Bol. Mus. Para. Emílio Goeldi. Cienc. Nat., Belém, v. 20, n. 2, e2025-1035, maio-ago. 2025

The invisible architects: evaluating our understanding of planktonic tunicates in the Atlantic

Arquitetos invisíveis: uma avaliação sobre o conhecimento dos tunicados planctônicos no Atlântico

Ályssa Thayna Pedrosa Cardoso de Araújo[I] | Thaynara Raelly da Costa Silva[II] | Elton Alex Correa da Silva[II] | Xiomara Franchesca García Díaz[III] | Sigrid Neumann Leitão[I]

[I]Zooplankton Laboratory. Museum of Oceanography. Federal University of Pernambuco. Recife, Pernambuco, Brazil

[II]Plankton and Microalgae Cultivation Laboratory. Institute of Coastal Studies. Federal University of Pará. Bragança, Pará, Brazil

[III]Laboratory of Aquatic Ecology and Tropical Aquaculture (LECAT). Socio-Environmental and Water Resources Institute (ISARH). Federal Rural University of the Amazon. Belém, Pará, Brazil

Abstract: Appendicularia are planktonic tunicates that construct numerous gelatinous houses each day, being an important source of food and vertical carbon transport in pelagic environments. However, little is known about these organisms in the Atlantic Ocean. This study aimed to provide an overview of the current state of research of the Appendicularia class in the Atlantic southwest. For this work, we reviewed the state of the art on this group based on bibliographic surveys on academic platforms conducted between October and December 2021, resulting in the selection of 83 publications. Of these, only 13.3% corresponded to studies focused on Appendicularia, and the vast majority addressed is zooplankton. A total of 34 species were recorded in the Brazilian ecoregions, *Oikopleura dioica*, *Oikopleura fusiformis*, *Oikopleura longicauda* and *Oikopleura rufescens* represent 50% of the records. No research group focusing on Appendicularia was found in Brazil, while Argentina has a strong research group for the Southwestern Atlantic. Contrasting, is required a better data management, and enabling future research and the training of researchers focusing on the study of this class.

Keywords: Urochordata. Larvacea. Ecoregion. Bibliographic review.

Resumo: Appendicularia são tunicados planctônicos que constroem diversas casas gelatinosas diariamente, desempenhando papel relevante como fonte de alimento e no transporte vertical de carbono em ambientes pelágicos. Apesar dessa importância ecológica, o conhecimento sobre esses organismos no oceano Atlântico ainda é limitado. Este estudo teve como objetivo apresentar uma visão abrangente do estado atual das pesquisas sobre a classe Appendicularia no Atlântico Sudoeste. Para isso, foi realizada uma revisão bibliográfica em plataformas acadêmicas entre outubro e dezembro de 2021, resultando na seleção de 83 publicações. Destas, apenas 13,3% eram voltadas especificamente para Appendicularia, enquanto a maioria tratava do zooplâncton de forma geral. Nas ecorregiões brasileiras, foram registradas 34 espécies, sendo que *Oikopleura dioica*, *Oikopleura fusiformis*, *Oikopleura longicauda* e *Oikopleura rufescens* representaram 50% dos registros. Não foram identificados grupos de pesquisa especializados em Appendicularia no Brasil, ao passo que a Argentina conta com um grupo consolidado na investigação da fauna do Atlântico Sudoeste. Os resultados ressaltam a necessidade de aprimorar o gerenciamento de dados, incentivar novas investigações e promover a formação de pesquisadores dedicados ao estudo dessa classe.

Palavras-chave: Urochordata. Larvacea. Ecorregião. Revisão bibliográfica.

Araújo, A. T. P. C., Silva, T. R. C., Silva, E. A. C., Díaz, X. F. G., & Leitão, S. N. (2025). The invisible architects: evaluating our understanding of planktonic tunicates in the Atlantic. *Boletim do Museu Paraense Emílio Goeldi. Ciências Naturais*, *20*(2), e2025-1035. http://doi.org/10.46357/bcnaturais.v20i2.1035

Corresponding author: Ályssa Thayna Pedrosa Cardoso de Araújo. Zooplankton Laboratory. Museum of Oceanography. Federal University of Pernambuco. Arquitetura Ave. Recife, PE, Brazil. CEP 50740-550 (alyssa.thayna@ufpe.br).

Received on 10/01/2024
Approved on 07/22/2025
Editorial responsibility: José Nazareno Araújo dos Santos Júnior

INTRODUCTION

Appendicullarians are cosmopolitan planktonic tunicates and filter-feeders, grazing mainly on bacteria and phytoplankton cells (Kiørboe, 2011) and occupying an important role in the process of estuarine and marine ecosystem carbon cycling and energy flux (Hopcroft et al., 1998; D'Alelio et al., 2016; Taucher et al., 2024). Appendicularians are unique among Tunicates due to their retention of larval traits, pedomorphosis, in adults, resembling the tadpole larvae of other Tunicata; hence their classification as Larvacea (Di Dario, 2005; Esnal, 1999).

Due to their characteristics, studies in recent decades demonstrate their roles in biogeochemical cycles and ecological processes of the marine environment as: consumers of colloidal particles of dissolved organic carbon (Flood et al., 1992; Jaspers et al., 2023), filters of microplastic particles (1 to 5 mm) in ocean areas, serving as potential bioindicators of marine pollution (Katija et al., 2017; Di Mauro et al., 2017), controllers of primary production, being great herbivorous filter-feeders (Alldredge, 1981; Deibel, 1988; Sato et al., 2008; Lawrence et al., 2018); producers of organic aggregates through their houses and fecal pellets, contributing to marine snow formation and nutrient cycling (Jaspers et al., 2014, 2023). Studying their house filtration mechanisms clarifies their impact on marine food webs (Lombard et al., 2010; Conley et al., 2018; Menschel & González, 2019). Appendicularia is also an important source of food for small carnivorous, such as invertebrates and fish larvae (flounders and engraulids) (Capitanio et al., 2005, 2018; Purcell et al., 2005; Spinelli et al., 2013).

Studies of this group have been developed since the nineteenth century, where most research was focused on the taxonomy, following a stable taxonomic classification until the mid-twentieth century (Lohmann, 1896; Fenaux, 1986; Hopcroft et al., 1998). However, giving the way sampling is carried out and the lack of taxonomic information, new validations, occurrence records and new species are still published around the globe (Aravena & Palma, 2002; Capitanio et al., 2003; Hopcroft & Robison, 2005). In the study of these animals there are leading research groups from the Pacific (*e.g.*: Shiga, 1985; Sato et al., 2001; Hopcroft & Robison, 2005; Li et al., 2012; Sato, 2023; Sandoval-Navarrete et al., 2024) and Atlantic Oceans (*e.g.*: Forneris, 1964; Tundisi, 1970; Capitanio, 1995; Hopcroft et al., 1998; Aravena & Palma, 2002; Capitanio et al., 2018; Jaspers et al., 2023). However, few researchers specialized in the study of Appendicularia from the South Atlantic region, especially from the Brazilian coast (Forneris, 1964; Esnal & Castro, 1977; Vega-Pérez et al., 2011). In this study, we provide an overview of the research carried out with the Appendicularia class in the Atlantic Ocean, from north to south, to provide an overview and a baseline for comparisons with other regions. We assess the available literature in the form of published works with a literature review, and identified the main gaps about this group in the Atlantic Ocean.

MATERIAL AND METHODS

We searched Scopus and Web of Science in October and December 2021 for literature on Atlantic Appendicularia. We applied the following inclusion criteria: 1) Scientific works directed to the class Appendicularia or Larvacea, 2) Studies that contained data on these animals (zooplankton community articles) and 3) Studies carried out in the Atlantic Ocean and related seas (coastal and oceanic areas). We searched title, abstract, and keyword fields for papers in English, French, and Spanish. The search conducted in October 2021 returned 344 results, after removing duplicate work and other research areas, only 42 remained for the present study. For this search, we used the keywords 'Appendicular' and 'larvac' to encompass as many derived terms as possible, such as 'appendicularians' and 'larvaceans,' present in the titles, abstract, and keywords. The second search was carried out in a more comprehensive way, encompassing works that included the zooplankton community and

making use of keywords such as 'apendicularia,' 'larvac' and 'zooplank,' using the same criteria for maximizing the search. The searches returned 2,876 articles, after screening according to pre-defined exclusion criteria, 41 articles from the second search remained. We followed PRISMA (Preferred Reporting Items for Systematic reviews and Meta-Analyses) guidelines (Page et al., 2021) for systematic review protocols (Figure 1). We generated plots in R Studio v.4.3.2 (Posit team, 2020) with ggplot2 (Wickham, 2016). The maps were created using the QGIS Desktop program (version 2.18.14) (QGIS.org, 2024).

