



RESEARCH ARTICLE
TAXONOMIC CATALOG OF THE BRAZILIAN FAUNA

Biodiversity of Porifera in Brazil

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ABSTRACT. The sponge fauna of Brazil is highly diverse and still underestimated. Until 2011, 443 species were recorded, representing 5.3% of the Porifera diversity worldwide. Nowadays, the complete list of sponge species in Brazil is available online at the Taxonomic Catalog of the Brazilian Fauna (CTFB). This study aimed to present the current state of knowledge about the Porifera biodiversity in Brazil based on the list of valid extant sponge species up to December 2022 in the CTFB and World Porifera Database (WPD). By then, a total of 612 species of sponges were listed from Brazil, including 551 marine and 61 freshwater sponges. Demospongiae is the most diverse class, with 508 species, followed by Calcarea (68), Hexactinellida (19) and Homoscleromorpha (17). Among the Brazilian sponge fauna, 310 species are endemic (50%), with the majority belonging to the Class Demospongiae (256). Marine sponges are distributed across all the Brazilian coast and the regions with the highest number of marine species were the Northeast and Southeast regions, with 343 and 229 species, respectively. Among the hydrographic basins, freshwater sponges are more diverse in the Paraná basin, with 33 species recorded. The sponge diversity in Brazil is probably higher, since these numbers are limited by the collection effort in each region.

KEY WORDS. Distribution, diversity, freshwater sponges, history, marine sponges, sponges, taxonomy.

INTRODUCTION

Sponges (phylum Porifera) are among the most abundant and diverse groups of benthic invertebrates. They are mainly sessile filter feeders, with the exception of a small group of carnivorous sponges almost restricted to the deep sea (Van Soest et al. 2012). Sponges are important ecological components of benthic communities and participate in a diverse array of interactions with other organisms, including commensalism, competition, cooperation, predation, decomposition of organic matter, symbiosis with microorganisms, etc. (Wulff 2006, Bell 2008, Pawlik and McMurray 2020). They are also important sources of natural products with a diverse array of pharmacological properties besides other biotechnological applications (Thakur and Müller 2004, Laport et al. 2009).

Despite their importance, sponge taxonomy is still incipient. The reduced number of both taxonomists and useful taxonomic characters led to a general underestimation of sponge biodiversity worldwide. The widespread use of molecular taxonomy in the 21st century helped to distinguish many sibling species, increasing the biodiversity estimates and leading to major changes in higher taxa classification (Morrow and Cárdenas 2015). There are 9,639 valid extant species of sponges known worldwide, but an average of 120 new species were described per year in the last decade (de Voogd et al. 2024).

In Brazil, the number of sponge species is also underestimated and rapidly increasing. Previous attempts to list the sponge species of Brazil were made in the 1960's (Mello-Leitão et al. 1961: 82 species), 1970's (Hechtel 1976: 156 species, only

marine demosponges) and in the 21st century (Muricy et al. 2011: 443 species). Other reviews focused exclusively on deep-sea sponges (Hajdu and Lopes 2007, Fernandez et al. 2018). The complete list of sponge species in Brazil is now available online at the Taxonomic Catalog of the Brazilian Fauna (CTFB – <http://fauna.jbrj.gov.br>), which is constantly updated (Pinheiro et al. 2024). By December 2022 it listed 612 valid extant sponge species for Brazil, but further 18 species have been registered since (Pinheiro et al. 2024) and there are many other species still to be described. Other online initiatives with information on the taxonomy and distribution of the Brazilian sponges are the World Porifera Database (WPD; de Voogd et al. 2024) and the database of the Brazilian environmental agency ICMBio for extinction risk and endangered species, called SALVE (ICMBio 2024).

The goals of this study were: 1) to revise the history of sponge taxonomy in Brazil; 2) to list and count the currently valid extant sponge species in Brazil, comparing the different taxonomic groups and regions; 3) to determine the percentage of endemic species per taxonomic group and geographical region; 4) to evaluate the current state of knowledge about Brazilian sponges; and 5) to point out trends, areas and taxonomic groups that should be studied in more detail.

