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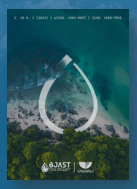

POLYCHAETA (ANNELIDA) OF THE ITAJAÍ-AÇU RIVER ESTUARY, BRAZIL – ECOLOGICAL REMARKS AND A CHECK LIST OF SPECIES

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ABSTRACT

Based on the result of six samplings carried out in 2021 and 2022, compiled with data from literature reviews, the present study aimed to carry out a description of the Polychaeta species that inhabit the region of the estuary of the Itajaí-Açu River. The list includes 29 taxa, of which twenty have already been catalogued in the area and seven have yet to be identified. The species *Capitella* cf. *nonatoi*, previously identified as *Capitella capitata*, was included in the list. The low values of richness found in the region, as well as the dominance of *Heteromastus similis*, corroborate the pattern exhibited by most benthic assemblages of urbanized estuaries in southern Brazil.

Keywords: Annelida. Benthos. Estuarine Ecosystem. Species List.

1 Introduction

Estuaries are described as restricted bodies of water in which marine water mixes with fresh water from the mainland (Cameron & Pritchard, 1963). This ecosystem is extremely relevant, as it makes up a highly productive environment, which provides ecologically indispensable goods and services, retains substances and contaminants, and harbors a rich diversity of species and habitats (Kwok, 2014; Burton, 2020). The estuary of the Itajaí-Açu river is also of great ecological importance for the regional coastal zone, as it constitutes the largest river system between the Patos-Mirim lagoon system in Rio Grande do Sul, 700 km to the south, and the Ribeira do Iguape river in São Paulo, 300 km to the north. In addition, the region is of great economic importance, since the main port of the state of Santa Catarina is located in this estuary, comprising one of the main port complexes in Brazil, and a large number of fishing industries and shipyards (Schettini, 2002; Porto Itajaí, 2023).

Urbanization and associated activities have caused numerous changes in estuaries, which can contribute to biological invasions (Santana et al., 2020), decline in water quality (Ren et al., 2003; 2014), inhibition of biodiversity maintenance (Barbier et al., 2011), and replacement of important species or loss of functional diversity (Airoldi et al., 2008). One of the groups of organisms affected by urbanization is the benthic macrofauna community, which is formed by metazoans greater than 0.5 mm long (Tovar-Hernández, 2021), composed of invertebrates such as crustaceans, molluscs, and annelids (Tawanggian et al., 2022). Annelids are commonly a major component of any benthic community, in terms of richness and abundance, they may represent the dominant component, being able to form up to 2/3 of the benthic associations (Rouse & Pleijel, 2006; Dean, 2008).

The group Annelida have representatives at all trophic levels and exhibit a wide variety of feeding habits, including surface deposit feeding, suspension feeding, mud swallowing, carnivory, herbivory and even parasitism in a few species (Fauchald & Jumars, 1979; Hutchings, 1998; Kanhai, 2022; Sandgaard et al., 2023). Bottom bioturbation, generated by some species, directly influences sediment transport and redistribution (Lopez & Levinton, 1987; DelValls et al., 2007), organic matter decomposition (Heilskov & Holmer, 2001), and oxygen diffusion (Mann & Whitney, 1947). Traditionally the phylum was classified into Clitellata and Polychaeta. However, this classification has undergone major changes due to recent molecular analyzes, that evidenced that other groups, such as Sipuncula, Myzostomida, Vestimentifera, Pogonophora and Echiura, hitherto considered distinct phylum, present annelid affinities (Capa & Hutchings, 2021).

Due to their high abundance and diversity, polychaetes represent a key taxon for understanding diversity patterns (Grassle & Maciolek, 1992; Olsgard et al., 2003). In Brazil, scientific research on this group began in the 1960s, when around 210 species were estimated to occur in the country (Nonato, 1965). Since then, several scientific articles, guides, and catalogues have been published (Nonato & Luna, 1970; Amaral & Nonato, 1981; 1982; 1984; 1994; 1996; Amaral et al., 2006; Lana et al., 2006; Amaral et al., 2013; Ribeiro et al., 2014; Costa et al., 2017; Teodoro et al., 2018; Lana et al., 2021; Steiner et al., 2021). The latest revisions list 1,341 species of polychaetes on the Brazilian coast, however, most of these studies are restricted to the states of Paraná and São Paulo (Lana et al., 2021).