In order to perform the visualization and bibliometric analysis of the works, we used the Bibliometrix package (Aria & Cuccurullo, 2017), in R (R Core Team, 2016). This allowed the exclusion of duplicates and the union of searches in a single database to perform the analyses. For each selected study after initial screening (N = 83), information was compiled regarding authors, year of publication, study location, type of work (article, review article, conference paper, book/ book chapter), species found, as well as biogeographic ecoregion, following the classification criterion of Spalding et al. (2007).

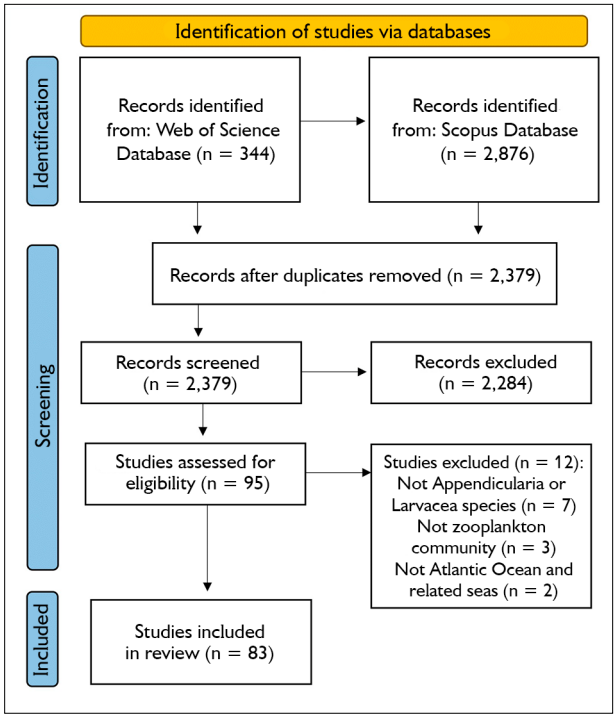

Figure 1. PRISMA flow diagram for systematic review of Appendicularia in the Atlantic Ocean, including sample sizes and exclusion criteria. Graphic by the authors (2025).

RESULTS

BIBLIOGRAPHIC REVIEW

Through the bibliographic review, we obtained 83 studies from 1977 to 2021. The results depend on the database available on the day of the search on the platforms used, so the total sampling of the terms used in the search is not guaranteed. Thus, the analysis of secondary data showed that, among the decades of the sampled studies, 2010-2019 corresponded to 50.6% of the relative frequency in the studies, while individually the most representative year was 2018, corresponding to the highest frequency of studies, 13.25% (Figures 2A, 2B).

The studies found were categorized into studies of ecology, taxonomy, biomonitoring, and trophic study. Most of the studies belonged to the ecology category, corresponding to approximately 69% of the relative frequency, and were related to research on the distribution, composition and abundance of species or communities (Figures 3A-3C). The articles were organized into: research dedicated to the class Appendicularia, zooplankton community, ichthyology, and others (ornithology, environmental monitoring, oceanography, laboratory experiment, trophic study and species description). We observed that the studies focused on Appendicularia corresponded to only 13.3%, most of the studies refer to the zooplankton community (72.3%), while the other studies corresponded to 14.5%. Regarding the nature of the studies, most of the studies analyzed were classified as articles, totaling 88% of the frequency and the area of interest of most of the studies analyzed was general ecology.

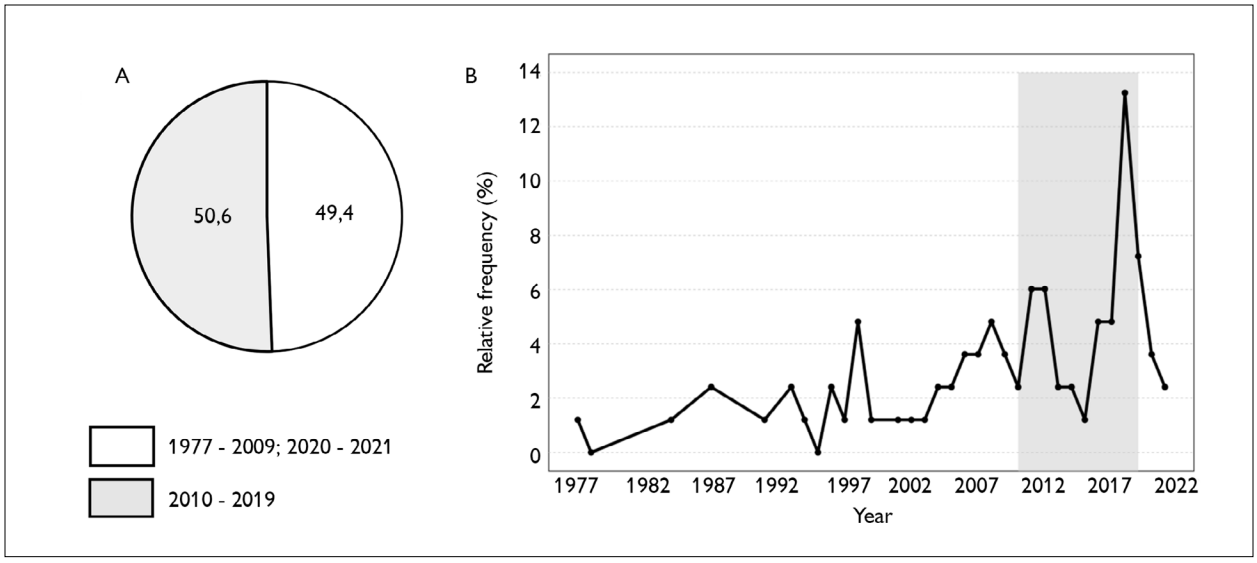

Figure 2. A) Relative frequency of Appendicularia studies in the Atlantic Ocean researched in the years 1977 to 2021 (41 studies); B) the years 2010-2019 (42 studies) are highlighted in gray. Graphic by the authors (2025).

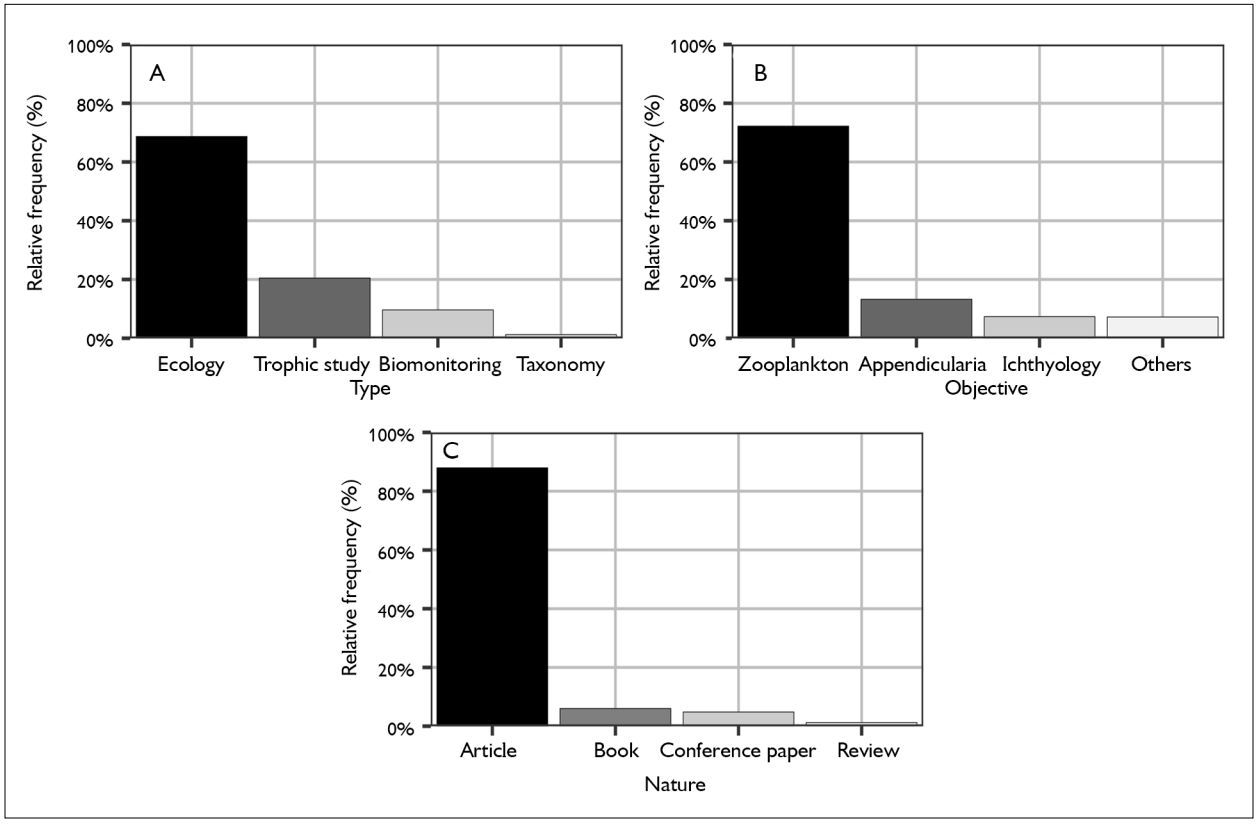

Figure 3. A) Relative frequency of objectives of studies researched on Appendicularia in the Atlantic Ocean; B) relative frequency of topics covered; C) relative frequency of the nature of the work carried out in relation to Appendicularia. Graphic by the authors (2025).