MATERIAL AND METHODS

Because this report was written during the year 2023, all analyses were based on the list of valid extant sponge species in Brazil up to 31 December 2022 available in the Taxonomic Catalog of Brazilian Fauna (CTFB) (Pinheiro et al. 2024), the World Porifera Database (WPD) (de Voogd et al. 2024) and all the published literature on Brazilian sponges. Records from PhD Thesis were not considered, except in one case as a basis to estimate the richness and endemism per state (Annunziata 2019).

RESULTS AND DISCUSSION

History of the discovery of sponge species in Brazil

The first taxonomic studies about sponges from Brazil were those of Bowerbank (1863) describing six Amazonian freshwater sponges (*Acalle recurvata*, *Drulia brownii*, *Metania reticulata*, *Tubella gregaria*, *Tubella paulula* and *Uruguaya corallioides*) and of Müller (1865) and Schultze (1865) describing and renaming the marine sponge *Darwinella muelleri* Schultze, 1865.

The number of marine species recorded per year from Brazil was initially related to the results of major oceano-

graphic expeditions such as the H.M.S. Challenger in the 1880's (Poléjaeff 1884, Ridley and Dendy 1886, 1887, Schulze 1887, Sollas 1888) and the R/Vs Calypso and Oregon II in the 1970's (Boury-Esnault 1973, Collette and Rützler 1977), and of collections by foreign researchers such as Jacques Laborel (Hechtel 1983) (Figs 1A, 2A).

In the inland habitats, the records of sponges were the result of collections made by foreign naturalists in Brazil who sent material to researchers in Europe (Bowerbank 1863, Carter 1881, Weltner 1895, Traxler 1895) and the USA (Potts 1887, Hinde 1888) at the end of the 19th century (Figs 1B, 2B).

There were two major shifts from European and American taxonomists to Brazilian specialists, in the 1960's for freshwater sponges (Fig. 2B) and in the 1990's for marine sponges (Fig. 2A). In the 21st century, several sponge taxonomists were established in Brazil (Fig. 2) and the number of species described per year became higher and more constant, although it still varies widely from year to year (Fig. 1).

Diversity of Porifera in Brazil

Until December 2022, 612 valid sponge species were recorded from Brazil, including 551 marine sponges and 61 freshwater sponges (see Supplementary Tables 1 and 2). Of these, 339 marine and 45 freshwater sponges were originally described from Brazil.

Sponge species of all four classes of Porifera are recorded in Brazil. Demospongiae is by far the richest class (508 species), followed by Calcarea with 68 species, Hexactinellida with 19 species and Homoscleromorpha with 17 species (Fig. 3). All 61 species of freshwater sponges belong to the Class Demospongiae (Order Spongillida), since the other three classes are exclusively marine.

The Northeast (NE) and Southeast (SE) regions showed the highest numbers of records of marine sponges, with 343 and 229 species, respectively, whereas the North (N) and South (S) regions have the lowest numbers, with 60 and 68 species, respectively (Fig. 4A).

Regarding the oceanic islands of Brazil, the most diverse sponge fauna is found in Fernando de Noronha Archipelago, with 72 species, followed by Rocas Atoll (46 spp.), São Pedro e São Paulo Archipelago (28 spp.), and Trindade and Martim Vaz Islands (22 spp.) (Fig. 4A).

Among the coastal states from Brazil, Bahia (NE) has the highest diversity, with 193 species, followed by Rio de Janeiro (SE), Pernambuco (NE) and São Paulo States (SE), with 156, 109 and 95 species, respectively. Piauí (NE) and Paraná (S) states remain poorly known, with only one and four records, respectively (Fig. 4B).

