



Mapping and sharing scientific polychaete collections in Brazil: challenges for the Ocean Decade

Mônica A. V. Petti*¹, Paulo C. Paiva², Tatiana M. Steiner^{3,4}, Camila S. M. A. Messias⁵,
Marcelo V. Fukuda⁶, Joana Zanol⁵, Sandra Bromberg¹, A. Cecília Z. Amaral^{3,4}

¹ Departamento de Oceanografia Biológica – Instituto Oceanográfico – Universidade de São Paulo (Praça do Oceanográfico, 191 – São Paulo – SP – Brazil).

² Departamento de Zoologia – Instituto de Biologia – Universidade Federal do Rio de Janeiro (Ilha do Fundão, CCS – Bloco A – Rio de Janeiro – RJ – Brazil).

³ Departamento de Biologia Animal – Instituto de Biologia – Universidade Estadual de Campinas (Rua Monteiro Lobato, 255 – Campinas – SP – Brazil).

⁴ Museu de Diversidade Biológica – Instituto de Biologia Universidade Estadual de Campinas (Rua Monteiro Lobato, 255 – Campinas – SP – Brazil).

⁵ Laboratório de Biodiversidade de Annelida – Departamento de Invertebrados – Universidade Federal do Rio de Janeiro – Museu Nacional (Quinta da Boa Vista, s/n – Horto Botânico – RJ – Brazil).

⁶ Museu de Zoologia – Universidade de São Paulo (Avenida Nazaré, 481 – São Paulo – SP – Brazil).

* Corresponding author: mapetti@usp.br

ABSTRACT

Biological scientific collections provide a robust framework for studying past and present biodiversity through different perspectives. Mapping and sharing their information content may aid to reduce biodiversity shortfalls, such as those observed in annelid polychaetes. These are among the most important groups of marine invertebrates, playing pivotal ecological roles in benthic habitats, and being important bioindicators. The main scientific polychaete collections in Brazil are concentrated in four institutions: Museum of Zoology and Oceanographic Institute of University of São Paulo, Museum of Biological Diversity of State University of Campinas, and National Museum of Federal University of Rio de Janeiro. This paper explores the history and taxonomic knowledge of these collections, offering a comprehensive overview of their current statuses and highlighting challenges for the future. Together, these four collections safeguard over 300,000 samples from 68 polychaete families and 1,267 species representing 89% of the families and 94% of the species reported for the Brazilian coast. Among these samples, 252 are holotypes, which have rapidly increased in numbers in the past couple of decades due to the rise of species originally described from Brazil. Despite the long-standing presence of some of these institutions, the organization of their polychaete collections only began in the late 1990s and early 2000s. The organization of these official collections allowed the rescue of samples scattered around the institutions and made them available for further studies. All the Brazilian coastline is represented in these collections, but São Paulo and Rio de Janeiro are overrepresented. Historical factors, such as collection mergers, expeditions, and targeted projects, also influenced the geographic distribution of samples. Brazilian scientific polychaete collections have significantly advanced in the last 15 years. However, the associated data still needs better structuring and accessibility to the scientific community via open-access online platforms allowing further investigation on Brazilian polychaete biodiversity.

Keywords: Biodiversity, Conservation, Scientific collection, Annelida

Submitted: 29-Feb-2024

Approved: 10-Nov-2024

Associate Editor: Maikon Di Domenico



© 2024 The authors. This is an open access article distributed under the terms of the Creative Commons license.

INTRODUCTION

Biodiversity conservation relies on the presence of biological collections, the refinement of specimen identification, and the improvement in

the quality of records and documentation linked to specimens. An adequate storage infrastructure and modernization of the means of sharing information associated with specimens are essential elements for the proper functioning of a collection (Migotto and Marques, 2006). The collections gathered by natural history museums over the centuries contain invaluable data on the fauna of environments that frequently undergo changes. This information is important as a basis for understanding biological communities and their potential implications for ecosystem restoration.

Biological scientific collections play a fundamental role in the study of biodiversity, as they form the basis for taxonomic and systematic research, providing a robust framework for comparing different populations, describing new species, as well as for research on the evolution and biogeography of living and extinct organisms. Additionally, these collections are essential for studies on ecology, phylogeography, morphology, diseases, conservation, and historical declines, among others. Furthermore, they represent an irreplaceable heritage for future generations, particularly considering threats such as global change, which could lead to the extinction of numerous species (Álvarez-Campos and Sanchez-Almazán, 2010).

The Southeastern region of Brazil currently holds a high percentage of the national scientific collections of marine invertebrates, including mollusks, crustaceans, echinoderms and polychaetes, despite the different history of the institutions.

The Museum of Zoology of the University of São Paulo (MZUSP) was founded in the late 19th century, initially as part of the Museum Paulista (MP), with material from a mixture of origins (Borges et al., 2022). During the first decades of the 20th century, the MP became an important center for exhibitions and research, with its collections steadily growing. In 1939, the zoological part was separated and formed the Department of Zoology of the Secretariat of Agriculture, Industry, and Commerce of the State of São Paulo. This department was formally transferred to the University of São Paulo in 1969, and the museum renamed Museum of Zoology (Taddei et al., 1999).

The National Museum of the Federal University of Rio de Janeiro was inaugurated in 1880, as the Royal Museum by D. João VI, King of the United Kingdom of Portugal, Brazil and the Algarves. It was an independent institution built to follow the models of European natural history and anthropological museums with exhibitions, library, archives, laboratories, and scientific collections (Pires, 2017). In 1946, the museum became part of the Federal University of Rio de Janeiro. However, it was only from 1960 that the collections grew steadily due to the creation of graduate programs and the strengthening of research groups (Serejo, 2020).

The Natural History Museum of the State University of Campinas was established in the 1990s. In 2006, extensive changes were made in the organization of the Museum, when it started functioning as a museum genuinely focused on the curation of scientific collections, having been renamed as the Museum of Zoology Adão José Cardoso, incorporating new collections, particularly of marine invertebrates. In 2021, the merger of the Museum of Zoology (ZUEC) and the Herbarium (UEC) formed the Museum of Biological Diversity (MDBio).

The Biological Collection “Prof. Edmundo F. Nonato” at the Oceanographic Institute of the University of São Paulo (ColBIO), established in 2012, is home to one of the most extensive collections of marine organisms in Brazil. The specimens were collected in Brazilian waters from the 1950s to the present day (Borges et al., 2022). This collection is named in honor of Dr Edmundo F. Nonato, Professor Emeritus of the Oceanographic Institute (IOUSP), a great supporter of oceanographic studies in Brazil and the pioneering researcher of polychaetes in the country. The present biological collection at IOUSP holds invaluable historical significance, representing over seven decades of oceanographic research.