There are few evaluations focused on establishing a list of Polychaeta species for the state of Santa Catarina. The first studies related to the group were developed by the naturalist Fritz Müller, who during the second half of the 19th century described 13 new species (Müller, 1858). In 2012 Almeida et al. published the first checklist of polychaete species for the northern region of the state, however, only beach species were described. In the same year, Pagliosa *et al*., presented a study summarizing taxonomic information on polychaetes from Santa Catarina, which included estuarine species. However, the work did not include the estuary of the Itajaí-Açu river.

In view of the above and considering the environmental and socioeconomic importance of the region, the present study aims to carry out a description of the Polychaeta species that inhabit the estuary of the Itajaí-Açú river, seeking to group and contribute with information related to the group, in order to create a preliminary baseline for future taxonomic and ecological research.

2 Material and Methods

2.1 Study Area

The estuary of the Itajaí Açu River is approximately 70 km long and is located on the central north coast of Santa Catarina, Brazil, flowing into the Atlantic Ocean at 26° 54.7' S and 048° 38.1' (Figure 1). As for the geomorphological type, the estuary is characterized as a coastal plain (Pritchard, 1967) and, in relation to the physiographic classification, it is called a deltaic front (Fairbridge, 1980). The marine influence on the estuary is essentially due to the characteristics of the water masses present in the region, as well as to the fluctuations in sea level caused by astronomical and meteorological effects. In general, the estuary exports most of the suspended sediments brought by the river and exhibits a saline wedge-type circulation, being controlled mainly by river discharge and, to a lesser extent, by oscillations in sea level. In periods of lower discharges, the sediment is dominated by silts and clays, and may have high amounts of sand due to river transport in periods of greater discharges (Schettini et al., 1996; Schettini, 2002; Pereira Filho et al., 2003).

2.2 Sample collection

The description of Polychaeta taxa in the region of the estuary of the Itajaí-Açu River was prepared based on a bibliographic review of articles published in the scientific literature, compiled with new records identified from sampling campaigns carried out in this study. In addition, was compared the abundance patterns of taxa found in the campaigns. Subclasses, families, genera, and species names have been organized in alphabetical order to facilitate the search for a particular taxon. The list of taxa focuses on the nomenclature available in the World Register of Marine Species (WoRMS, 2024). The description, as well as photos of the taxa found during the sampling campaigns, will be presented only for the organisms identified at the species level.

To evaluate the polychaetes, three campaigns were carried out in 2021 (Feb/02, Mar/05 and Apr/07) and three in 2022 (Sep/02, Sep/09 and Oct/03). In each campaign, samples were collected in triplicate at 10 points in two stations with depths ranging from 7 m to 8 m, using a van Veen deep-search dredger with an area of 0.042 m² (Figure 2). The samples were fixed in 4% formaldehyde, washed in a 0.5 mm sieve, preserved in 70% alcohol, and identified at the lowest possible taxonomic level. The sampling stations from the only study regarding polychaetes conducted in the same area were included on the map to facilitate the visualization of the data coverage (Figure 1).

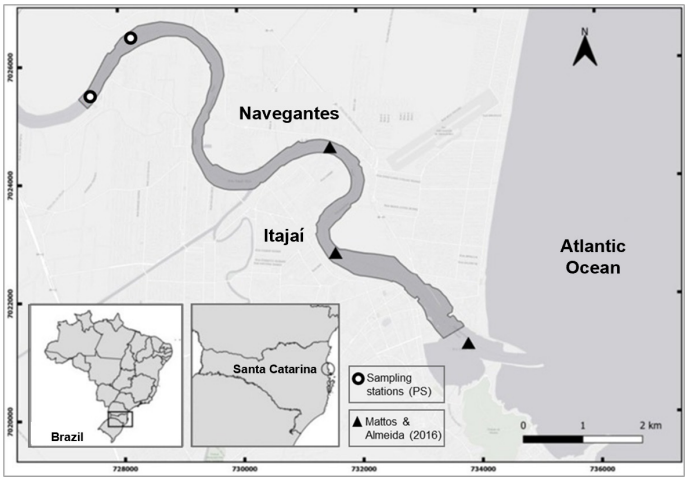

Figure 1. The sampling stations from the present study (○) and from Mattos & Almeida (2016) paper (▲) along the estuary of the Itajaí-Açu River in Santa Catarina, Brazil. PS, present study.