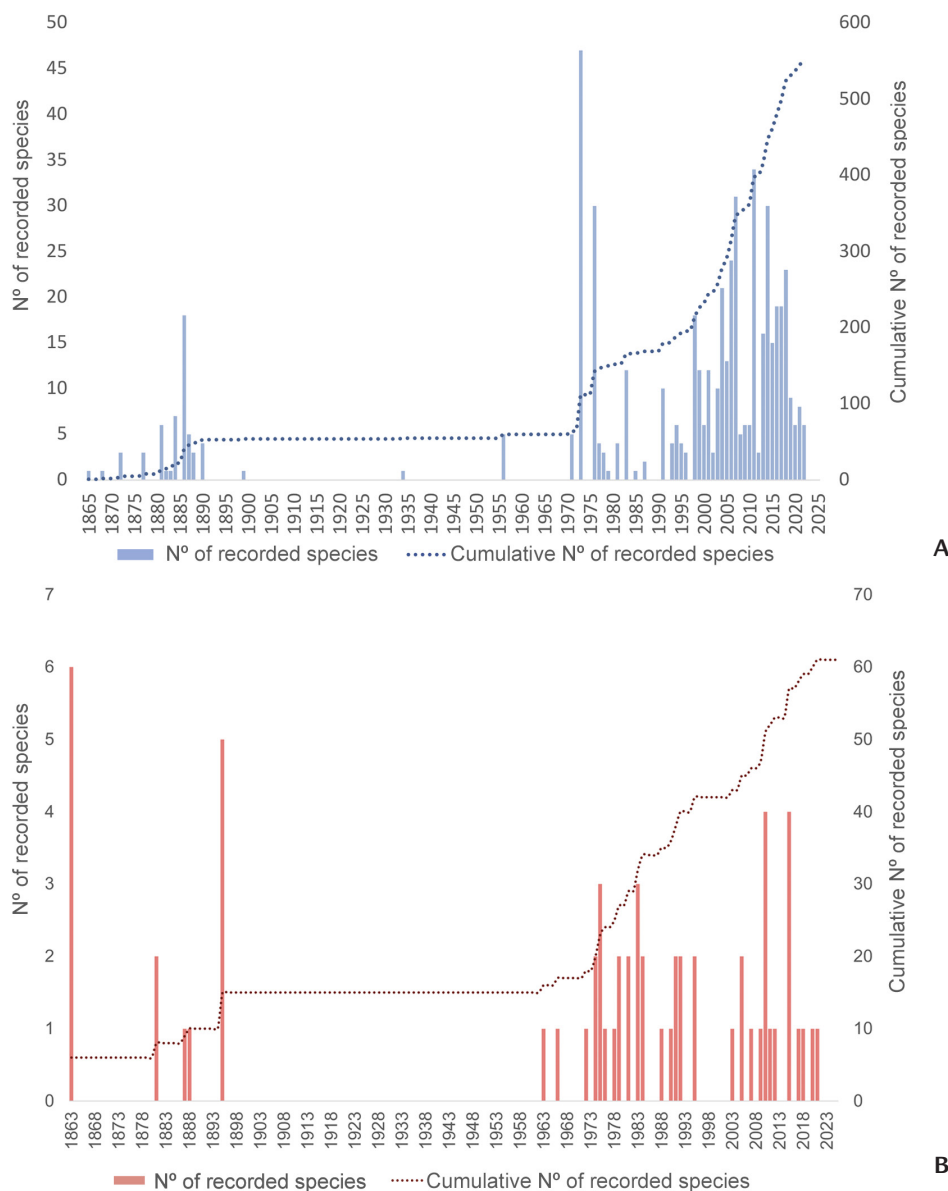


Figure 1. Rate of new records of sponge species from Brazil: (A) Absolute number and cumulative number of marine species recorded per year (1865–2022); (B) Absolute number and cumulative number of freshwater species recorded per year (1863–2022). Data from the World Porifera Database (de Voogd et al. 2024).