Polychaete annelids are one of the most important groups of marine invertebrates, playing pivotal ecological roles, especially in benthic habitats, also representing important indicators of environmental health, providing valuable information about the state of many

marine ecosystems (Pocklington and Wells, 1992). The phylogenetic arrangement of the Phylum Annelida, as conceived until the last years of the 20th century, has been questioned regarding not only its positioning among the protostomes, but also in its internal relations, e.g., the monophyly of traditional groups such as Polychaeta and Oligochaeta. In modern proposals (Struck, 2011; Weigert and Bleidorn, 2016; Rouse et al., 2022), Annelida has been considered to contain the groups Errantia and Sedentaria (with the Clitellata in a highly derived position among the latter), in addition to Pleistoannelida, Echiura and Sipuncula (Purschke et al., 2020).

Distributed along a coastline with an extent greater than 37° of latitude, the Brazilian polychaete fauna reflects the diversity of habitats characteristic of the different geographic areas. Among the various types of environments are coral reefs, rocky shores, estuaries, coastal lagoons, mangroves, beaches, sand, muddy sand, and muddy bottoms from shallow to deep areas.

Polychaetes have been studied more effectively in Brazil since the 1970s, with research conducted by Prof. Edmundo Ferraz Nonato (IOUSP), responsible for the inventory of biological samples collected by some oceanographic expeditions from the latter half of the 19th century (Nonato, 1964). Additionally, he played a fundamental role in describing new Brazilian species (Nonato, 1958, 1963, 1965, 1966, 1981) and in training successive generations of Brazilian polychaetologists. Since then, his first students, A. Cecilia Z. Amaral (1970s-1980s), and subsequently Paulo C. Lana (1990s), Paulo C. Paiva, and Monica A.V. Petti (2000s) trained many students interested in the group, together playing a significant role in expanding the knowledge on polychaetes in the country. During that time, the first polychaete identification keys in Brazil were published (Amaral and Nonato, 1981, 1982, 1984, 1996).

To date, around 70 specialists are distributed across several Brazilian locations. Most of them are listed in Lana et al. (2017). With the collaborative efforts of many of these experts, including young scientists, around 30 articles per year during the last decade are being produced with new species and new occurrences of polychaetes from Brazil

(Nascimento et al., 2024), as well as identification manuals for marine invertebrates (Pagliosa et al., 2014; Amaral et al., 2022). The two manuals' volumes already published include the description of several species from different families, accompanied by refined illustrations to assist in the identification of species recorded in Brazil (Amaral et al., 2006; Steiner et al., 2021).

Lana et al. (2017) undertook a comprehensive synthesis outlining the social trajectory and advances of polychaete research in Brazil. The authors delineated a temporal continuum of investigations and expounded upon the regional heterogeneity in polychaete knowledge, highlighting the predominantly small scale of studies in both temporal and spatial dimensions. Additionally, they underscored the limited knowledge concerning the polychaete fauna along the Eastern, Northeastern, and Northern coastal regions. This deficiency, attributed to the limited availability of human resources in these specific geographic areas during the period investigated, has been overcome by hiring more specialists in recent years.

Biological scientific collections are essential resources for the study of biodiversity, enabling research across various fields, including the traditionally recognized areas of systematics, ecology, and biogeography, in both extant and extinct organisms. Additionally, they can be explored in disciplines such as epidemiology and food security, thanks to new opportunities created by technological advancements (Johnson et al., 2023). By housing historical material, often from regions that have undergone significant changes over time, collections not only help address contemporary questions but also allow for retrospective analyses using modern approaches with ex situ material (Funk, 2018). When properly maintained, these collections hold immense potential to reduce the major knowledge gaps related to biodiversity (Hortal et al., 2015), making them not only scientific but also strategic assets for a nation. In this context, this paper aims to explore the history and taxonomic knowledge associated with scientific polychaete collections in Brazil, offering a comprehensive overview of their current statuses and highlighting challenges for the future.

METHODS

The classification into Errantia, Sedentaria, and others (e.g. Amphinomidae, Chaetopteridae) followed the taxonomic framework proposed by Struck (2011) latter modified by Rouse et al. (2022). However, for historical reasons regarding the arrangement of the collections, echiurans and sipunculans were excluded from the analyses, although some of the collections (MNRJ, MDBio and MZUSP) have recently incorporated them into the same catalog as the other annelids. The taxonomic classification of families was based on the World Register of Marine Species (WoRMS, accessed on November 30, 2023). The numbers recorded for each collection include specimens obtained until November 2023.

Before conducting species counts across collections, we compiled a unified list, addressing potential issues like synonymies, misspellings, and nomenclatural conflicts. For species with questionable names, such as unpublished new species or doubtful records, we opted to retain the names as cataloged in the collections until further analysis of the deposited material can be performed.

RESULTS AND DISCUSSION

MUSEUM OF ZOOLOGY – MZUSP

Over the decades, the polychaetes were scattered among long-established and prominent collections in the Museum’s divisions. One important contribution to the organization of the polychaete collection occurred in 2005/2006 by Alexandra E. Rizzo, then a post-doctoral researcher, and specialist in the group. The current structure, concatenated within the scope of the “Marine Invertebrates Collection”,

was established in 2008/2009; Marcelo V. Fukuda has been serving as its curator since 2018.

Despite being relatively recent, the MZUSP Polychaete Collection houses testimonies that date back to the early days of the establishment of the Museum Paulista itself. The oldest specimens in the collection, identified as *Diopatra chilensis* Quatrefages, 1866, were collected in 1895, the year Museum Paulista was founded. These first specimens were probably identified only years later by Aaron L. Treadwell (1866-1947), an established American researcher focused on polychaetes; while examining material from Brazil, he described several new species, with four holotypes deposited in the MZUSP collection.

Throughout its history, the Polychaete Collection has received material from different sources, e.g., projects from researchers and students associated with the museum and other institutions and material from consulting agencies. Among the main contributions we can mention names of eminent researchers, such as Jeanete M. Ramos (Universidade Santa Úrsula – RJ), whose collection was transferred to the MZUSP in 2011, some years after her passing, and Ana Maria S. Pires-Vanin (IOUSP), who donated part of the material gathered during her career before retiring.