3 Results

A total of 2,034 polychaetes were collected, classified into 14 taxa, and distributed into 10 families. The most abundant taxon was *Heteromastus similis*, representing 42% of fauna, followed by *Paraprionospio pinnata* and *Nephtys fluviatilis*, corresponding to 25% and 18%, respectively. Together, the other taxa made up about 15% of the samples (Figure 2 and Table 1).

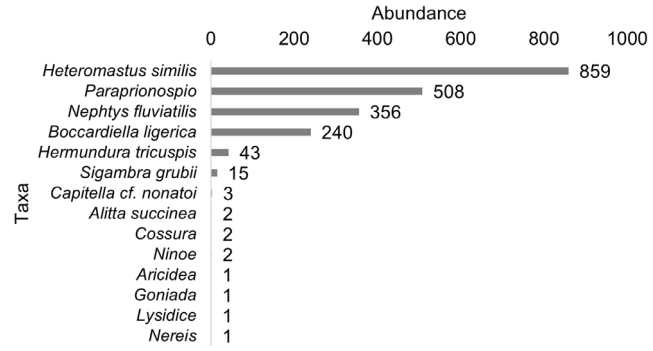

Figure 2. Numeric abundance of polychaetes from the sampling campaigns carried out in 2021 and 2022 at the estuary of the Itajaí-Açu River, Santa Catarina, Brazil.

As a result of the bibliographical review referring to the description of the polychaetes of the Itajaí-Açu river estuary, the only published study, disregarding the gray literature (theses, dissertations, monographs, and unpublished technical reports) was carried out by Mattos and Almeida (2016), in which the presence of 20 taxa was described (Table 1).

Table 2. List of Polychaeta taxa collected at the Itajaí-Açu river estuary. PS, present study; Mattos and Almeida, literature review; 0, absence; X, presence.

Subclass	Family	Taxon	PS	Mattos and Almeida (2016)
	Eunicidae	*Lysidice* sp.	x	0
	Goniadidae	*Goniadella* sp.	x	0
	Lumbrineridae (Schmarda, 1861)		0	x
	Nephtyidae	*Nephtys* sp.	x	0
		Nephtys fluviatilis (Monro, 1937)	x	x
		Alitta succinea (Leuckart, 1947)	x	x
Errantia	Nereididae	*Laeonereis acuta* (Treadwell, 1923)	x	x
		Nereis sp.	x	0
	Onuphidae	*Kinbergonuphis difficilis* (Fauchald, 1982)	0	x
	Pilargidae	*Hermundura tricuspis* (Müller, 1858)	x	0
		Sigambra grubii (Müller, 1858)	x	x
	Sigalionidae (Kinberg, 1856)		0	x
	Syllidae (Grube, 1850)		0	x
	Ampharetidae (Malmgren, 1866)		0	x
	Capitellidae	*Capitella* cf. *capitata* (Fabricius, 1780)	x	x
		Capitella cf. *nonatoi* (Silva and Amaral, 2017)	x	0
		Heteromastus similis (Southern, 1921)	x	x
	Cirratulidae (Ryckholt, 1851)		0	x
	Cossuridae	*Cossura* sp.	x	0
Sedentaria	Flabelligeridae (Saint-Joseph, 1894)		0	x
	Opheliidae	*Armandia hossfeldi* (Hartman-Schroeder,1956)	0	x
	Paraonidae	*Paraonis* sp.	x	0
		Boccardia sp.	0	x
	Spionidae	*Boccardiella ligerica* (Ferronière, 1898)	x	x
		Paraprionospio pinnata (Ehlers,1901)	x	x
	Sabellidae (Latreille, 1825)		0	x
Polychaeta *incertae sedis*	Magelonidae	*Magelona* sp.	0	x
	Oweniidae	*Owenia* sp.	0	x

Subclasse Errantia

Family Nephtyidae Grube, 1850

Genus *Nephtys* Cuvier, 1817

Nephtys fluviatilis Monro, 1937

Material examined. BRAZIL – Santa Catarina • Itajaí, Itajaí-Açu river; 26°51'49.7"S, 48°41'53.3"W; elev. 2 m; 2021; van Veen dredge; 106 adult, sex undet.; WIDNF-21.