The freshwater species are more diverse in the Paraná (35 spp.), Amazon (33 spp.), Tocantins-Araguaia (27 spp.) and South Atlantic (23 spp.) basins. On the other hand, the fauna in the Parnaíba (0 spp.), Eastern Atlantic (3 spp.), Southeastern Atlantic (4 spp.) and Northwestern Atlantic (6 spp.) basins are poorly known (Fig. 5).

Regarding the marine sponges, it would be strategic to focus new collection efforts on the areas with the lowest

number of known species, such as Paraná, Piauí, Sergipe and the Northern Region. However, these areas are largely influenced by sediment plumes from river mouths, decreasing the opportunities for diving to study the shallow coastal benthos and increasing the investments needed to study deeper reefs.

On the other hand, there are specimens already deposited in Porifera collections, such as the material from the mesophotic reefs of the Amazon River plume and from

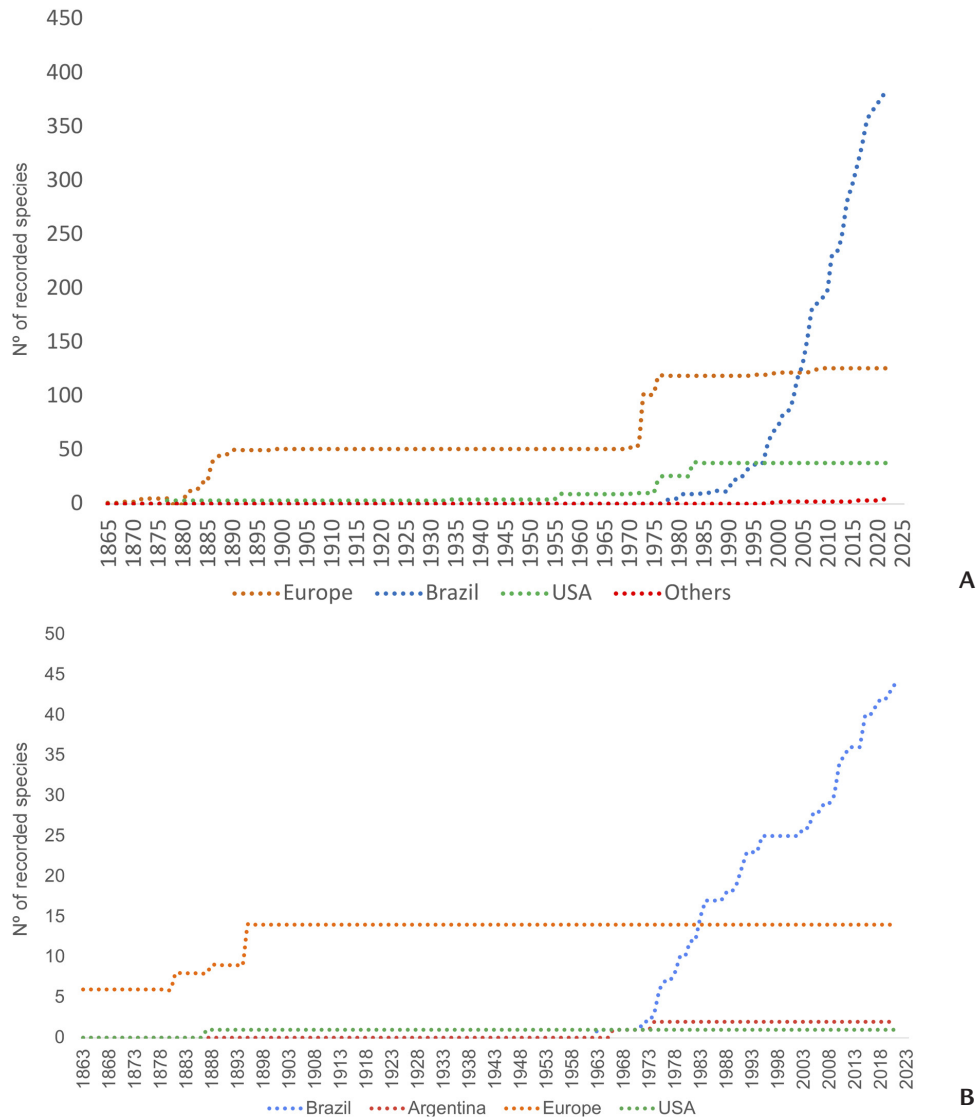


Figure 2. Cumulative number of sponge species from Brazil per year according to the nationality of the first author: (A) Records of marine species (1865–2022); (B) Records of freshwater species (1863–2022). Data from the World Porifera Database (de Voogd et al. 2024).

the state of Paraná in the Porifera Collection of the Museu Nacional/Universidade Federal do Rio de Janeiro (MN/UFRJ) and from the state of Piauí in the Porifera Collection of the Museu de Zoologia of the Universidade Federal de Pernambuco (UFPE), but the current human resources are not enough to meet this demand.

Even in the states where the spongi fauna is best known, the diversity in some regions is still underestimated. Bettcher et al. (2023), who studied sponges collected only in the intertidal environment of four reefs in southern Bahia,