Because the collection organization was only recently established, most of the material remains to be taxonomically qualified, and only a small fraction has its identification to at least the Family level, a requirement generally established for a given lot to be cataloged. Thus, currently the collection has around 40,000 cataloged specimens, representatives of 49 families and 324 species, among which are 100 holotypes and 298 lots of paratypes (Table 1, Figure 1).

Table 1. Numerical information from the four scientific polychaete collections treated herein.

| Collection | Total Families | Total Species | Lots* | Cataloged Specimens* | Uncataloged Specimens* | Type Material | | |
|------------|----------------|---------------|--------|----------------------|------------------------|---------------|-----------|-------------|
| | | | | | | Holotypes | Paratypes | Other types |
| MZUSP | 49 | 324 | 6,000 | 40,000 | 50,000 | 100 | 298 | 11 |
| MNRJP | 56 | 577 | 7,488 | 46,200 | 9,000 | 50 | 185 | 1 |
| MDBio | 56 | 647 | 21,431 | 220,000 | 40,000 | 101 | 809 | 11 |
| ColBIO | 59 | 506 | 3,000 | 15,000 | 30,000 | 1 | 39 | 0 |
| TOTAL | 68 | 1,267 | 37,919 | 311,200 | 129,000 | 252 | 1331 | 23 |

*some numbers are approximate

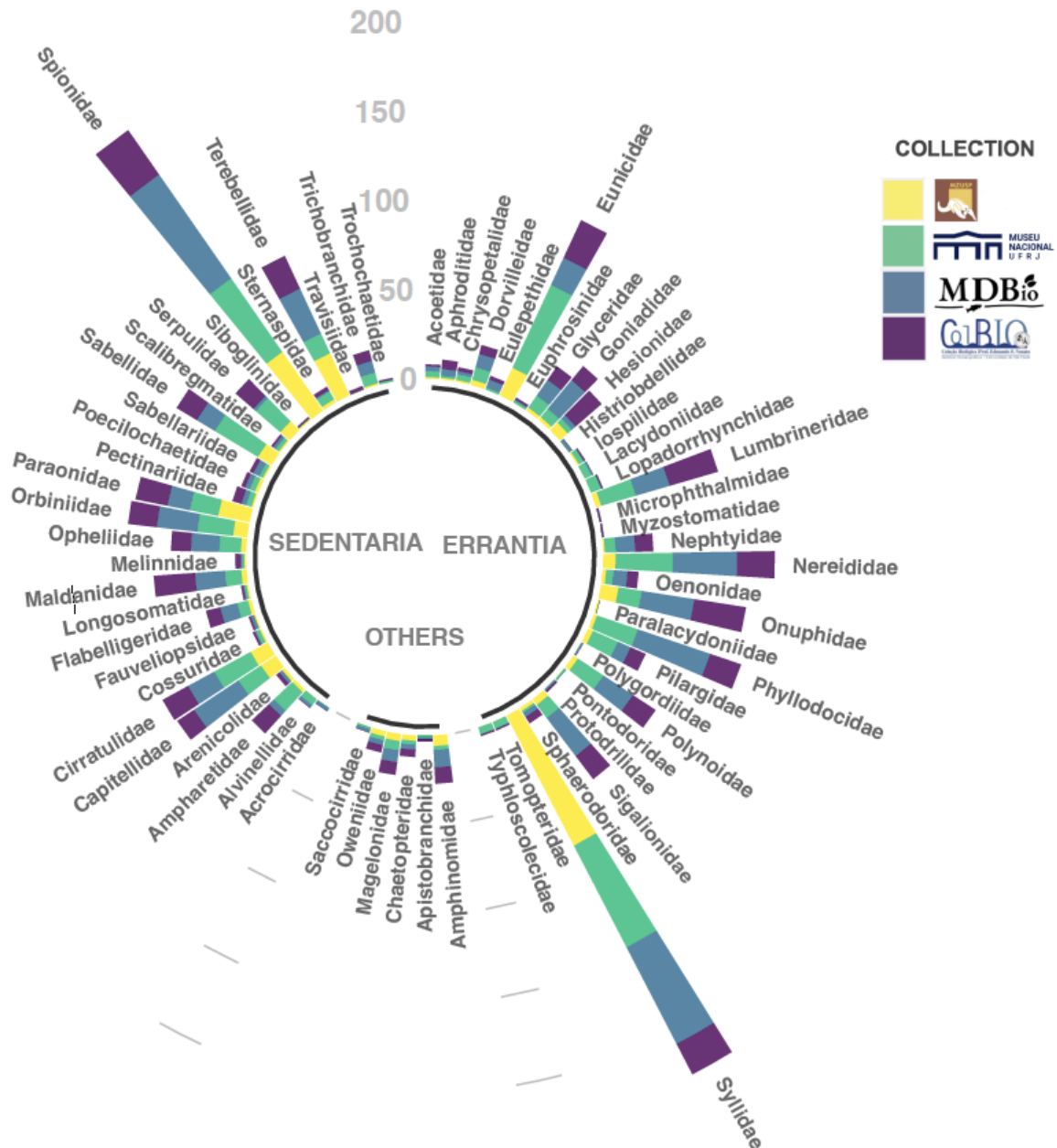


Figure 1. Number of polychaete species per family in the four Brazilian polychaete collections treated herein.

The cataloged material presents a distribution more focused on Brazilian representatives, from 13 Brazilian states (Figure 2), but also includes specimens from eight other countries (Table S1). Most of this material refers to specimens collected in coastal regions, from the intertidal zone to shallow depths, but with some highlights from projects that explored deeper areas, up to

4204 m, and expeditions to oceanic islands such as São Pedro and São Paulo, Trindade, Fernando de Noronha and the Rocas Atoll. The data and metadata of the collection are in the process of digitization, using Specify software, with plans to make the information available online in the near future, through the *SiBBR* (Brazilian Biodiversity Information System) platform.