Identification. Prostomium with antennae and palps. Well developed and recurved branchiae. Interramal branchiae starting from parapodium 5 (disappearing after 36th); acicular lobes without prominent medial bulb or papilla; dorsally yellowish to brownish (Lana, 1986; Rizzo & Amaral, 2007) (Figure 3 A).

Subclasse Errantia

Family Nereididae Blainville, 1818

Genus *Alitta* Kinberg, 1865

Alitta succinea (Leuckart, 1947)

Material examined. BRAZIL – Santa Catarina • Itajaí, Itajaí-Açu river; 26°51'49.7"S, 48°41'53.3"W; elev. 2 m; 2021; van Veen dredge; 2 adult, sex undet.; WIDAS-21.

Identification. Two pairs of eyes almost equal in size, arranged trapezoidally; anterior pair reniform; posterior pair round (subdermal eyes unclear in some epitokous specimens). Peristomium with four pairs of tentacular cirri of unequal length; posterior dorsal tentacular cirri longest, reaching back to chaetigers 4 to 15. Pharynx with yellow amber jaws. Paragnath numbers as follows, group I: 1–6, II: around 20 on each side in two or three arched rows, III: 20–60 in three or four transverse rows, IV: around 25 on each side in two or three arched rows, V: 0–6, VI: around 10 on each side in circular cluster, VII–VIII: two or three rows of paragnaths, extending to lateral surface, not reaching group VI (Sato, 2013; Villalobos-Guerrero & Carrera-Parra, 2015) (Figure 3 B).

Remark: *Alitta succinea* was previously known as *Nereis succinea* Leuckart, 1847 (Worms, 2023).

Subclasse Errantia

Family Nereididae Blainville, 1818

Genus *Alitta* Kinberg, 1865

Alitta succinea (Leuckart, 1947)

Material examined. BRAZIL – Santa Catarina • Itajaí, Itajaí-Açu river; 26°51'49.7"S, 48°41'53.3"W; elev. 2 m; 2021; van Veen dredge; 2 adult, sex undet.; WIDAS-21.

Identification. Two pairs of eyes almost equal in size, arranged trapezoidally; anterior pair reniform; posterior pair round (subdermal eyes unclear in some epitokous specimens). Peristomium with four pairs of tentacular cirri of unequal length; posterior dorsal tentacular cirri longest, reaching back to chaetigers 4 to 15. Pharynx with yellow amber jaws. Paragnath numbers as follows, group I: 1–6, II: around 20 on each side in two or three arched rows, III: 20–60 in three or four transverse rows, IV: around 25 on each side in two or three arched rows, V: 0–6, VI: around 10 on each side in circular cluster, VII–VIII: two or three rows of paragnaths, extending to lateral surface, not reaching group VI (Sato, 2013; Villalobos-Guerrero & Carrera-Parra, 2015) (Figure 3 C).

Remark: *Alitta succinea* was previously known as *Nereis succinea* Leuckart, 1847 (Worms, 2023).

Subclasse Errantia

Family Pilargidae Saint-Joseph, 1899

Genus *Sigambra* Müller, 1858

Sigambra grubii Müller, 1858

Material examined. BRAZIL – Santa Catarina • Itajaí, Itajaí-Açu river; 26°51'49.7"S, 48°41'53.3"W; elev. 2 m; 2021; van Veen dredge; 5 adult, sex undet.; WIDSG-21.