found at least 64 species, leaving others 40 morphotypes that were not identified at a specific level. It is important to emphasize here that the Bahian coastline extends for about 1,200 km and this state has almost 565,000 km². Therefore, although 193 species had already been recorded to Bahia – leading it to the first place in the Brazilian sponge diversity rank – this number indicates the presence of 0.16 marine species/km of coast, which is a remarkably low number considering the variety of ecosystems in Bahia. On the other hand, this number is still higher when compared to the 0.065

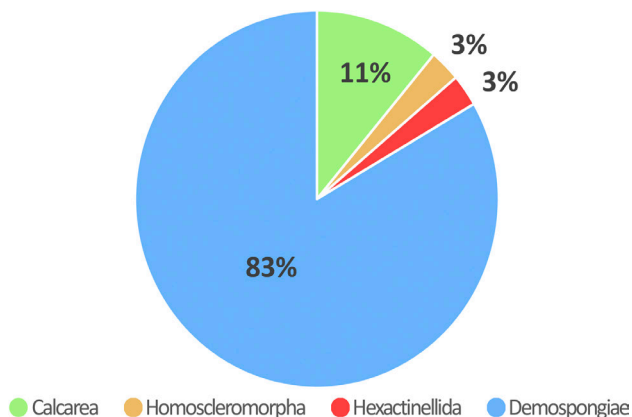


Figure 3. Diversity (in percentage) of the four classes of sponges recorded from Brazil until December 2022.

species/km of the entire Brazilian coast. In this sense, it is no exaggeration to say that our knowledge of the Brazilian spongiofauna is just the tip of the iceberg.

For freshwater sponges, the situation is even more dramatic: most of the known diversity has been reported by a single Brazilian researcher, Cecília Volkmer-Ribeiro, who has mainly studied sponges from the South Atlantic, Paraná, Tocantins-Araguaia and Amazon basins. Since 2004, Pinheiro's work has focused on the São Francisco and Northeast Atlantic basins, complementing Volkmer-Ribeiro's efforts. The difficulty of sampling in these environments, coupled with the scarcity of human resources trained in freshwater sponge taxonomy are the major challenges to overcome.

Endemism of Porifera in Brazil

Of the 612 sponge species from Brazil, a total of 310 are endemic, of which 282 are marine species. Considering only those 339 species originally described from this country, 280 species are Brazilian endemics, with 195 species known only from a single locality, whereas 85 are also found along the Brazilian coast. In regard to the freshwater sponges, of the 61 species, 28 are Brazilian endemics.