MOST REPRESENTATIVE ECOREGION AND SPECIES

Considering the ecoregions generated in the present study, the results showed that of the 28 biogeographic ecoregions analyzed (Spalding et al., 2007), 7 had the highest frequencies: Ecoregion 180 - ECO 180 (11.7%), ecoregion 184 - ECO 184 (9.7%), ecoregion 75 - ECO 75 (7.8%), ecoregion 76 - ECO 76 and ecoregion 21 - ECO 21 (6.8% each), and ecoregion 183 - ECO 183 and ecoregion 27 - ECO 27 (5.8% each) (Figure 4). Of these locations, 4 belong to the geographical limits of the Brazilian coast, with ECO 180 as the Southeast of Brazil, ECO 75 the Northeast and ECO 76 East of the Brazilian coast. Despite the great importance of areas such as the Caribbean and the African coast, data for these regions were not found. This can be explained by the responsiveness of the platforms, since it is not possible to return all existing academic works in a search.

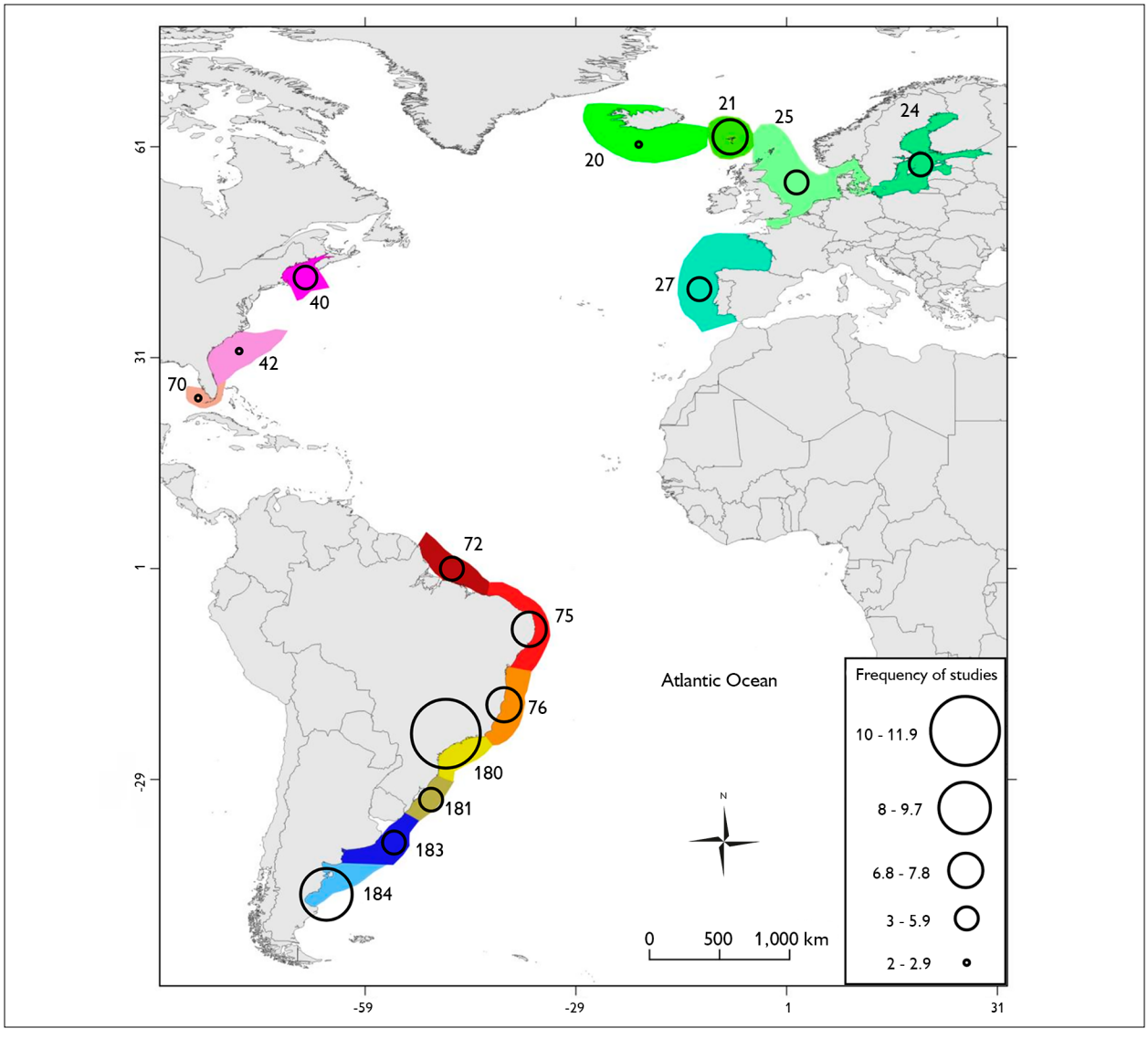

Figure 4. Relative frequency of the most representative ecoregions in studies in the Atlantic Ocean. Map by the authors (2025).

Brazil accounted for 34.9% of the results found, where most of the studies were dedicated to zooplankton. For the North Atlantic, research groups in the United States of America and Spain stood out, together corresponding to 19.2% of the total number of studies. Another 14 countries in Europe and America were sampled, but in total they corresponded to 27.8%. A total of 34 species of Appendicularia were found in the 83 studies analyzed. Among these, the most representative in the Brazilian ecoregions were: *Oikopleura dioica*, *Oikopleura fusiformis*, *Oikopleura longicauda* and *Oikopleura rufescens*, with frequencies higher than 5% and accounted for 45.2% of the total observed.

When we analyze by ecoregion, we can observe a change in more representative species, since ECO 72 obtained *O. dioica* with the highest relative frequency (25%), followed by *O. longicauda* (18.8%), *O. rufescens* (13%), and *Oikopleura cophocerca*, *O. fusiformis*, *Fritillaria formica* with 6.3% each. At ECO 75, the species that stood out were *O. longicauda* (23,1%), *O. dioica* (19.2%), *O. rufescens* (11.5%) and *O. fusiformis* (7.7%). ECO 76 had the species *O. dioica* and *O. longicauda* (12.8% each), *O. rufescens* (10.3%), *O. cophocerca*, *O. fusiformis*, *Fritillaria haplostoma* with 7.7% each, *Oikopleura albicans*, *Oikopleura cornutogastra*, *Fritillaria tenella* with 5.1% each. The species found for ECO 180 were *O. longicauda* (13%),