Identification. Prostomium with three antennae, longer than palps; palps biarticulate. Tentacular cirri as long as half width of tentacular segment. Parapodia biramous. Dorsal and ventral cirri foliose to tapered, dorsal ones usually longer than ventral ones. Notopodia include dorsal hooks along many segments, sometimes with accessory capillaries. Neuropodia with shorter pectinates, medium-sized denticulates, and longer finely denticulate capillaries, often twisted distally. Medium antennae reaching setigers 3-4, posterior region with 4-6 setigers without hooks (Salazar-Vallejo et al., 1990; Salazar-Vallejo et al., 2019; González et al., 2021) (Figure 3 D).

Subclasse Sedentaria

Family Capitellidae Grube, 1862

Genus *Capitella* Blainville, 1828

Capitella cf. *nonatoi* Silva and Amaral, 2017

Material examined. BRAZIL – Santa Catarina • Itajaí, Itajaí-Açu river; 26°51'49.7"S, 48°41'53.3"W; elev. 2 m; 2021; van Veen dredge; 3 ♂; WIDCN-21.

Identification. Thoracic setigers 1-7 with capillary setas. Hooded hooks on chaetigers 8 and 9. Peristomium forming an incomplete achaetous ring. Eyespots present. Abdominal hooded hooks with three teeth above main fang arranged in two rows (Figure 3 E).

Remark: *C. nonatoi* was previously misidentified as *C. capitata* (Fabricius, 1780). *C. capitata* is a species complex that probably is only distributed in the Arctic and subarctic areas (Blake, 2009; Silva et al., 2017).

Subclasse Sedentaria

Family Capitellidae Grube, 1862

Genus *Heteromastus* Eisig, 1887

Heteromastus similis Southern, 1921

Material examined. BRAZIL – Santa Catarina • Itajaí, Itajaí-Acu river; 26°51'49.7"S, 48°41'53.3"W; elev. 2 m; 2021; van Veen dredge; 536 adult, sex undet.; WIDHS-21.

Identification. Body size length 55 mm. Eyespots absent. Thoracic capillary chaetae 1- 5. Thoracic hooded hooks in chaetigers 6-11 with a few teeth and indistinct node. Abdominal hooded hooks with a few teeth and distinct node. Triangular-shaped branchiae with hooded hooks (Choi & Yoom, 2016) (Figure 3 F).

Subclasse Sedentaria

Family Spionidae Grube, 1850

Genus *Paraprionospio* Caullery, 1914

Paraprionospio pinnata (Ehlers, 1901)

Material examined. BRAZIL – Santa Catarina • Itajaí, Itajaí-Açu river; 26°51'49.7"S, 48°41'53.3"W; elev. 2 m; 2021; CA Stramosk leg.; van Veen dredge; 508 adult, sex undet.; WIDPP-21.

Identification. Peristomium with large lateral wings folded over the prostomium. With a caruncle. Gills from setiger 1 with two or three pairs of pinnate gills (González et al., 2021) (Figure 3 G).

Remark: *Paraprionospio pinnata* was described as *Prionospio pinnata* Ehlers, 1910 (superseded original combination).

Subclasse Sedentaria

Family Spionidae Grube, 1850

Genus *Boccardiella* Blake and Kudenov, 1978

Boccardiella ligerica (Ferronière, 1898)

Material examined. BRAZIL – Santa Catarina • Itajaí, Itajaí-Açu river; 26°51'49.7"S, 48°41'53.3"W; elev. 2 m; 2021; CA Stramosk leg.; van Veen dredge; 240 adult, sex undet.; WIDBL-21.

Identification. Setiger 5 with modified seta. In setiger 5 hooks only falcate simple. Caruncle extends from setiger 2. With branchiaes on setigers 2, 3 and 7 (González et al., 2021) (Figure 3 H).

Remark: *Boccardiella ligerica* was previously known as *Boccardia ligerica* Ferronnière, 1898.

Figure 3. A) *Nephtys fluviatilis*, B) *Alitta succinea*, C) *Hermundura tricuspis*, D) *Sigambra grubii*, E) *Capitella* cf. *nonatoi*, F) *Heteromastus similis*, G) *Paraprionospio pinnata*, and H) *Boccardiella ligerica*.