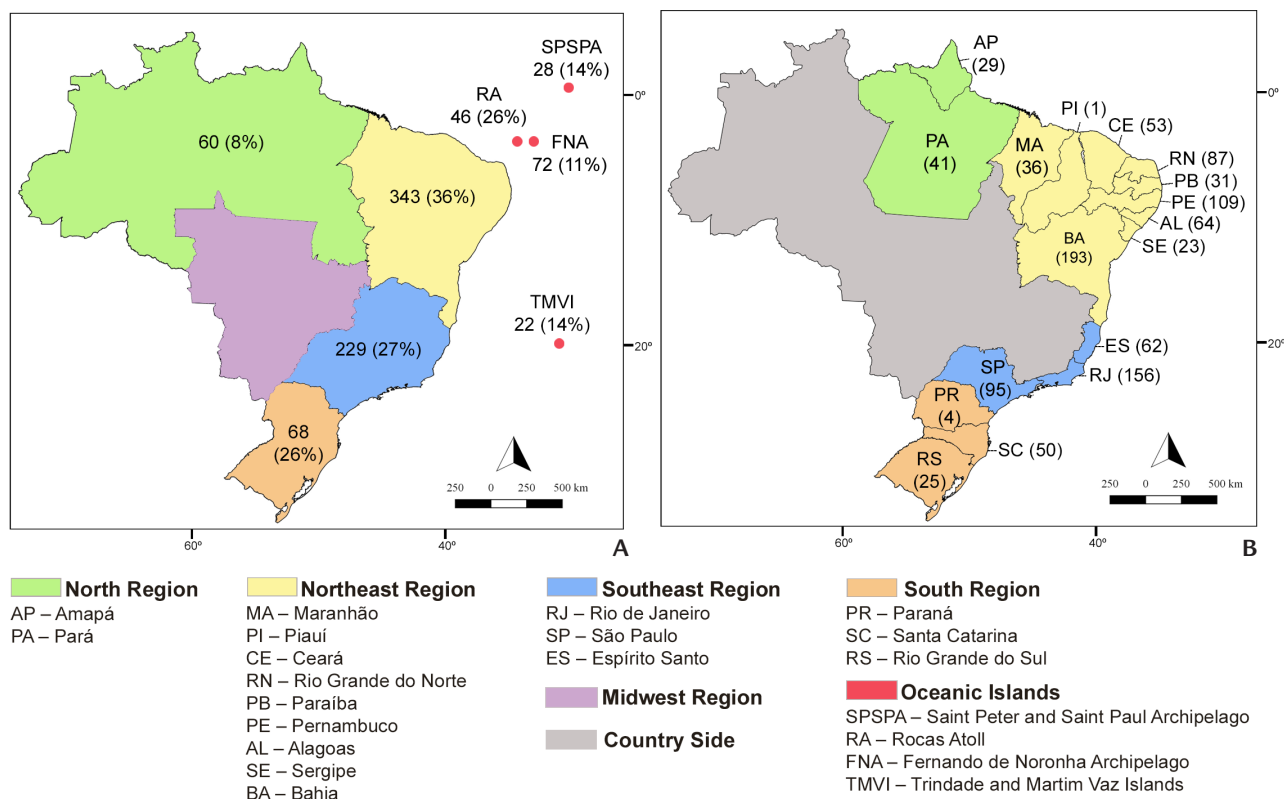


Figure 4. Diversity of marine species from Brazil until December 2022: (A) Number of records and endemism rates (%) in the North, Northeast, Southeast and South regions and oceanic islands; (B) Number of records in the coastal states. Modified from Muricy et al. (2011).

