.

All figures (illustrations, graphs, pictures, diagrams, etc.) (PDF with images) should be presented on separate, numbered pages with their respective captions in the language of the text and in English, and submitted separately on the online platform. Images require minimum resolution of 300 dpi and minimum size of 1,500 pixels, in JPEG or TIFF format. If possible, respect the page sizes of the Bulletin, namely 16.5 cm wide and 20 cm tall (for images occupying two columns) or 8 cm wide and 20 cm tall (for images occupying one column). When text is contained in images, the font used should be Arial, 7 to 10 pt. All tables, graphs and images must be necessarily mentioned in the text body.

Keys have to be presented in the following format:

1. Lizard with 4 small limbs.....	2
Lizard with 4 well developed limbs.....	3
2. Fingers and toes generally without nails, dorsals smooth	<i>Bachia flavescens</i>
Fingers and toes with nails, dorsals keeled.....	<i>Bachia panoplia</i>
3. Hands with only 4 fingers.....	4
Hands with 5 fingers.....	5
4. Dorsalscales smooth.....	<i>Gymnophthalmusunderwoodii</i>
Dorsal scales keeled.....	<i>Amapasaurus tetradactylus</i>
5. Head with large scales.....	6
Head with small scales.....	7
6. Posterior scales of head forming a rounded line	<i>Alopoglossus angulatus</i>
Posterior scales of head forming a straight line.....	<i>Arthrosaura kockii</i>
7. Etc. Etc.	

To highlight terms or phrases, please use single quotation marks. Only foreign language words and phrases, and Latinized scientific names should be in italics. Articles must follow the recommendations of the APA 7th Edition - Citation Guide (<https://apastyle.apa.org/stylegrammar-guidelines/references/examples>) for the use and presentation of citations and references. All quotations in the text body must be accurate and listed at the end of the paper.

Basic text structure

Title – The title must appear both in the original language of the text and in English (when English is not the original language). Title must be centralized and in bold. Do not use capitals.

Abstract – This section should be one paragraph long and highlight the goals, methods, and results of the study. Maximum length: 200 words. The abstract should be presented both in Portuguese/Spanish and in English. The authors are responsible for the English translation.

Keywords – Three to six words that identify the topics addressed, for the purpose of indexing the paper in databases.

Introduction – The introduction should contain a clear and concise description based on state-of-the-art knowledge on the topic addressed. It should provide relevant quotations, and express the goals of the study clearly.

Materials and Methods – This section contains clear information on methods, procedures and data analysis. Previously published studies should not be described, only mentioned. Scientific terms, including the names of plants and animals, should be provided correctly and accurately (name, author, year of description).

Results and Discussion – The results and discussion can be comparative or analytical, or emphasize new and important aspects of the study. They can be addressed together under the same topic, or separately according to the logical order of the paper by using tables, graphics and pictures depending on the structure of the text.

Conclusion – The conclusion should be clear and concise, and should mirror the goals of the study.

Acknowledgements – Acknowledgements are brief and can mention: support and funding; connections to graduate programs and/or research projects; acknowledgement to individuals and institutions. The names of institutions should be written in full, those of individuals with initials and family name, indicating what motivated the acknowledgement.

References – References should appear at the end of the text in alphabetical order according to the last name of the first author. In the event of two or more references to the same author, please use chronological order starting with the earliest work. In case there are several publications by the same author in the same year, use lower case letters behind the year to differentiate them. Theses and academic dissertations preferably must have been published. All references must follow the recommendations of the APA 7th Edition - Citation Guide:

Book: Weaver, C. E. (1989). *Clays, muds and shales*. Elsevier.

Chapter in book: Aranha, L. G., Lima, H. P., Makino, R. K., & Souza, J. M. (1990). Origem e evolução das bacias de Bragança - Viseu, S. Luís e Ilha Nova. In E. J. Milani & G. P. Raja-Gabaglia (Eds.), *Origem e evolução das bacias sedimentares* (pp. 221-234). Petrobras.

Article in journal: Gans, C. (1974). New records of small amphisbaenians from northern South America. *Journal of Herpetology*, 8(3), 273-276. <http://dx.doi.org/10.2307/1563187>

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Electronic document: Instituto Brasileiro de Geografia e Estatística (IBGE) (2011). *Censo Demográfico 2010*. <https://censo2010.ibge.gov.br/>

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2 - After acceptance, the papers will be published according to order of arrival. The Scientific Editor may also decide on the most convenient time for publication.

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A new species of freshwater crab, genus *Kingsleya* Ortmann, 1897 (Decapoda: Brachyura: Pseudothelphusidae), from the remote southern Guyana

Uma nova espécie de caranguejo de água doce do gênero *Kingsleya* Ortmann, 1897 (Decapoda: Brachyura: Pseudothelphusidae) do extremo sul da Guyana

Célio Magalhães | Tiago Arantes | Fernando L. Mantelatto

Echinodermata Collection from the Museu Paraense Emílio Goeldi: new research on the Amazonian biodiversity heritage

Coleção de Echinodermata do Museu Paraense Emílio Goeldi: uma nova pesquisa sobre o patrimônio da biodiversidade amazônica

Dimitri de Araújo Costa | Karolina Rocha | Nívia Cristo de Melo Guimarães | Paulo Afonso Brito Beltrão | Danielle Baia Pires | Jéssica Prata | Cléverton Rannieri Meira dos Santos | Rafael Anaisce das Chagas | Wagner Cesar Rosa dos Santos | Flavio de Almeida Alves-Júnior | Daiane Aviz

Nova espécie de *Perissocytheridea* (Crustacea, Ostracoda, Cytheridae) da zona entremarés de uma ilha costeira da Amazônia oriental

New species of *Perissocytheridea* (Crustacea, Ostracoda, Cytheridae) from the intertidal zone of a coastal island in Eastern Amazonia

Victor Adriano Ruivo dos Santos | Maria Inês Feijó Ramos

Coleção didática de invertebrados marinhos como recurso para compreensão da biodiversidade e ensino em ciências do mar na Amazônia

Educational collection of marine invertebrates as a resource for understanding biodiversity and teaching marine sciences on the Amazon

Larissa Gisele Gonçalves Almeida | Daiane Aviz | José Eduardo Martinelli Filho | Marcelo Petracco

Benthic biodiversity of the Brazilian Equatorial Margin: a systematic review with recommendations for conservation priorities and research

Biodiversidade bentônica da Margem Equatorial Brasileira: uma revisão sistemática com recomendações para prioridades de conservação e pesquisa

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From roots to burrows: how *Spartina alterniflora* (Poaceae) structure modulates brachyuran diversity in Amazonian saltmarshes

Das raízes às tocas: como a estrutura de *Spartina alterniflora* (Poaceae) modula a diversidade de Brachyura em marismas amazônicas

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Benthic meiofauna response to mangrove oyster farming (*Crassostrea gasar*) in an Amazonian estuary

Resposta da meiofauna bentônica à criação de ostras-do-mangue (*Crassostrea gasar*) em um estuário amazônico

Ana Beatriz Moreira Ferreira-Ramos | Emanuelle Fernanda Silva de Souza | James Tony Lee | Thuareag Monteiro Trindade dos Santos

Zooplankton diversity in freshwater environments of Parintins, Amazonas, Brazil

Diversidade do zooplâncton em ambientes de água doce de Parintins, Amazonas, Brasil

Ewertton Souza Gadelha | João Marcos Souza Coêlho | Mayara Ribeiro Casartelli | Elton Augusto Lehmkuhl | Angela Maria da Silva-Lehmkuhl