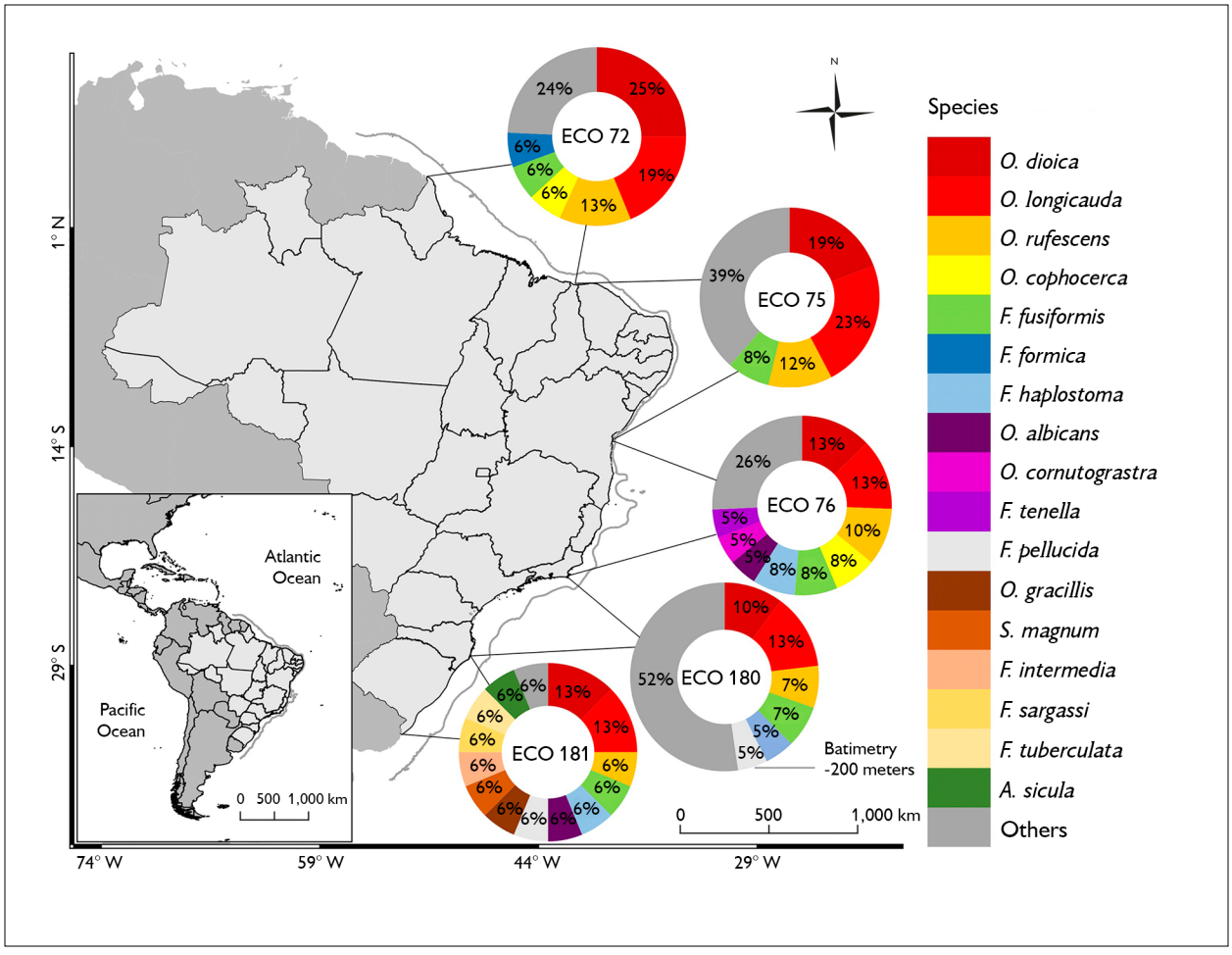

Figure 5. Relative frequency of occurrence of Appendicularia species by ecoregion (ECO) in Brazil. Map by the authors (2025).

O. dioica (10.1%), *O. fusiformis* and *O. rufescens* (7.2%), *Fritillaria haplostoma* and *Fritillaria pellucida* with 5.1% each. In ECO 181 the species were *O. longicauda* and *O. dioica* (13% each), *O. rufescens*, *O. fusiformis*, *F. haplostoma*, *O. albicans*, *F. pellucida*, *Oikopleura gracilis*, *Stegosoma magnum*, *Fritillaria intermedia*, *Fritillaria sargassi*, *Fritillaria tuberculata*, and *Appendicularia sicula* (6.3% each) (Figure 5). Other species were also found in the studies, but with less representation (Table 1).

DISCUSSION

BIBLIOGRAPHIC REVIEW

In the 21st century, concern about the oceans and their implications for human life continues to be debated, with threats to marine life through anthropogenic impacts. To address these impacts, the United Nations Union launched an international campaign in 2016, the United Nations Decade of Ocean Science for Sustainable Development (UNESCO),

Table 1. Relative frequency of occurrence of all Appendicularia species by ecoregion (ECO) in Brazil.

Family Species/Subspecies	Ecoregion (Frequency %)				
	ECO 72	ECO 75	ECO 76	ECO 180	ECO 181
Oikopleuridae Lohmann, 1915					
Oikopleura spp. Mertens, 1830	12.5	15.38	2.56	4.35	6.25
Oikopleura (Vexillaria) albicans (Leuckart, 1854)	0	0	5.13	2.9	6.25
Oikopleura (Vexillaria) cophocerca (Gegenbaur, 1855)	6.25	3.85	7.69	4.35	0
Oikopleura (Vexillaria) dioica Fol, 1872	25	19.23	12.82	10.14	12.5
Oikopleura (Coecaria) fusiformis Fol, 1872	6.25	7.69	7.69	7.25	6.25
Oikopleura (Coecaria) fusiformis cornutogastra Aida, 1907	0	0	5.13	4.35	0
Oikopleura (Coecaria) gracilis Lohmann, 1896	0	0	2.56	4.35	6.25
Oikopleura (Coecaria) intermedia Lohmann, 1896	0	0	2.56	1.45	0
Oikopleura (Coecaria) longicauda (Vogt, 1854)	18.75	23.08	12.8	13.04	12.5
Oikopleura (Vexillaria) rufescens Fol, 1872	12.5	11.54	10.26	7.25	6.25
Oikopleura (Vexillaria) parva Lohmann, 1896	0	0	0	2.9	0
Stegosoma magnum (Langerhans, 1880)	0	0	0	1.45	1.45
Megalocercus abyssorum Chun, 1887	0	0	0	6.25	0
Fritillaridae Lohmann, 1915					
Fritillaria spp. Fol, 1872	6.25	15.38	5.13	1.45	0
Fritillaria aequatorialis Lohmann, 1896	0	0	0	1.45	0
Fritillaria borealis Lohmann, 1896	0	0	2.56	1.45	0
Fritillaria borealis intermedia Lohmann, 1905	0	0	0	1.45	6.25
Fritillaria borealis sargassi Lohmann, 1896	0	0	2.56	2.9	6.25
Fritillaria formica Fol, 1872	6.25	3.85	0	4.35	0
Fritillaria formica tuberculata Lohmann in Lohmann & Buckmann, 1926	0	0	0	1.45	6.25
Fritillaria haplostoma Fol, 1872	0	0	7.69	5.8	6.25
Fritillaria pellucida (Busch, 1851)	0	0	2.56	5.8	6.25
Fritillaria tenella Lohmann, 1896	0	0	5.13	4.35	0
Appendicularia sicula Fol, 1874	6.25	0	2.56	4.35	6.25

to encourage increased oceanographic research, international collaboration, and the promotion of sustainability. Thus, there is an important mobilization of the scientific community for the study of the oceans and its socio-environmental aspect (Ryabinin et al., 2019; IOC, 2021; Zappes et al., 2021).

The increase in the number of scientific articles and journals is shown through surveys in the Global Ocean Science Report (GOSR) in the 2017 and 2020 editions, demonstrating a qualitative and quantitative growth in scientific production. These data corroborate the expectation of international efforts to meet the goals established by the United Nations (UN), such as the Sustainable Development Goals (SDGs) and for the Ocean Decade, in addition to other international agreements, such as Conference of the Parties of the United Nations Framework Convention on Climate Change (UNFCCC) and the Paris Agreement of 2015 (IOC, 2017, 2020). Another important factor for the increase in research in recent years is due to global funding opportunities, although at insufficient levels to address knowledge gaps, seeking knowledge about climate change and its effects, food security, development and sustainable management of resources, dynamics of coastal and oceanic areas, among others. However, greater investments in financial and infrastructure resources will still be necessary for ocean science to be able to expand its knowledge (Ryabinin et al., 2019; IOC, 2020).

Such knowledge about zooplankton in Brazil, published in scientific journals, can be encompassed in lines of research of taxonomy and new occurrences, biology, trophic study, ecology, conservation biology, biomonitoring, and aquaculture. The choice of the line of research and the location depends, basically, on the interest of the researchers, the infrastructure for the fieldwork and the financial incentive of the funding agencies, resulting in the concentration of studies in some coastal areas, such as the southeast and south regions, the Amazon region, and areas with important research centers in the Northeast, enabling greater chances of being sampled (Neumann-Leitão & Matsumura-Tundisi, 1998; Lopes, 2007; Tosetto et al., 2022).

The area of interest of most of the studies analyzed was general ecology, showing how in situ research of the class Appendicularia is still in the phase of basic research for the Atlantic, since large study groups in the Pacific were already developing research with cultivation, trophic ecology and genetics since the 90s and early 2000s (Sato et al., 1999, 2001; Nishida, 2008). This demonstrates information gaps specific to the class Appendicularia in Atlantic work, especially for the equatorial portion (Leite et al., 2020).