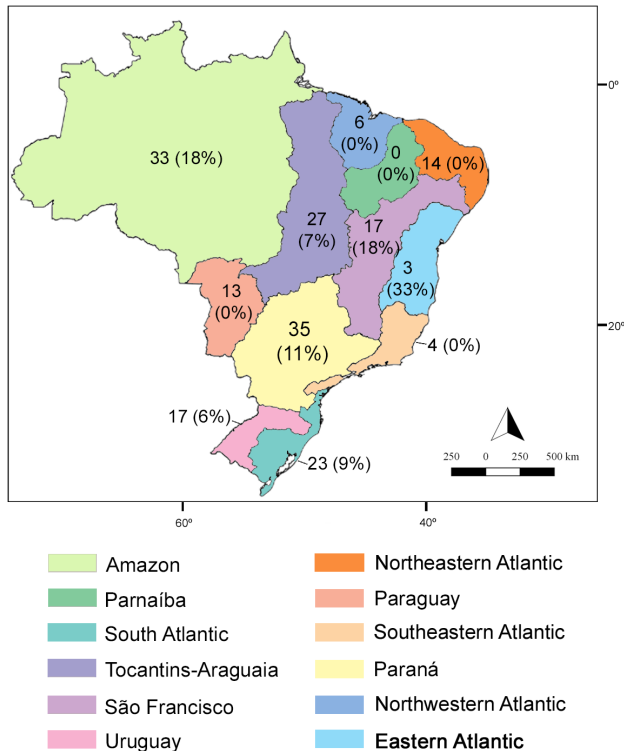


Figure 5. Records and endemism rate (%) of freshwater sponges in the twelve hydrographic basins of Brazil until December 2022. Modified from Muricy et al. (2011).

The class Homoscleromorpha has the highest endemism rate, with 12 endemic species of the 17 species. Calcareae and Demospongiae have similar endemism rates, with 35 endemic species and 256 endemic species, considering both marine and freshwater sponges, of the 68 and 512 species, respectively. Hexactinellida has the least endemism with eight endemic species, of the 19 species (Fig. 6).

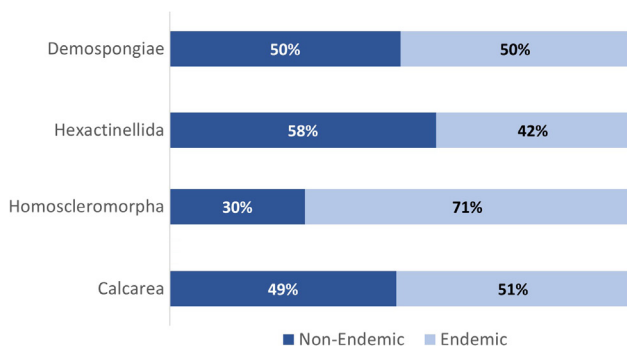


Figure 6. Percentage of Brazilian non-endemic and endemic species in the four classes of sponges until December 2022.

The Northeast Region has 123 endemic species (in a total of 343 species) followed by the Southeast Region with 63 endemic species (out of 229) and the South Region with 18 endemic out of 68 species. The North Region has five endemics out of 60 species. Rocas Atoll is the Brazilian oceanic island with the highest endemism rate, with 12 endemics out of 46 species (Fig. 4A).

Another factor that should not be overlooked when analyzing endemism rates is under-sampling: 195 marine species are known only from their type localities, but some of them will probably be found when collections in new localities of the Brazilian coast occur. Additionally, many species considered to be co-specific with Caribbean populations are probably distinct species waiting for further investigation, e.g. *Aplysina fulva* (Pallas, 1766) and *Amphimedon compressa* Duchassaing & Michelotti, 1864. In this sense, we believe that differences in the rates of endemism between the Brazilian coast regions tend to decrease as studies progress, whereas the endemism of Brazil tends to increase, especially when compared to the Caribbean spongiofauna.

Seven of the twelve hydrographic basins have endemic freshwater sponge species: Amazon (6 spp.), Paraná (4 spp.), São Francisco (3 spp.), Tocantins-Araguaia (2 spp.), South Atlantic (2 spp.), Eastern Atlantic (1 spp.), and Uruguay basin (1 sp.) (Fig. 5).

Considering South America as a whole, the endemism rate for freshwater sponges is even higher. Of a total of 67 species, only six occur outside the borders of South America. There is a possibility that some of these six species belong to species complexes, which could make the endemism rate even higher (Pinheiro and Calheira 2020).