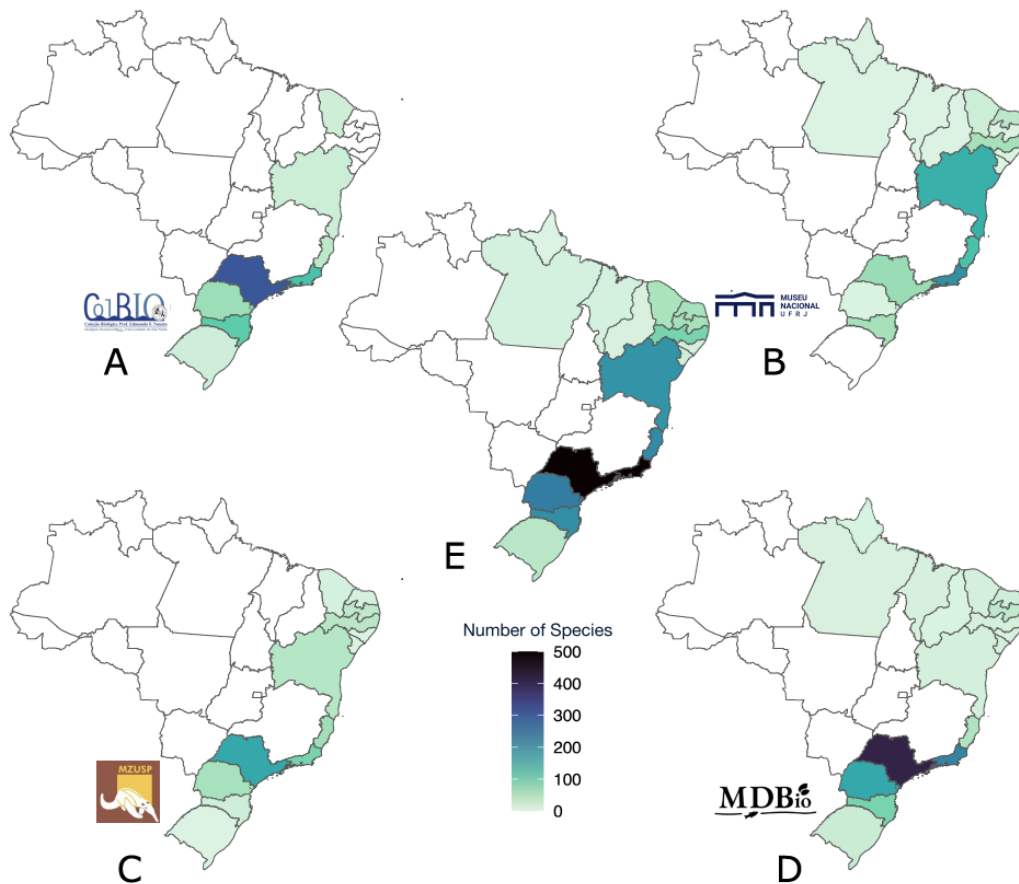


Figure 2. Distribution of polychaete species across Brazilian states from each collection treated in the present paper. Central map representing the total number of polychaete species from all four collections.

NATIONAL MUSEUM – MNRJ

The polychaete collection of the National Museum (MNRJP) was established in 1999 by Elianne Omena, a visiting professor at the museum, specialist in polychaetes and curator for two years. After that, there was no in-house curator for the collection. Also in 1999, Paulo C. Paiva started a polychaete collection in the Biology Institute of the same university (IBUFRJ), named in honor of Prof. Edmundo F. Nonato. He was the curator until 2015, when the collection was donated and moved to the National Museum. In 2023, this collection was incorporated into the MNRJP, receiving new catalog numbers under the acronym MNRJP. In the previous year, the Echiura and Sipuncula collections had been incorporated into the polychaete collection, consequently renamed as the Annelida Collection. Before 2019, only temporary technical

personnel and students had maintained the collection. Currently, the collection management team includes Joana Zanol as curator and Camila Messias as permanent technical staff, since 2015 and 2019, respectively.

The collection has 577 species from 56 families of polychaetes (Figure 1, Table 1). From a total of 7,488 lots, 236 lots are part of a type series (50 holotypes, 185 paratypes and 1 neotype). In addition to these, about 9,000 specimens are deposited, awaiting cataloging (Table 1). The MNRJP collection has representatives from the intertidal zone to 4204 m depth. The cataloged specimens are mainly from Brazil (6657 lots, 88.9% of the collection), totaling 16 states (Figure 2), but also contain specimens from another 24 countries from all continents, including Antarctica (Table S1). The MNRJP database is now partially accessible for online

consultation via the SiBBR portal. The curatorial team is currently engaged in efforts to fully integrate the database into the management program developed by the Specify Collections Consortium. This integration will enable streamlined online access and updates within the SiBBR platform. The collection also houses a specimen of historical importance, a *Hermodice carunculata* (Pallas, 1776) collected in 1875 by the Geological Commission of the Empire in Brazil (1875-1877), which collected in several locations on the Brazilian coast, particularly in the Northeast and North regions.

MUSEUM OF BIOLOGICAL DIVERSITY – MDBio

In 2006, the small collection of polychaetes (ZUEC POL), which currently includes Echiura and Sipuncula, began to develop under the responsibility of A. Cecília Z. Amaral and Tatiana M. Steiner, current curators of the collection, adding material from projects developed in the marine part of the Department of Animal Biology at UNICAMP. The participation of undergraduate and graduate students, as well as temporary technical personnel, contributed effectively to the growth of the collection over the years.

In 2009, the collection was improved with the incorporation of the Polychaeta collection (MCBM/MCEM) from the Centro de Estudos do Mar of the Federal University of Paraná (CEM/UFPR). This collection was started by our late friend Paulo C. Lana, who contributed substantially to Brazilian research in the area, with around 1300 lots and almost 5,000 individuals transferred.

The MDBio polychaete collection stands out for its great representation: around 220,000 cataloged specimens, encompassing 56 families and 647 species, 101 holotypes, 809 lots of paratypes and 11 other types. In addition to these, ca. 40,000 specimens are deposited, awaiting cataloging (Table 1, Figure 1). This collection is available online with digitized data through the SpeciesLink network¹. The specimens were collected in different

marine environments in 17 Brazilian states (Figure 2), in addition to six other countries, and Antarctica (Table S1), and the mid-Atlantic Ridge, at depths of up to approximately 4200 m. The species *Lepidasthenia esbelta* Amaral & Nonato, 1982, collected in 1969 by the GEDIP project (Executive Group for the Development of the Fishing Industry), an expedition considered a milestone in oceanography in Brazil, was cataloged as ZUEC POL 1 of the collection, in honor of Prof. Edmundo F. Nonato. The oldest specimen in the collection, *Hyalinoecia tubicola*, 20 cm long, was collected in Antarctica in 1962.