4 Discussion

From the sampling campaigns carried out in the present study, it was possible to observe that *Heteromastus similis* Southern, 1921 represented 42% of the identified fauna. This result corroborates that found by other works developed in estuarine regions, where the species is cited as dominant (Rao, 1980; Lana et al., 1989; Ieno & Elias 1995; Brauko et al., 2020; Villarmarzo et al., 2021). The Capitellidae family, which includes *H. similis*, is recognized for its opportunistic behavior (Grassle & Grassle 1974; Reyes-Rojas et al., 2022), cosmopolitan distribution (Grassle & Grassle, 1976), high tolerance to a wide range of physical factors, and ability to survive in regions with low oxygen concentration (Irham et al., 2022).

The species *H. similis* is a deposit feeder, burrower, motile, and has an unarmed proboscis (Olivier et al., 1972b; Fauchald & Jumars, 1979). In general, its presence has been associated with a sediment dominated by fine and very fine sand (Olivier et al., 1972a; Fasano et al., 1982; Lana *et al*., 1989). However, variations in the sediment composition not appear to be a barrier to the existence of this species (Southward, 1957; Tenore, 1972). According to Rao (1980), the main factor that affects its distribution is the concentration of organic matter, since sediments with high concentrations of organic matter attract capitelids.

When evaluating the distribution of benthic macrofauna from the estuary of the Itajai-Açu River, Mattos and Almeida (2016) verified the presence of 20 taxa, of which the species *H. similis, Paraprionospio pinnata, Alitta succinea, Nephtys fluviatilis, Sigambra grubii*, and *Boccardiella ligerica* were also identified in the present study. The low values of species richness found in the region corroborate the pattern exhibited by most benthic assemblages of urbanized estuaries in southern Brazil (Hsieh, 1995; Netto & Gallucci, 2003; Skilleter, 2006; Ortega et al., 2018).

In their study, Mattos and Almeida (2016) identified individuals of the genus *Capitella* as belonging to the species *Capitella capitata* (Fabricius, 1780). However, from molecular markers (allozyme), Grassle and Grassle (1976) concluded that this species is, in fact, a complex of many sibling species. *C. capitata* was originally described in Greenland and probably has its distribution restricted to arctic and subarctic areas (Blake 2009). Silva et al. (2017), based on morphological and molecular analyzes (mtDNA sequences), revealed the existence of four new species of *Capitella* in Brazil, including *Capitella nonatoi* Silva and Amaral, 2017, thus confirming that the species recorded as *C. capitata* apparently was misidentified.

The species *Hermundura tricuspis* and the genera *Goniada*, *Nereis*, *Ninoe*, *Cossura*, and *Aricidea* have already been identified in the state of Santa Catarina (Amaral et al., 2006; Vivan et al., 2009; Almeida et al., 2012; Pagliosa et al., 2012). Although the genus *Lysidice* has not yet been cataloged in the region, there is a record of *Nematonereis*, which, as suggested by Zanol *et al*. (2010), might be a synonym of *Lysidice*. Therefore, this should not be considered as the identification of a new genus in the state, as it is configured as a case of synonymy.

References

Airoldi, L.; Balata, D. & Beck, M.W. 2008. The Gray Zone: Relationships between habitat loss and marine diversity and their applications in conservation. Journal of Experimental Marine Biology and Ecology. 366:8–15. https://doi.org/10.1016/j.jembe.2008.07.034.

Almeida, T.; Pesserl, B.; Vivan, J. & Lana, P. 2012. Polychaetes of the north-central Santa Catarina state, Brazil. Check List. 8:204. https://doi.org/10.15560/8.2.204.

Amaral, A.C.Z. & Nonato, E.F. 1981. Anelídeos poliquetos da costa brasileira. 1–2. Características e chaves para famílias; Glossário. CNPq/Coordenação Editorial, Brasília, Brasil. 47 p.

Amaral, A.C.Z. & Nonato, E.F. 1982. Anelídeos poliquetos da costa brasileira. 3. Aphroditidae e Polynoidae. CNPq/ Coordenação Editorial, Brasília, Brasil. 46 p.

Amaral, A.C.Z. & Nonato, E.F. 1984. Anelídeos poliquetos da costa brasileira. 4. Polydontidae, Pholoidae, Sigalionidae e Eulepethidae. CNPq/ Coordenação Editorial, Brasília, Brasil. 54 p.