MOST REPRESENTATIVE ECOREGION AND SPECIES

Through the results obtained, it was possible to visualize that only one research group is dedicated to the study of Appendicularia's in the South Atlantic, located in Argentina (ECO 184), developing research in general and trophic ecology (Capitanio et al., 1997, 2018; Spinelli et al., 2012). The results found for ECO 180 refer to zooplankton research groups in the southeastern region of Brazil, which developed specific studies with Appendicularia (Carvalho & Bonecker, 2010; Carvalho et al., 2016; Vega-Pérez et al., 2011). Brazil accounted for 34.9% of the results found, where most of the studies were dedicated to the abundance and distribution of zooplankton. For the North Atlantic, research groups in the United States of America and Spain stood out, together corresponding to 19.2% of the total number of studies. Another 14 countries in Europe and America were also sampled, but in total they corresponded to 27.8%. We can conclude that there are few research groups dedicated to the class Appendicularia in the world, and it is possible to observe that most of the works are focused on the zooplankton community and large fishery resources (Maar et al., 2004; Catalán et al., 2011; Suca et al., 2018).

Overall, Oikopleuridae were more abundant and more frequent than Fritillaridae, an expected pattern

for these organisms, since Oikopleuridae species prefer warmer waters, and Fritillaridae prefers places with cooler temperatures (Forneris, 1964). In addition, coastal and estuarine regions were indicative of a higher concentration and distribution of appendicularian species, being generally related to the supply of nutrients in coastal regions of river mouths and turbulence, in addition to milder temperatures (Boltovskoy, 1981). An area in the south of South America, from Rio de Janeiro to the Gulf of San Matías, stands out, with a high occurrence of these organisms (Forneris, 1964; Capitanio, 1995; Hopcroft et al., 1998).

Based on the frequency observed in the studies, *O. dioica*, *O. longicauda*, *O. fusiformis* and *O. rufescens* were found in all ecoregions sampled in Brazil, and are already known in the literature as species commonly found on the Brazilian coast (Forneris, 1964; Esnal & Castro, 1977). In the literature, *O. dioica* and *O. rufescens* are mentioned as frequent species along the Brazilian coast, with *O. dioica* being particularly abundant on the southern coast of the country (Forneris, 1964; Boltovskoy, 1981). On the other hand, *O. fusiformis* and *O. longicauda* are described as abundant throughout the South Atlantic (Esnal, 1999) and more abundant in surface layers, where temperatures are high and chlorophyll-a levels are low, as observed by Miyashita and Lopes (2011). In warm, temperate offshore waters around the world, *O. longicauda*, *O. rufescens*, and *O. fusiformis* are often found in abundance (Gorsky & Fenaux, 1998; Miyashita & Lopes, 2011). The species of Fritillaridae, in particular, *F. formica*, *F. pellucida*, *F. borealis* and *F. sargassi* are considered to be more abundant in areas with warm waters, being *F. borealis* cosmopolitan and occurring all over the globe with a preference for oceanic or mixed waters (Esnal & Castro, 1977; Esnal, 1999).

ECO 75 presented the lowest number of species when compared to the other ecoregions, followed by ECO 72, which can be explained by the presence of oligotrophic waters, influenced by the South Equatorial Current, without the influence of the contribution of large rivers and with low concentration of nutrients in the surface layers with a well-defined thermocline (Knoppers et al., 1999; Weigert & Madureira, 2011). The Northeast coast of Brazil is a region with nutrient-poor waters with great influence of oceanic waters, with few nutrients found compared to the North region (Ovalle et al., 1999; Araujo et al., 2019). In contrast, oceanic areas close to islands and sea banks have topography that favors the 'island effect,' where deeper and enriched waters are transported to more superficial areas, causing an increase in primary productivity (Doty & Oguri, 1956; Melo et al., 2012; Jales et al., 2015). The northern region is marked by the important contribution of the Amazon plume, contributing with nutrients and suspended material, and is also an important biogeographic barrier for the species, but still containing a low primary productivity (Nittrouer & DeMaster, 1996; Jo et al., 2005; Tosetto et al., 2022).

The Brazilian southeastern and southern coasts are areas with the highest primary productivity (Knoppers et al., 1999), corroborating the results found for ECO 181, ECO 76, ECO 180. Although the Brazilian coast is defined as oligotrophic, some localities located in the southeastern portion may present vortex formations and upwelling areas, contributing to the increase of nutrients from colder currents (Aidar et al., 1993; Gaeta et al., 1999; Andrade et al., 2004). The southern region has oligotrophic waters enriched by important fluvial inputs, such as the Patos Lagoon and the Pratas River, and there are also upwellings at the shelf break (Ciotti et al., 1995; Attisano et al., 2008; Bernardes et al., 2012). This region has also its nutrients influenced by southeast winds and climatic events such as El Niño and La Niña, when compared to less atypical periods (Brandini, 1988; Brandini et al., 2007).

OUTLOOK FOR BRAZIL

The current scenario for studies dedicated to Appendicularia is still uncertain, since there are no groups of researchers specialized in the taxonomic identification and biology in Brazil, and few studies have been carried out with this class (*e.g.*: Campos & Vega-Pérez, 2003; Carvalho & Bonecker,

2010, 2016; Vega-Pérez et al., 2011; Carvalho et al., 2016). Some reference research and teaching institutions in oceanographic studies, such as Oceanographic Institute of the University of São Paulo (IOUSP), University of São Paulo (USP), Federal University of Rio de Janeiro (UFRJ), Federal University of Pernambuco (UFPE), Federal University of Rio Grande do Norte (UFRN), Federal University of Rio Grande (FURG) among others hold collections of zooplankton capable of remedying the main gaps that still exist in the study of Appendicularia (Rocha et al., 2024); however, some of these collections may present specimens that are difficult to identify due to the state of preservation, requiring better efforts for the conservation of the collection.

Despite its relevance and wide distribution, this group remains poorly studied in many regions of the Atlantic, mainly due to the lack of taxonomists, infrastructure, and adequate conservation of organisms. In addition, there is a notable heterogeneity in relation to the resources allocated, infrastructure and consequent scientific production between the North-Northeast regions, compared to the South-Southeast (Albuquerque et al., 2005; Gonçalves, 2007; Sidone et al., 2016; Santos, 2022). In view of this scenario, the use of existing biological collections for scientific development is essential (Vega-Pérez et al., 2011; Souza et al., 2020). Research groups from the Federal University of Pernambuco and the Federal Rural University of the Amazon are currently developing research with the Appendicularia class, including the present research (Magalhães personal, communication, 2024)

CONCLUSIONS

The analysis of secondary data showed that most of the work was carried out between 2010-2019, and may be associated with the constant international efforts in the last decade to mitigate human impacts on the oceans. Of the 34 species of Appendicularia listed in the studies, the most frequent on the Brazilian coast were *O. dioica*, *O. fusiformis*, *O. longicauda* and *O. rufescens*. Corroborating with previous studies that demonstrate a greater richness of these species in the southern portion of South America. In general, no groups of specialists were found in Brazil, while Argentina has a strong research group for the South Atlantic, developing research in ecology, trophic structure, taxonomy and other areas.

In view of the above and the potentially revealing results, it is necessary to encourage research on the Appendicularia class on neritic and oceanic regions of Brazil. Is required a better data management and enabling future research and the training of specialist researchers in the class. In addition to these aspects, it is essential to carry out more comprehensive studies in order to better understand the role of Appendicularia as essential elements in Brazilian marine ecosystems.

ACKNOWLEDGEMENTS

The first author benefited for the doctoral scholarship from the *Conselho Nacional de Desenvolvimento Científico e Tecnológico* (CNPq) and the *Programa de Pós-Graduação em Oceanografia* at the Federal University of Pernambuco. We would also like to thank Walter Dennis de Oliveira for his help in carrying out the bibliometric surveys.

REFERENCES

Aidar, E., Gaeta, S. A., Gianesella-Galvão, S. M. F., Kutner, M. B. B., & Teixeira, C. (1993). Ecossistema costeiro subtropical: nutrientes dissolvidos, fitoplâncton e clorofila-a e suas relações com as condições oceanográficas na região de Ubatuba, SP. *Publicação Especial do Instituto Oceanográfico*, *10*(2019), 9–43.