BIOLOGICAL COLLECTION – COLBIO

Regarding the polychaete collection, countless samples collected since the 1950s were consolidated in cabinets under Prof. Nonato's care, encompassing some paratypes of species he described. In 2015, efforts were initiated by Monica A. V. Petti, current curator, and Sandra Bromberg, a collaborator, to review and register all these samples. The involvement of undergraduate students has been crucial to the organization and expansion of the collection. In addition to these earlier samples, the collection includes numerous specimens obtained through major projects developed by IOUSP and a lot of samples collected during several Brazilian Antarctic expeditions, particularly around the Brazilian Station “Comandante Ferraz” on King George Island, South Shetlands.

The ColBIO collection at IOUSP houses approximately 3,000 lots and 15,000 cataloged specimens of polychaetes, encompassing 59 families and 506 species, one holotype and 39 paratypes (Table 1, Figure 1). Of the total, 124 species (24.5%) are from the Antarctic region. It is worth noting that more than 27,000 benthic specimens and around 3,000 holoplanktonic specimens are still awaiting analysis and cataloging. The ColBIO collection is registered in the SiBBR, and the data is being added to the Specify software, but not yet available online. The specimens were collected from the intertidal zone to the deep sea, representing diverse marine environments across eight Brazilian states (Figure 2), as well as from eight other countries and Antarctica (Table S1).

¹ <https://specieslink.net/col/ZUEC-POL/>

The oldest specimen in the collection belongs to the genus *Glycera*, collected from São Sebastião Island (state of São Paulo) in 1952. Several specimens mentioned in Nonato (1981), as well as original ink drawings detailing the species, are also deposited in the ColBIO collection.

COLLECTION REPRESENTATION BY FAMILIES AND HOLOTYPES

The total of families and their diversity in each collection is similar, therefore most families that occur in Brazil are well represented in these museums. Of the 83 polychaete families, excluding Echiura, Sipuncula and Clitellata (WoRMS, 2023), 68 are in these collections.

The Catalog of Polychaeta of Brazil (Amaral et al., 2022) presents the most comprehensive reference for species occurrences in the country. It includes species mentioned in taxonomic works, as well as in studies related to ecology and conservation, among others. This compilation is the result of an extensive and historical bibliographic review, involving 848 references including complete articles, book chapters, dissertations, theses, and abstracts. According to the Catalog, Brazil has records of 76 families, 463 genera, and 1,343 species. In the four museums treated herein 68 families and 1,267 species (Table S2) are housed, accounting for 89% and 94% of the national totals, respectively. It's important to note that these figures may not necessarily represent the same taxa.

In these four collections, a total of 252 holotypes are curated (Table 1). Eight of these holotypes were described exclusively by foreign researchers, while the others have at least one Brazilian author. Examining the timeline of Brazilian descriptions, 5.3% were documented between 1981 and 1990, 6.1% between 1991 and 2000, 18.9% between 2001 and 2010, and 48.4% between 2011 and 2020. From 2021 until present, 21.3% have been described. These findings highlight the growth of the polychaete specialist community in Brazil, reflecting an increased understanding of our marine biodiversity.

The enrichment, both numerical and specific, of certain families in each collection is directly related to the specialty of the researchers belonging to institutions linked to the museum but may also be related to the presence of a

specialist curator. For example, the prominence of Syllidae is observed in MZUSP because there are specialists of this family at the Biosciences Institute, at USP. Furthermore, the expansion of this family's collection is also occurring due to the curator's expertise. Similarly, the prevalence of Eunicidae at MNRJ can be attributed to the curator's specialized knowledge in this family, as well as the extensive sampling conducted in reef ecosystems, where Eunicidae exhibits significant species diversity.

The predominance of Spionidae in MDBio can be explained by the historical focus on collecting materials from shallow soft sediments and beaches, but also by the significant material deposited by a foreign specialist, Vasily Radashevsky. Notably, the distribution of species among the families in ColBIO is relatively even, with no significant concentration of species in any particular family, as observed in other collections. This reflects the generalist nature of researchers from the 1960s to the 1990s, a trend initiated by Prof. Edmundo F. Nonato.

COLLECTION REPRESENTATION BY STATES

Over the years, several significant research projects funded by different sources, such as the National Council for Scientific and Technological Development (CNPq), the São Paulo Research Foundation (FAPESP), and the Brazilian Energy Company PETROBRAS have expanded these collections, contributing to the description of new species and new occurrence records. These projects encompass different habitats, including large depth ranges.

Regarding the representation of species richness in Brazilian polychaete collections by state, we clearly observe a general pattern of overrepresentation of the southeastern states, especially São Paulo and Rio de Janeiro, both with more than 500 species each (Figure 2E). This result is expected, as all the collections are located within these two states. The dominance of these two states extends to neighboring regions, such as Paraná and Santa Catarina (southern coast), Espírito Santo, and Bahia (eastern coast) with ca. 200 species each.

An analysis of each collection reveals distinct biases in species representation. ColBIO (Figure 2A) and MDBio (Figure 2D) show a bias toward species from southern states, which are underrepresented

in the MNRJP collection (Figure 2B). Conversely, species from eastern and northern states are better represented in MNRJP but less so in ColBIO and MDBio. Although MZUSP (Figure 2C) contains fewer species, it exhibits a more balanced distribution across many Brazilian states.

Despite the “collection location bias” in species representation, a clear trend is observed, closely linked to historical factors such as collection mergers, expeditions, and projects dedicated to specific regions (Figure 2). The overrepresentation of southern species in ColBIO can be attributed to historical surveys conducted by IOUSP, particularly in São Paulo (SP), Rio de Janeiro (RJ) and Rio Grande do Sul (RS). On the other hand, MDBio, which includes extensive surveys supported by FAPESP and primarily centered in São Paulo (SP), shows a bias resulting from the fusion of the CEM-Polychaete collection, originally situated in Paraná (PR) under Paulo da Cunha Lana curation. MZUSP, although the least biased collection, still displays an overrepresentation of species from the states of Pernambuco (PE) and Paraíba (PB). This bias is linked to collaborative projects developed by João M. M. Nogueira and Marcelo V. Fukuda, which focused on the study of intertidal annelids, particularly Syllids. MNRJP's bias toward northeastern species also reflects the research projects of its curators, Paulo Cesar de Paiva and Joana Zanol. The former IBUFRJ collection was built from surveys and projects in reef areas, primarily concentrated in eastern (Abrolhos – Bahia) and northern regions (Atol das Rocas – Rio Grande do Norte), contributing to this observed bias.