Amaral, A.C.Z. & Nonato, E.F. 1994. Anelídeos poliquetos da costa brasileira. 5. Pisionidae, Chrysopetalidae, Amphinomidae e Euphrosinidae. Revista Brasileira de Zoologia. 11(2):361–390. https://doi.org/10.1590/S0101-81751994000200022.

Amaral, A.C.Z. &Nonato, E.F. 1996. Annelida Polychaeta: características, glossário e chaves para famílias e gêneros da costa brasileira. Editora da UNICAMP, Campinas, Brasil. 124 p.

Amaral, A.C.Z.; Rizzo, A.E. & Arruda, E.P. 2006. Manual de Identificação dos Invertebrados Marinhos da região sudeste-sul do Brasil. Vol. I. Edusp, São Paulo, Brasil, 287 p.

Amaral, A.C.Z.; Nallin, S.A.H.; Steiner, T.M.; Forroni, T.O. & Gomes-Filho, D. 2013. Catálogo das espécies de Annelida Polychaeta do Brasil. Unicamp, Campinas. 183 p.

Barbier, E.B.; Hacker, S.D.; Kennedy, C.; Koch, E.W.; Stier, A.C. & Silliman, B.R. 2011. The value of estuarine and coastal ecosystem services. Ecological monographs. 81(2):169–193. https://doi.org/10.1890/10-1510.1.

Blake, J.A. 2009. Redescription of Capitella capitata (Fabricius) from West Greenland and designation of a neotype (Polychaeta, Capitellidae). Zoosymposia. 2:55–58. https://doi.org/10.11646/zoosymposia.2.1.7.

Brauko, K.M.; Cerveira, A.F.; Freitas, R.F.; Hadlich, H.L.; Beras, T.; Fonseca, A.L. & Pagliosa, P.R. 2020. Comparing structural and functional approaches to distinguish benthic communities from eutrophic and non-eutrophic estuaries. Marine Pollution Bulletin. 157:111290. https://doi.org/10.1016/j.marpolbul.2020.111290.

Burton, S. 2020. Marine protected areas - the importance of positive partnerships

and stakeholder engagement for delivering environmental outcomes in an estuary. Marine Protected Areas. 475–488. https://doi.org/10.1016/B978-0-08-102698-4.00024-1.

Cameron, W.M. & Pritchard, D.W. 1963. Estuaries. The Sea, 2, p. 324.

Capa, M. & Hutchings, P. 2021. Annelid diversity: historical overview and future perspectives. Diversity. 13(3):129. https://doi.org/10.3390/d13030129.

Choi, H.K. & Yoon, S.M. 2016. First record of Heteromastus filiformis (Polychaeta: Capitellidae) from Korean waters, with a taxonomic note on the genus. Journal of Species Research. 5(3):264–271. https://doi.org/10.12651/JSR.2016.5.3.264.

Costa, D.D.; Fernandes, H.F.; Assis, F.S. & Christoffersen, M.L. 2017. Checklist of species of Polychaeta (Annelida) of the Seixas Beach, João Pessoa, state of Paraíba, northeast Brazil. Revista Brasileira de Gestão Ambiental e Sustentabilidade. 4(8):313–320. https://dx.doi.org/10.21438/rbgas.040806.

Dean, H.K. 2008. The use of polychaetes (Annelida) as indicator species of marine pollution: a review. Revista de Biología Tropical. 56(4):11–38. https://doi.org/10.15517/RBT.V56I4.27162.

Delvalls, T.A.; Chapman. P.M.; Drake, P.; Dulce, M.S.; Vale, C.; Reguera, D. & Blasco, J. 2007. Benthos sediment quality assessments. In: Sustainable Management of Sediment Resourses: Sediment Quality and Impact Assessment of Pollutants. Elsevier. 215–261 pp. https://doi.org/10.1016/S1872-1990(07)80078-X.

Fairbridge, R.W. 1980. The estuary: its definition and geodynamic cycle. In: Chemistry and biogeochemistry of estuaries. John Wiley & Sons, New York. 1–35 pp.