Albuquerque, E. M., Baessa, A. R., Kirdeikas, J. C. V., Silva, L. A., & Ruiz, R. M. (2005). Produção científica e tecnológica das regiões metropolitanas brasileiras. *Revista de Economia Contemporânea*, *9*(3), 615–642. https://doi.org/10.1590/s1415-98482005000300006

Alldredge, A. L. (1981). The impact of appendicularian grazing on natural food concentrations in situ. *Limnology and Oceanography*, *26*(2), 247–257. https://doi.org/10.4319/lo.1981.26.2.0247

Andrade, L., Gonzalez, A. M., Valentin, J. L., & Paranhos, R. (2004). Bacterial abundance and production in the southwest Atlantic Ocean. *Hydrobiologia*, *511*(2004), 103–111. https://doi.org/10.1023/B:HYDR.0000014033.81848.48

Araujo, M., Noriega, C., Medeiros, C., Lefèvre, N., Ibánhez, J. S. P., Montes, M. F., Silva, A. C., & Santos, M. L. (2019). On the variability in the CO_2 system and water productivity in the western tropical Atlantic off North and Northeast Brazil. *Journal of Marine Systems*, *189*, 62–77. https://doi.org/10.1016/j.jmarsys.2018.09.008

Aravena, G., & Palma, S. (2002). Taxonomic identification of appendicularians collected in the epipelagic waters off northern Chile (Tunicata, Appendicularia). *Revista Chilena de Historia Natural*, *75*(2), 307–325. https://doi.org/10.4067/S0716-078X2002000200005

Aria, M., & Cuccurullo, C. (2017). bibliometrix: An R-tool for comprehensive science mapping analysis. *Journal of Informetrics*, *11*(4), 959–975. https://doi.org/10.1016/j.joi.2017.08.007

Attisano, K. K., Niencheski, L. F. H., Milani, I. C. B., Machado, C. S., Milani, M. R., Zarzur, S., & Andrade, C. F. F. (2008). Evidences of continental groundwater inputs to the shelf zone in Albardão, RS, Brazil. *Brazilian Journal of Oceanography*, *56*(3), 189–200. https://doi.org/10.1590/S1679-87592008000300004

Bernardes, M., Knoppers, B., Rezende, C., Souza, W., & Ovalle, A. (2012). Land-sea interface features of four estuaries on the South America Atlantic coast. *Brazilian Journal of Biology*, *72*(3 suppl.), 761–774. https://doi.org/10.1590/s1519-69842012000400011

Boltovskoy, D. (1981). *Atlas del zooplancton del Atlántico Sudoccidental y métodos de trabajo con el zooplancton marino*. Instituto Nacional de Investigacion y Desarrollo Pesquero.

Brandini, F. P. (1988). Hydrography, phytoplankton biomass and photosynthesis in shelf and oceanic waters off southeastern Brazil during autumn (may/june, 1983). *Boletim do Instituto Oceanográfico*, *36*(1–2), 63–72. https://doi.org/10.1590/s0373-55241988000100007

Brandini, F. P., Silva, A. S., Silva, E. T., & Kolm, H. (2007). Sources of nutrients and seasonal dynamics of chlorophyll in the inner shelf off Paraná State - South Brazil bight. *Journal of Coastal Research*, *23*(5), 1131–1140. https://doi.org/10.2112/04-0360.1

Campos, M. A. G., & Vega-Pérez, L. A. (2003). Apendiculárias da região entre Cabo Frio e Ilha Grande (RJ) e sua relação com a hidrodinâmica local. In *Anais do Congresso Brasileiro de Pesquisas Ambientais e Saúde*, Instituto Oceanográfico, Universidade de São Paulo.

Capitanio, F. L. (1995). *Estudio ecológico (distribución , relaciones tróficas y desarrollo gonadal) de Appendicularia (chordata , tunicata) en aguas costeras de Uruguay y Argentina hasta los 47° S* [Doctoral thesis, Universidade de Buenos Aires]. http://digital.bl.fcen.uba.ar/Download/Tesis/Tesis_2733_Capitanio.pdf

Capitanio, F. L., Pájaro, M., & Esnal, G. B. (1997). Appendicularians (Chordata, Tunicata) in the diet of anchovy (*Engraulis anchoita*) in the Argentine Sea. *Scientia Marina*, *61*(1), 9–15.

Capitanio, F. L., Daponte, M. C., & Esnal, G. B. (2003). The classification of Antarctic appendicularians: The *Oikopleura gaussica* group. *Antarctic Science*, *15*(4), 476–482. http://doi.org/10.1017/S0954102003001585

Capitanio, F. L., Pájaro, M., & Esnal, G. B. (2005). Appendicularians: An important food supply for the Argentine anchovy *Engraulis anchoita* in coastal waters. *Journal of Applied Ichthyology*, *21*(5), 414–419. https://doi.org/10.1111/j.1439-0426.2005.00657.x

Capitanio, F. I., Spinelli, M. L., Presta, M. L., Aguirre, G. E., Cervetto, G., Pájaro, M., & Derisio, C. M. (2018). Ecological role of common appendicularian species from shelf waters off Argentina. In M. S. Hoffmeyer, M. E. Sabatini, F. P. Brandini, D. L. Calliari, & N. H. Santinelli (Eds.), *Plankton ecology of the Southwestern Atlantic from the subtropical to the subantarctic realm* (pp. 201–218). Springer. https://doi.org/10.1007/978-3-319-77869-3_10

Carvalho, P. F., & Bonecker, S. L. C. (2010). Seasonal and spatial variability of appendicularian density and taxonomic composition in the caravelas estuary (Northeastern Brazil) and adjacent coastal area. *Brazilian Archives of Biology and Technology*, *53*(1), 161–169. https://doi.org/10.1590/S1516-89132010000100020

Carvalho, P. F., & Bonecker, S. L. C. (2016). Variação da composição e abundância das espécies da Classe Appendicularia e seu uso como potenciais bioindicadoras de regiões e massas de água superficiais na área da Bacia de Campos, Rio de Janeiro, Brasil. *Iheringia, Serie Zoologia*, *106*, e2016022. https://doi.org/10.1590/1678-4766e2016022

Carvalho, P. F., Bonecker, S. L. C., & Nassar, C. A. G. (2016). Analysis of the Appendicularia class (subphylum Urochordata) as a possible tool for biomonitoring four estuaries of the tropical region. *Environmental Monitoring and Assessment*, *188*, 606. https://doi.org/10.1007/s10661-016-5616-5

Catalán, I. A., Tejedor, A., Alemany, F., & Reglero, P. (2011). Trophic ecology of Atlantic bluefin tuna *Thunnus thynnus* larvae. *Journal of Fish Biology*, *78*(5), 1545–1560. https://doi.org/10.1111/j.1095-8649.2011.02960.x

Ciotti, Á. M., Odebrecht, C., Fillmann, G., & Moller, O. O. (1995). Freshwater outflow and Subtropical Convergence influence on phytoplankton biomass on the southern Brazilian continental shelf. *Continental Shelf Research*, *15*(14), 1737–1756. https://doi.org/10.1016/0278-4343(94)00091-Z

Conley, K. R., Lombard, F., & Sutherland, K. R. (2018). Mammoth grazers on the ocean's minuteness: A review of selective feeding using mucous meshes. *Proceedings of the Royal Society B: Biological Sciences*, *285*(1878), 20180056. https://doi.org/10.1098/rspb.2018.0056

D'Alelio, D., Libralato, S., Wyatt, T., & Ribera D'Alcalà, M. (2016). Ecological-network models link diversity, structure and function in the plankton food-web. *Scientific Reports*, *6*, 21806. https://doi.org/10.1038/srep21806

Deibel, D. (1988). Filter feeding by *Oikopleura vanhoeffeni*: grazing impact on suspended particles in cold ocean waters. *Marine Biology*, *99*(2), 177–186. https://doi.org/10.1007/BF00391979

Di Dario, F. (2005). Chordata. In E. E. Ruppert, R. S. Fox, & R. D. Barnes (Eds.), *Zoologia dos invertebrados: uma abordagem funcional-evolutiva* (7th ed., pp. 1083–1122). Editora Roca.

Di Mauro, R., Kupchik, M. J., & Benfield, M. C. (2017). Abundant plankton-sized microplastic particles in shelf waters of the northern Gulf of Mexico. *Environmental Pollution*, *230*, 798–809. https://doi.org/10.1016/j.envpol.2017.07.030

Doty, M. S., & Oguri, M. (1956). The island mass effect. *Journal du Conseil*, *22*(1), 33–37. https://doi.org/10.1093/icesjms/22.1.33

Esnal, G. B., & Castro, R. J. (1977). Distributional and biometrical study of appendicularians from the west south Atlantic ocean. *Hydrobiologia*, *56*(3), 241–246. https://doi.org/10.1007/BF00017510

Esnal, G. B. (1999). Appendicularia. In D. Boltovoskoy (Ed.), *South Atlantic Zooplankton* (1st ed., pp. 1375–1398). Backhuys Publishers.

Fenaux, R. (1986). The house of *Oikopleura dioica* (Tunicata, Appendicularia): Structure and functions. *Zoomorphology*, *106*(4), 224–231. https://doi.org/10.1007/BF00312043

Flood, P. R., Deibel, D., & Morris, C. C. (1992). Filtration of colloidal melanin from sea water by planktonic tunicates. *Nature*, *355*(6361), 630–632. https://doi.org/10.1038/355630a0

Forneris, L. (1964). Appendicularian species groups and southern Brazil water masses. *Boletim do Instituto Oceanográfico*, *14*, 53–113. https://doi.org/10.1590/s0373-55241965000100004

Gaeta, S. A., Lorenzzetti, J. A., Miranda, L. B., Susini-Ribeiro, S. M. M., Pompeii, M., & Araujo, C. E. S. (1999). The Vitória Eddy and its relation to the phytoplankton biomass and primary productivity during the austral fall of 1995. *Archive of Fishery and Marine Research*, *47*(2–3), 253–270.