MAIN CHALLENGES: HUMAN RESOURCES, INFRASTRUCTURE, EXPANSION AND DISSEMINATION OF INFORMATION

The training of personnel for the development of research, as well as curators and technicians in the management of biological collections is essential. Different institutions in Brazil have regularly offered specific courses on the taxonomy of polychaetes. However, courses on curation and organization of collections are still scarce.

In addition to engaged researchers, the participation of undergraduate and graduate students is necessary to carry out research projects with material from the museums, resulting in the improvement of the information quality of the collections and in the expansion of the taxonomic knowledge on polychaetes. Therefore, museums must keep their collections available, facilitating access and thus allowing the advancement of research in different areas of knowledge (Krishtalka and Humphrey, 2000; Suarez and Tsutsui, 2004; Johnson et al., 2023).

Regarding the growth of biological collections in Brazil, it is observed that the expansion of the collection is also directly related to the constant presence of technical and curatorial staff within the museums. For instance, the absence of an in-house specialist curator and support team at MNRJP resulted in a lack of deposited material from 2001 to 2015 (Figure 3). The number of cataloged lots increased at both MNRJP and IBUFRJ in years with dedicated temporary or permanent technical staff (Figure 3). The decreasing growth in 2020 and 2021 shows the effect of the COVID-19 pandemic on cataloging.

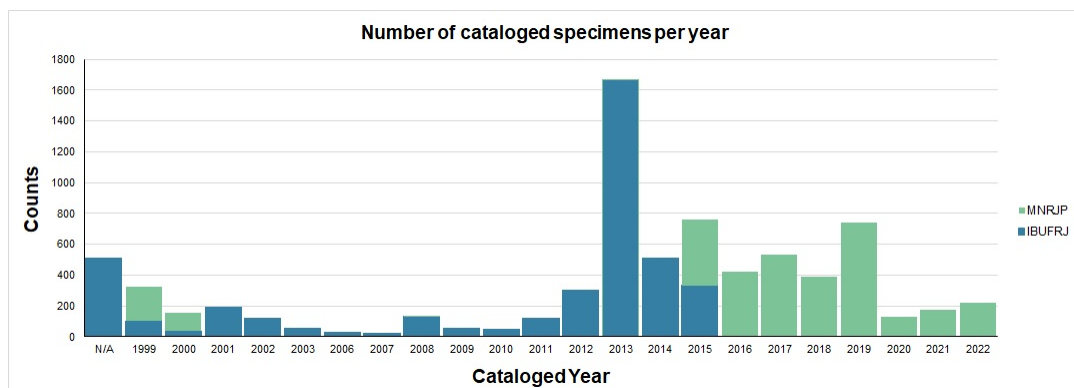


Figure 3. Number of specimens cataloged over the years in the National Museum of Federal University of Rio de Janeiro (MNRJP) Annelida collection. (N/A = not available, for lots without year cataloged information).

Scientific collections in institutions that have an active curatorial team and constant maintenance are able to improve storage of scientific material (Vivo et al., 2014; Sánchez-Almazán, 2017). In Brazil, researchers commonly store private collections in their laboratories, without an adequate curatorial structure, risking the loss of biological material. Some initiatives have been taken to better safeguard this material. For example, the private collections of Paulo da C. Lana (MCEM/UFPR) and Paulo C. Paiva (IB/UFRJ), were donated to MDBio and MNRJ, respectively, for safe storage and more appropriate maintenance.

Although the museums presented here have good infrastructure for storage and technical curatorial training, much progress still needs to be made in Brazil (Marinoni et al. 2024). Unfortunately, these institutions are exceptions, as most collections in the country lack even basic institutional recognition. Even when housed within established institutions, the specific requirements for proper collection maintenance and the full curatorial process are rarely achieved or considered (Vivo et al., 2014; Marinoni et al., 2024). As a result, the involvement of museum leadership is critical, particularly in mobilizing resources and coordinating efforts to strategically fill gaps in the collections (Johnson et al., 2023).

Museums must allocate efforts toward cataloging, curation, and documentation of their collections, as well as the dissemination and sharing of the information. The MDBio is the only institution to date that provides remote consultation of its collections on online platforms integrating data on Brazilian biodiversity, such as the SpeciesLink network (<http://splink.cria.org.br/>) and the Brazilian Biodiversity Information System – SiBB². These platforms aim to stimulate national research and public policies for promoting the conservation and sustainable use of biodiversity. MZUSP, MNRJ and ColBIO are in the process of making information from their collections available.

To help expand knowledge of the diversity of polychaetes in Brazil, the scientific community also has the support of two large databases, the Catalog

of Polychaeta of Brazil (Amaral et al., 2022) and NONATObase (Pagliosa et al., 2014), which are repositories with information about the polychaete species recorded from the Southwest Atlantic Ocean. These significant databases provide records of occurrences, with information regarding locations, dates, depths, and environments from different areas of research, such as taxonomic and ecological, among others.

CONCLUSION

Scientific collections of polychaetes in Brazil have significantly advanced in the last 15 years and are currently much more structured. Despite this, much could still be improved by increasing the number of researchers working directly with the collections, both in the taxonomic refinement of species already deposited, and in contributing to their expansion. There is also a need to increase the number of professionals working directly in curation and maintenance. Although Brazil has a considerable number of taxonomy specialists, less than 1/3 are hired in research institutions, and even fewer are linked to museums. The increase in the number of polychaete species described by Brazilian researchers over the past two decades highlights the demand for specialists with the background, training, and working conditions to address the many challenges facing our understanding of biodiversity, such as the Linnean and Wallacean shortfalls (cf. Hortal et al., 2015), especially in the context of a rapidly changing planet.

Curatorial courses are rare in the country. Therefore, the majority of curators are polychaete specialist researchers, who are also directly involved in the training of human resources, including offering specific courses, for the development of taxonomy in Brazil.

The data associated with the scientific collections still needs better structuring, in terms of sharing and making it available to the scientific community on open-access online platforms. Catalogs, guides, manuals, and illustrated identification keys should be produced and made available in both print and interactive (online) formats, so that knowledge on Brazilian polychaete species can be expanded and disseminated.