Porifera taxonomy in Brazil

Currently, there are 29 researchers with PhD working on the taxonomy and systematics of Porifera, 15 of which are employed by Higher Education Institutions (HEI). The other 14 are either on fixed-term contracts, post-doctoral fellows or collaborators with other researchers. Almost 15 years ago, Zilberberg et al. (2010) counted 13 researchers, nine of which were employed by HEIs. This doubling of the number of researchers helps to explain the increase in scientific production over the last decade. This increase also changed the distribution of professionals linked to HEIs by region, currently with the Northeast with the highest number of professionals (7), followed by the Southeast (5), South (2) and Central-West region (1).

Some projects have also been instrumental in the advancement of knowledge of Brazilian spongiofauna, such as the REVIZEE project in the 1990's, funded by the Federal

Government of Brazil, and the Porifera Network in the 2000's, funded by Petrobras. The REVIZEE project provided access to the spongiofauna of different bathymetries along most of the Brazilian coast. This project yielded a huge amount of material for the Porifera Collections, which is still being studied. The Porifera Network, on the other hand, although focused only on the Potiguar Basin, where sponges from different bathymetries were also collected, provided an increase in the infrastructure of the Porifera Laboratories in the states of Rio de Janeiro, Bahia and Pernambuco, and covered the costs of the publication of the field guides of Bahia (Hajdu et al. 2011) and Brazilian oceanic islands (Moraes 2011). In addition, it also provided the digitalization of the collection's databases so that all Porifera researchers could have broad access to them.

Another important milestone for Porifera taxonomy was the Catalogue of Brazilian Porifera (Muricy et al. 2011), the result of a joint effort by all Brazilian spongiologists. This book cataloged all species described or recorded from Brazil up to December 2010, providing synonyms, type locality, location of type material, distribution records, as well as comments on taxonomic issues of each species. This work provided easy access to all the taxonomic problems of each species and served as the basis for most subsequent studies.

Muricy et al. (2011) listed 443 species of sponges known from Brazil. After 12 years, 178 other species have been recorded, representing an increase of more than 40% of the Brazilian spongiofauna, which has gone from 5.3 to 6.5% of the world's spongiofauna. Due to the increase in the number of researchers in the country, as well as the large number of graduate students without permanent positions who have been trained in Porifera taxonomy and systematics, there is a great potential to discover more new species and to better understand their distribution in Brazil. But for this to happen, maintaining PhD researchers in the HEIs is extremely important, together with the need of more government incentives through grants and postdoctoral fellowships to keep these researchers working in the Academia.

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JS: Conceptualization, Data curation, Formal Analysis, Writing – original draft, Writing – review & editing. GM, UP, BBA: Conceptualization, Data curation, Formal Analysis, Updated the CTFB database, Writing – original draft, Writing – review & editing. FFC: Updated the CTFB database, Writing – original draft.

Competing Interests

The authors have declared that no competing interests exist.

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Supplementary material 1

Supplementary Table S1. Marine sponge species recorded from Brazil until December 2022. Data from World Porifera Database (de Voogd et al. 2024), Taxonomic Catalog of Brazilian Fauna (Pinheiro et al. 2024) and Catalogue of Brazilian Porifera (Muricy et al. 2011).

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Link: <https://doi.org/10.1590/S1984-4689.v41.e24017>

Supplementary material 2

Supplementary Table S2. Freshwater sponge species (Demospongiae: Spongillida) recorded from Brazil until December 2022. Data from World Porifera Database (de Voogd et al. 2024), Taxonomic Catalog of Brazilian Fauna (Pinheiro et al. 2024) and Catalogue of Brazilian Porifera (Muricy et al. 2011).

Authors: J. Sandes, G. Muricy, F.F. Cavalcanti, U. Pinheiro, B.B. Annunziata

Data type: Species data.

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