Gonçalves, E. (2007). O padrão espacial da atividade inovadora brasileira: uma análise exploratória. *Estudos Econômicos*, *37*(2), 405–433. https://doi.org/10.1590/s0101-41612007000200007

Gorsky, G., & Fenaux, R. (1998). The role of appendicularians in marine food webs. In Q. Bone (Ed.), *The biology of pelagic tunicates* (pp. 161–169). Oxford Academic. https://doi.org/10.1093/oso/9780198540243.003.0010

Hopcroft, R. R., Roff, J. C., & Bouman, H. A. (1998). Zooplankton growth rates: The larvaceans Appendicularia, Fritillaria and Oikopleura in tropical waters. *Journal of Plankton Research*, *20*(3), 539–555. https://doi.org/10.1093/plankt/20.3.539

Hopcroft, R. R., & Robison, B. H. (2005). New mesopelagic larvaceans in the genus Fritillaria from Monterey Bay, California. *Journal of the Marine Biological Association of the United Kingdom*, *85*(3), 665–678. https://doi.org/10.1017/S0025315405011598

Intergovernmental Oceanographic Commission (IOC). (2017). *Global Ocean Science Report 2017: The current status of ocean science around the world*. United Nations Educational, Scientific and Cultural Organization. https://doi.org/10.18356/9789216040048

Intergovernmental Oceanographic Commission (IOC). (2020). *Global Ocean Science Report 2020: Charting capacity for ocean sustainability*. United Nations Educational, Scientific and Cultural Organization. https://doi.org/10.18356/9789216040048

Intergovernmental Oceanographic Commission (IOC). (2021). *The United Nations decade of ocean science for sustainable development (2021-2030): Implementation plan*. United Nations Educational, Scientific and Cultural Organization. https://unesdoc.unesco.org/ark:/48223/pf0000377082

Jales, M. C., Feitosa, F. A. N., Koening, M. L., Montes, M. J. F., Araújo Filho, M. C., & Silva, R. A. (2015). Phytoplankton biomass dynamics and environmental variables around the Rocas Atoll Biological reserve, South Atlantic. *Brazilian Journal of Oceanography*, *63*(4), 443–454. https://doi.org/10.1590/S1679-87592015093906304

Jaspers, C., Acuña, J. L., & Brodeur, R. D. (2014). Interactions of gelatinous zooplankton within marine food webs. *Journal of Plankton Research*, *37*(5), 985–988. https://doi.org/10.1093/plankt/fbv068

Jaspers, C., Hopcroft, R. R., Kiørboe, T., Lombard, F., López-Urrutia, Á., Everett, J. D., & Richardson, A. J. (2023). Gelatinous larvacean zooplankton can enhance trophic transfer and carbon sequestration. *Trends in Ecology and Evolution*, *38*(10), 980–993. https://doi.org/10.1016/j.tree.2023.05.005

Jo, Y. H., Yan, X. H., Dzwonkowski, B., & Liu, W. T. (2005). A study of the freshwater discharge from the Amazon River into the tropical Atlantic using multi-sensor data. *Geophysical Research Letters*, *32*(2), L02605. https://doi.org/10.1029/2004GL021840

Katija, K., Choy, C. A., Sherlock, R. E., Sherman, A. D., & Robison, B. H. (2017). From the surface to the seafloor: How giant larvaceans transport microplastics into the deep sea. *Science Advances*, *3*(8), e1700715. https://doi.org/10.1126/sciadv.1700715

Kiørboe, T. (2011). How zooplankton feed: Mechanisms, traits and trade-offs. *Biological Reviews*, *86*(2), 311–339. https://doi.org/10.1111/j.1469-185X.2010.00148.x

Knoppers, B., Ekau, W., & Figueiredo, A. G. (1999). The coast and shelf of east and northeast Brazil and material transport. *Geo-Marine Letters*, *19*(3), 171–178. https://doi.org/10.1007/s003670050106

Lawrence, J., Töpper, J., Petelenz-Kurdziel, E., Bratbak, G., Larsen, A., Thompson, E., Troedsson, C., & Ray, J. L. (2018). Viruses on the menu: The appendicularian *Oikopleura dioica* efficiently removes viruses from seawater. *Limnology and Oceanography*, *63*(S1), S244–S253. https://doi.org/10.1002/lno.10734

Leite, A. A. C., Queiroz, A. F. S., Morais, L. M. S., Azevedo, C. C., & Martinelli Filho, J. E. (2020). Zooplankton at the Northern Brazilian coast: Evaluation and gaps. *Journal of Coastal Research*, *95*(sp1), 12–17. https://doi.org/10.2112/SI95-003.1

Li, K., Jianqiang, Y., Liangmin, H., Shumin, L., & Jianlin, Z. (2012). Distribution patterns of appendicularians and copepods and their relationship on the northwest continental shelf of South China Sea during summer. *Acta Oceanologica Sinica*, *31*(5), 135–145. https://doi.org/10.1007/s13131-012-0243-7

Lohmann, H. (1896). Die Appendicularien der Plackton-Expediction. *Ergebnisse Der Plankton-Expedition Der Humboldt-Stiftung*, *2*, 1–148.

Lombard, F., Legendre, L., Picheral, M., Sciandra, A., & Gorsky, G. (2010). Prediction of ecological niches and carbon export by appendicularians using a new multispecies ecophysiological model. *Marine Ecology Progress Series*, *398*, 109–125. https://doi.org/10.3354/meps08273

Lopes, R. M. (2007). Marine zooplankton studies in Brazil - A brief evaluation and perspectives. *Anais da Academia Brasileira de Ciencias*, *79*(3), 369–379. https://doi.org/10.1590/s0001-37652007000300002

Maar, M., Nielsen, T. G., Gooding, S., Tönnesson, K., Tiselius, P., Zervoudaki, S., Christou, E., Sell, A., & Richardson, K. (2004). Trophodynamic function of copepods, appendicularians and protozooplankton in the late summer zooplankton community in the Skagerrak. *Marine Biology*, *144*(5), 917–933. https://doi.org/10.1007/s00227-003-1263-9

Melo, P. A. M. C., Diaz, X. F. G., Macedo, S. J., & Neumann-Leitão, S. (2012). Diurnal and spatial variation of the mesozooplankton community in the Saint Peter and Saint Paul Archipelago, Equatorial Atlantic. *Marine Biodiversity Records*, *5*, e121. https://doi.org/10.1017/S1755267212001054

Menschel, A. E., & González, H. E. (2019). Carbon and calcium carbonate export driven by appendicularian faecal pellets in the Humboldt current system off Chile. *Scientific Reports*, *9*(1), 16501. https://doi.org/10.1038/s41598-019-52469-y

Miyashita, L. K., & Lopes, R. M. (2011). Larvacean (Chordata, Tunicata) abundance and inferred secondary production off southeastern Brazil. *Estuarine, Coastal and Shelf Science*, *92*(3), 367–375. https://doi.org/10.1016/j.ecss.2011.01.007

Neumann-Leitão, S., & Matsumura-Tundisi, T. (1998). Dynamics of a perturbed estuarine zooplanktonic community: Port of Suape, PE, Brazil. *SIL Proceedings, 1922-2010*, *26*(4), 1981–1988. https://doi.org/10.1080/03680770.1995.11901089

Nishida, H. (2008). Development of the appendicularian *Oikopleura dioica*: Culture, genome, and cell lineages. *Development Growth and Differentiation*, *50*(s1), S239-S256. https://doi.org/10.1111/j.1440-169X.2008.01035.x

Nittrouer, C. A., & DeMaster, D. J. (1996). The Amazon shelf setting: Tropical, energetic, and influenced by a large river. *Continental Shelf Research*, *16*(5–6), 553–573. https://doi.org/10.1016/0278-4343(95)00069-0

Ovalle, A. R. C., Rezende, C. E., Carvalho, C. E. V., Jennerjahn, T. C., & Ittekkot, V. (1999). Biogeochemical characteristics of coastal waters adjacent to small river-mangrove systems, East Brazil. *Geo-Marine Letters*, *19*(3), 179–185. https://doi.org/10.1007/s003670050107

Page, M. J., McKenzie, J. E., Bossuyt, P. M., Boutron, I., Hoffmann, T. C., Mulrow, C. D., Shamseer, L., Tetzlaff, J. M., Akl, E. A., Brennan, S. E., Chou, R., Glanville, J., Grimshaw, J. M., Hróbjartsson, A., Lalu, M. M., Li, T., Loder, E. W., Mayo-Wilson, E., McDonald, S., . . . Moher, D. (2021). The PRISMA 2020 statement: An updated guideline for reporting systematic reviews. *The BMJ*, *2021*(71), 372. https://doi.org/10.1136/bmj.n71

Posit team. (2020). *RStudio: Integrated Development Environment for R*. Posit Software, PBC. http://www.posit.co/

Purcell, J. E., Sturdevant, M. V., & Galt, C. P. (2005). A review of appendicularians as prey of invertebrate and fish predators. In G. Gorsky, M. J. Youngbluth, & D. Deibel (Eds.), *Response of marine ecosystems to global change - Ecological impact of appendicularians* (pp. 359–434). Gordon and Breach Scientific Publishers.