² https://collectory.sibbr.gov.br/collectory/public/show/in26?lang=pt_BR

ACKNOWLEDGMENTS

This entire piece is a humble tribute to our dear colleague, Paulo da Cunha Lana, who played a fundamental role in advancing polychaete research in Brazil, both through his significant scientific contributions and his dedication to training highly qualified human resources. We extend our sincere gratitude to the referee for the extreme attention and care demonstrated during the review process. The authors wish to thank the National Council for Scientific and Technological Development (CNPq) for the Productivity grant to A.C.Z.A. (Proc. 30155/2019-7) and P.C.P. (Proc. 306788/2021-7). P.C.P. and J.Z. also received grants from Rio de Janeiro Research Foundation (FAPERJ) (respectively Proc. E-26/200.375/2023 and E-26/201.329/2021 – BOLSA). São Paulo Research Foundation (FAPESP) and CNPq contributed with several projects linked to the collections (FAPESP Proc. 2009/5494-3, 2014/15168-7 and 2018/10313-0; CNPq Proc. 562273/2010-7, 405744/2013-7 and 442718/2018-7). Special thanks to Dr Mario Katsuragawa for the dedicated effort towards the growth of ColBIO since its conception through the funding obtained from PETROBRAS (Proj. 4600237181 and 4600249986).

AUTHOR CONTRIBUTIONS

M.A.V.P.: Conceptualization – Data curation – Formal Analysis – Investigation – Methodology – Writing – original draft – Writing – review & editing.
 P.C.P.: Data curation – Formal Analysis – Investigation – Methodology – Writing – original draft – Writing – review & editing.
 T.M.S.: Data curation – Investigation – Methodology – Writing – original draft – Writing – review & editing.
 C.S.M.A.M.: Data curation – Investigation – Methodology – Writing – original draft – Writing – review & editing.
 M.V.F.: Data curation – Investigation – Methodology – Writing – original draft – Writing – review & editing;
 J.Z.: Data curation – Investigation – Methodology – Writing – original draft – Writing – review & editing.
 S.B.: Data curation – Investigation – Methodology – Writing – original draft – Writing – review & editing.
 A.C.Z.A.: Conceptualization – Data curation – Investigation – Methodology – Supervision – Writing – original draft – Writing – review & editing.

REFERENCES

- Álvarez-Campos, P. & Sánchez-Almazán, J. 2010. The Polychaeta Collection of the Museo Nacional de Ciencias Naturales Madrid: heritage and studies basis. *EDIT Newsletter* 20: 11-12.
- Amaral, A. C. Z., Nallin, S. A. H., Steiner, T. M., Forroni, T. O., Gomes-Filho, D., Araújo, G. R., Freitas, R., Costa, C. A. O., Ruta, C., Gomes, K. R. E. & Bonaldo, R. O. 2022. *Catálogo das espécies de Annelida "Polychaeta" do Brasil*. Available from: https://intranet.ib.unicamp.br/intranet/polychaeta/_apresentacao.php
- Amaral, A. C. Z. & Nonato, E. F. 1981. *Anelídeos poliquetos da costa brasileira: Características e Chave para Famílias – Glossário* (Volume 1/2). Brasília: Conselho Nacional de Desenvolvimento Científico e Tecnológico – CNPQ.
- Amaral, A. C. Z. & Nonato, E. F. 1982. *Anelídeos poliquetos da costa brasileira: Aphroditidae e Polynoidae* (Volume 3). Brasília: Conselho Nacional de Desenvolvimento Científico e Tecnológico – CNPQ.
- Amaral, A. C. Z. & Nonato, E. F. 1984. *Anelídeos poliquetos da costa brasileira. Polyodontidae, Pholoidae, Sigalionidae e Eulepethidae* (Volume 4). Brasília: Conselho Nacional de Desenvolvimento Científico e Tecnológico – CNPQ – .
- Amaral, A. C. Z. & Nonato, E. F. 1996. *Annelida Polychaeta: – características, glossário e chaves para famílias gêneros da costa brasileira*. Campinas: Editora da Unicamp.
- Amaral, A. C. Z., Rizzo, A. E. & Arruda, E. P. 2006. *Manual de identificação dos invertebrados marinhos da região sudeste-sul do Brasil* (Volume 1). São Paulo: Editora da Universidade de São Paulo.
- Borges, M., Petti, M. A. V., Fukuda, M. V., Cassano, V., Fujii, M. T. & Amaral, A. C. Z. 2022. Marine planktonic and benthic organisms: an ocean of diversity in the collections of the State of São Paulo. *Biota Neotropica*, 22(spe), e20221406. DOI: <https://doi.org/10.1590/1676-0611-BN-2022-1406>
- Funk, V. A. 2018. Collections-based science in the 21st Century. *Journal of Systematics and Evolution (Beijing)*, 56(3), 175-193. DOI: <https://doi.org/10.1111/jse.12315>
- Hortal, J., Bello, F., Diniz-Filho, J. A. F., Lewinsohn, T. M., Lobo, J. M. & Ladle, R. J. 2015. Seven shortfalls that beset large-scale knowledge of biodiversity. *Annual review of ecology, evolution, and systematics* 46, 523-549. DOI: <https://doi.org/10.1146/annurev-eolsys-112414-054400>
- Johnson, K. R., Owens, I. F. P. & The Global Collection Group. 2023. A global approach for natural history museum collections. *Science*, 379(6638), 1192–1194. DOI: <https://doi.org/10.1126/science.adf6434>
- Krishtalka, L. & Humphrey, P. S. 2000. Can Natural History Museums Capture the Future? *BioScience*, 50(7), 611–617. DOI: [https://doi.org/10.1641/0006-3568\(2000\)050\[0611:CNHMCT\]2.0.CO;2](https://doi.org/10.1641/0006-3568(2000)050[0611:CNHMCT]2.0.CO;2)
- Lana, P. C., Pagliosa, P., Paiva, P. C., Carrerette, O., Paresque, K., Nogueira, J. M. M., Amaral, A. C. Z., Steiner, T. M., Christoffersen, M. L., Garraffoni, A. R. S., Domenico, M., Barroso, R., Rizzo, A. E. & Fukuda, M. V. 2017. Polychaetes in Brazil: people and places, past, present and future. *Boletim del Instituto Oceanografico de Venezuela*, 1, 24–50. Available from: https://www.researchgate.net/publication/316217539_