QGIS.org. (2024). *QGIS Geographic Information System* (2.18.14). QGIS Association. https://qgis.org/

R Core Team. (2016). *R: A Language and Environment for Statistical Computing*. R Foundation for Statistical Computing. https://www.r-project.org/

Rocha, R. M., Monteiro, T., Bonecker, S., & Oliveira, L. D. M. (2024). A synopsis of Tunicata biodiversity in Brazil. *Zoologia (Curitiba)*, *41*, e23042. https://doi.org/10.1590/S1984-4689.v41.e23042

Ryabinin, V., Barbière, J., Haugan, P., Kullenberg, G., Smith, N., McLean, C., Troisi, A., Fischer, A. S., Aricò, S., Aarup, T., Pissierssens, P., Visbeck, M., Enevoldsen, H., & Rigaud, J. (2019). The UN decade of ocean science for sustainable development. *Frontiers in Marine Science*, *6*, 470. https://doi.org/10.3389/fmars.2019.00470

Sandoval-Navarrete, C. A., Hernández-Márquez, S., Zamudio-Resendiz, M. E., Núñez-Resendiz, M. L., Márquez-Valdelamar, L. M., & Sentíes, A. (2024). Nuevos registros de Appendicularia (Urochordata) y otras especies de zooplancton en el Pacífico tropical mexicano. *Acta Zoológica Lilloana*, *68*(2), 309–341. https://doi.org/10.30550/j.azl/1974

Santos, M. A. M. (2022). *Nutrientes inorgânicos dissolvidos nas zonas costeiras e oceânicas do Brasil: uma revisão sistemática* [Dissertação de mestrado, Universidade Federal do Espírito Santo]. https://oceanografia.ufes.br/pt-br/pos-graduacao/PPGOA/detalhes-da-tese?id=15975

Sato, R., Yu, J., Tanaka, Y., & Ishimaru, T. (1999). New apparatuses for cultivation of appendicularians. *Plankton Biology and Ecology*, *46*(2), 162–164.

Sato, R., Tanaka, Y., & Ishimaru, T. (2001). House production by *Oikopleura dioica* (Tunicata, Appendicularia) under laboratory conditions. *Journal of Plankton Research*, *23*(4), 415–423. https://doi.org/10.1093/plankt/23.4.415

Sato, R., Ishibashi, Y., Tanaka, Y., Ishimaru, T., & Dagg, M. J. (2008). Productivity and grazing impact of *Oikopleura dioica* (Tunicata, Appendicularia) in Tokyo Bay. *Journal of Plankton Research*, *30*(3), 299–309. https://doi.org/10.1093/plankt/fbn001

Sato, R. (2023). An improved cultivation device for appendicularians with notes on the biology of Fritillaria sp. collected in Sagami Bay, Japan. *Journal of the Marine Biological Association of the United Kingdom*, *103*, e68. https://doi.org/10.1017/S0025315423000541

Shiga, N. (1985). Seasonal and vertical distributions of Appendicularia in Volcano Bay, Hokkaido, Japan. *Bulletin of Marine Science*, *37*(2), 425–439.

Sidone, O. J. G., Haddad, E. A., & Mena-Chalco, J. P. (2016). A ciência nas regiões brasileiras: evolução da produção e das redes de colaboração científica. *Transinformação*, *28*(1), 15–31. https://doi.org/10.1590/2318-08892016002800002

Souza, D. L., Zambalde, A. L., Mesquita, D. L., Souza, T. A., & Silva, N. L. C. (2020). A perspectiva dos pesquisadores sobre os desafios da pesquisa no Brasil. *Educação e Pesquisa*, *46*, e221628. https://doi.org/10.1590/S1678-4634202046221628

Spalding, M. D., Fox, H. E., Allen, G. R., Davidson, N., Ferdaña, Z. A., Finlayson, M., Halpern, B. S., Jorge, M. A., Lombana, A., Lourie, S. A., Martin, K. D., McManus, E., Molnar, J., Recchia, C. A., & Robertson, J. (2007). Marine ecoregions of the world: A bioregionalization of coastal and shelf areas. *BioScience*, *57*(7), 573–583. https://doi.org/10.1641/B570707

Spinelli, M. L., Pájaro, M., Martos, P., Esnal, G. B., Sabatini, M., & Capitanio, F. L. (2012). Potenciales presas zooplanctónicas (Copepoda y Appendicularia) para *Engraulis anchoita* en relación con las distribuciones de larvas tempranas y de desove en la región frontal patagónica (océano Atlántico sudoccidental). *Scientia Marina*, *76*(1), 39–47. https://doi.org/10.3989/scimar.2012.76n1039

Spinelli, M., Guerrero, R., Pájaro, M., & Capitanio, F. (2013). Distribution of *Oikopleura dioica* (Tunicata, Appendicularia) associated with a coastal frontal system (39°-41°S) of the SW Atlantic Ocean in the spawning area of *Engraulis anchoita* anchovy. *Brazilian Journal of Oceanography*, *61*(2), 141–148. https://doi.org/10.1590/S1679-87592013000200006

Suca, J. J., Pringle, J. W., Knorek, Z. R., Hamilton, S. L., Richardson, D. E., & Llopiz, J. K. (2018). Feeding dynamics of Northwest Atlantic small pelagic fishes. *Progress in Oceanography*, *165*, 52–62. https://doi.org/10.1016/j.pocean.2018.04.014

Taucher, J., Lechtenbörger, A. K., Bouquet, J. M., Spisla, C., Boxhammer, T., Minutolo, F., Bach, L. T., Lohbeck, K. T., Sswat, M., Dörner, I., Ismar-Rebitz, S. M. H., Thompson, E. M., & Riebesell, U. (2024). The appendicularian *Oikopleura dioica* can enhance carbon export in a high CO_2 ocean. *Global Change Biology*, *30*(1), e17020. https://doi.org/10.1111/gcb.17020

Tosetto, E. G., Bertrand, A., Neumann-Leitão, S., & Nogueira Júnior, M. (2022). The Amazon River plume, a barrier to animal dispersal in the Western Tropical Atlantic. *Scientific Reports*, *12*(1), 537. https://doi.org/10.1038/s41598-021-04165-z

Tundisi, T. M. (1970). On the seasonal occurrence of appendicularians in waters off the coast of São Paulo state. *Boletim do Instituto Oceanográfico*, *19*, 131–144. https://doi.org/10.1590/s0373-55241970000100005

Vega-Pérez, L. A., Campos, M. A. G., & Schinke, K. P. (2011). Checklist da classe appendicularia (Chordata: Tunicata) do Estado de São Paulo, Brasil. *Biota Neotropica*, *11*(suppl. 1), 761–769. https://doi.org/10.1590/s1676-06032011000500037

Weigert, S. C., & Madureira, L. S. P. (2011). Registros acústicos biológicos detectados na zona econômica exclusiva da região Nordeste do Brasil – uma classificação em ecotipos funcionais. *Atlântica*, *33*(1), 15–32. https://periodicos.furg.br/atlantica/article/view/2676

Wickham, H. (2016). *Ggplot2: Gráficos elegantes para análise de dados* (4.3.2). Springer-Verlag. https://ggplot2.tidyverse.org

Zappes, C. A., Alves, L. D., Guarnier, L., Bignotto, N. R., Reis, L. A. C., & Rotta, C. S. (2021). Decade of ocean science and its relationship with social-environmental oceanography. *Brazilian Journal of Development*, *7*(7), 66513–66534. https://doi.org/10.34117/bjdv7n7-092

AUTHORS' CONTRIBUTION

Á. T. P. C. Araújo contributed to conceptualization, investigation, data curation, research, methodology, visualization and writing (original draft, review and editing); T. R. C. Silva contributed to conceptualization, visualization and writing (review and editing); E. A. C. Silva contributed to formal Analysis, methodology, software and visualization; X. F. G. Díaz contributed to project Administration, supervision, validation, visualization and writing (review and editing); and Sigrid Neumann Leitão contributed to project administration, funding acquisition, resources, supervision, validation, visualization and writing (review and editing).