- Polychaetes in Brazil: people and places past, present and future. Access date: 2024 nov 11.
- Marinoni, L., Gasper, A. L., Chiquito, E. A., Glienke, C., Fonseca, C. B., Juárez, K. E. M., Basílio, D. S., Henriques, D. K., Petters Vandresen, D. A. L., Morais, G. S., Jorge, I., Pimenta, A. D., Dal Molin, A., Souto, A. S. S., Santos, C. R. M., Serejo, C. S., Souzamotta, C. M., Attili-Angelis, D., Werneck, F. P., Carvalho, F. R., Garbino, G. S. T., Stehmann, J. R., Giacomini, L. L., Jesus, M. A., Silva, M., Fukuda, M. V., Rosa, R. S., Costa Araújo, R., Maués, M. M., Thiengo, S. C., Silva, T. R. S., Andrade, T. S., Cavalcanti, T. B., Dutra, V. F. & Vicente, V. A. 2024. *Introdução e orientações às boas práticas para as Coleções Biológicas Científicas Brasileiras*. Curitiba, PR: Sociedade Brasileira de Zoologia (Série zoologia: guias e manuais). DOI: <https://doi.org/10.7476/9786587590042>
- Migotto, A. E. & Marques, A. C. 2006. Invertebrados Marinhos. In: Lewinsohn T. (Coor.) *Avaliação do estado do conhecimento da biodiversidade brasileira* (pp. 149–202). Brasília: Ministério do Meio Ambiente.
- Nascimento, R. L., Mendes, S., Vital, M. V. C. & Paiva, P. C. 2024. Polychaete research in Brazil: a bibliometric analysis. *Ocean and Coastal Research*, 72(suppl 1) e24018. DOI: <https://doi.org/10.1590/2675-2824072.23105>
- Nonato, E. F. 1958. Sobre duas arenícolas da costa brasileira (Annelida, Polychaeta). *Contribuições avulsas do Instituto Oceanográfico. Oceanografia Biológica*, 3, 1-6.
- Nonato, E. F. 1963. *Poecilochaetus australis* sp. n. (Annelida, Polychaeta). *Neotropica*, 9, 17-26. Available from: <https://www.marinespecies.org/aphia.php?p=sourcedetails&id=51188>
- Nonato, E. F. 1964. Anelídeos poliquetas. In: Vanzolini, P. E. (Ed.). *História natural dos organismos aquáticos do Brasil*. pp. 133-137. São Paulo, Editora da FAPESP.
- Nonato, E. F. 1965. *Eunice sebastiani* sp. n. (Annelida, Polychaeta). *Boletim do Instituto Oceanográfico*, 14, 133–139. <https://doi.org/10.1590/S0373-55241965000100008>
- Nonato, E. F. 1966. *Sternaspis capillata* sp. n. (Annelida, Polychaeta). *Boletim do Instituto Oceanográfico*, 15, 79–84. <https://doi.org/10.1590/S0373-55241966000100011>
- Nonato, E. F. 1981. Contribuição ao conhecimento dos anelídeos poliquetas bentônicos da plataforma continental brasileira, entre Cabo Frio e Arroio Chuí (Livro Docência em Zoologia e Invertebrados Marinhos). São Paulo: Universidade de São Paulo. DOI: <https://doi.org/10.11606/T.21.1982.tde-23092009-144338>
- Pagliosa, P. R., Doria, J. G., Misturini, D., Otegui, M. B. P., Oortman, M. S., Weis, W. A., Faroni-Perez, L., Alves, A. P., Camargo, M. G., Amaral, A. C. Z., Marques, A. C. & Lana, P. C. 2014. NONATObase: a database for Polychaeta (Annelida) from the Southwestern Atlantic Ocean. *Database*, 2014(bau002). DOI: <https://doi.org/10.1093/database/bau002>
- Pires, D. O. 2017. *200 anos do Museu Nacional*. Rio de Janeiro, Associação de Amigos do Museu Nacional. Available from: https://www.museunacional.ufrj.br/200_anos/doc/200_anos_do_Museu_Nacional.pdf
- Pocklington, P. & Wells, P. G. 1992. Polychaetes: key taxa for marine environmental quality monitoring. *Marine Pollution Bulletin*, 24(12), 593-598. DOI: [https://doi.org/10.1016/0025-326X\(92\)90278-E](https://doi.org/10.1016/0025-326X(92)90278-E)
- Purschke, G., Westheide, W., Boggemann, M. 2020. *Handbook of Zoology*. Germany: De Gruyter.
- Rouse, G. W., Pleijel, F. & Tilič, E. 2022. *Annelida*. Oxford: Oxford University Press.
- Sánchez-Almazán, J. I. 2017. La gestión de colecciones de historia natural: criterios y parámetros para su evaluación. *Boletín de la Real Sociedad Española de Historia Natural: Sección aula, museo y colecciones*, 4, 69–79.
- Serejo, C. 2020. *Museu nacional: panorama dos acervos: passado, presente e futuro*. Rio de Janeiro: Editoria do Museu Nacional.
- Steiner, T. M., Amaral, A. C. Z. & Borges, M. 2021. *Manual de identificação dos invertebrados marinhos da região sudeste-sul do Brasil* (Volume 2). São Paulo: Editora da Universidade de São Paulo.
- Suarez, A. V. & Tsutsui, N. D. 2004. The value of museum collections for research and society. *BioScience*, 54(1), 66-74. DOI: [https://doi.org/10.1641/0006-3568\(2004\)054\[0066:TVOMCF\]2.0.CO;2](https://doi.org/10.1641/0006-3568(2004)054[0066:TVOMCF]2.0.CO;2)
- Struck, T. H. 2011. Direction of evolution within Annelida and the definition of Pleistoannelida. *Journal of Zoological Systematics and Evolutionary Research*, 49(4), 340-345. <https://doi.org/10.1111/j.1439-0469.2011.00640.x>
- Taddei, V. A., Martins, U. R., De Vivo, M. & Percequillo, A. R. 1999. O acervo das coleções zoológicas do Estado de São Paulo. In: Joly, C. A. & Bicudo, C. E. M. (Org.). *Biodiversidade do Estado de São Paulo, Brasil: síntese do conhecimento ao final do século XX, 7: infra-estrutura para a conservação da biodiversidade* (pp. 53–67). São Paulo: Editora da FAPESP.
- Vivo, M., Silveira, L. F. & Nascimento, F. O. 2014. Reflexões sobre coleções biológicas, sua curadoria e a inserção dos Museus na estrutura universitária brasileira. *Arquivos de Zoologia*, 45(esp.), 105-113. DOI: <https://doi.org/10.11606/issn.2176-7793.v45iespp105-113>
- Weigert, A. & Bleidorn, C. 2016. Current status of annelid phylogeny. *Organisms Diversity and Evolution*, 16, 345-362. DOI: <https://doi.org/10.1007/s13127-016-0265-7>
- WoRMS Editorial Board. 2024. *World Register of Marine Species*. DOI: <https://doi.org/10.14284/170>