Fasano, J.; Hernandez, M.A.; Isla, I.F. & Schnack, E. 1982. Aspectos evolutivos y ambientales de la laguna Mar Chiquita, Peia. Buenos Aires, Argentina. Acta Oceanologica. 4:2 85– 292.

Fauchald, K. & Jumars, P.A. 1979. The diet of worms: a study of polychaete feeding guilds. Oceanography and Marine Biology: An Annual Review. 17: 193–284.

Filho, J.P.; Spillere, L.C. & Schettini, C.A.F. 2003. Dinâmica de nutrientes na região portuária do estuário do Rio Itajaí-Açu, SC. Atlântica. 25(1): 1–20.

González, L.; Angel, J.; Zavala, B.; Rolando, J.; Parra, C.; Fernando, L.; Garza, G.; Elena, M.; Ignacio, S.; Vallejo, S.; Weiss, S. & Hernández, V.T. 2021. Anélidos marinos de México y América tropical. Universidad Autónoma de Nuevo León, Monterrey, Nuevo León. 1054 p.

Grassle, J.F. & Grassle, J.P. 1974. Opportunistic life histories and genetic systems in marine benthic polychaetes. Journal of Marine Research. 32(2) :253–284.

Grassle, J.F. & Maciolek, J.F. 1992. Deep-sea species richness: regional and local diversity estimates from quantitative bottom samples. American Naturalist. 139(2): 313–341. https://dx.doi.org/10.1086/285329.

Grassle, J.P. & Grassle, J.F. 1976. Sibling species in the marine pollution indicator Capitella (Polychaeta). Science. 192(4239): 567–569.

Heilskov, A.C. & Holmer, M. 2001. Effects of benthic fauna on organic matter mineralization in fish-farm sediments: importance of size and abundance. Ices Journal of Marine Science. 58: 427–434. https://doi.org/10.1006/jmsc.2000.1026.

Hsieh, H.L. 1995. Spatial and temporal patterns of polychaete communities in a subtropical mangrove swamp: influences of sediment and microhabitat. Marine Ecology Progress Series. 127: 157–167. https://doi.org/10.3354/meps127157.

Hutchings, P. 1998. Biodiversity and functioning of polychaetes in benthic sediments. Biodiversity & Conservation. 7(9): 1133–1145.

Ieno, E.N. & Elias, R. 1995. Heteromastus similis Southern, 1921 (Polychaeta: Capitellidae) in Mar Chiquita brackish coastal lagoon, Argentina. Nerítica. 9(1–2): 23–32.

Irham, I.; Salim, F.D. & Alhadad, M.S. 2022. Ecological study of Polychaeta (Family capitelidae) as a bio-indicator of organic pollution in Kasturian and Salero Coastal waters city of Ternate. Jurnal Agrikan. 15(2):722–728.

Kanhai, A. 2022. Spatial and seasonal variation in polychaete communities according to their trophic categories in Southwest Tobago, West Indies. Neotropical Biodiversity. 8(1):8–20. https://doi.org/10.1080/23766808.2021.2021051.

Kwok, C.K.; Liang, Y.; Wang, H.; Dong, Y.H.; Leung, S.Y. & Wong, M.H. 2014. Bioaccumulation of heavy metals in fish and Ardeid at Pearl River Estuary, China. Ecotoxicology and Environmental Safety. 106:62–67. https://doi.org/10.1016/j.ecoenv.2014.04.016.

Lana, P.C. 1986. Nephtyidae (Annelida; Polychaeta) do Litoral do Estado do Paraná (Brasil). Revista Nerítica. 1(1):135–154. http://dx.doi.org/10.5380/rn.v1i1.41022.

Lana, P.C.; Almeida, M.V.O.; Freitas, C.A.F.; Couto, E.C.G.; Conti, L.M.P.; Gonzalez-Peronti, A.L.; Giles, A.G.; Lopes, M.J.S.; Silva, M.H.C. & Pedroso, L.A. 1989. Estrutura espacial de associações macrobênticas sublitorais da Gamboa Perequê (Pontal do Sul, Paraná). Revista Nerítica. 4(1/2).

Lana, P.C.; Santos, C.S.; Garraffoni, A.R.; Oliveira, V.M. & Radashevsky, V. 2006. Checklist of polychaete species from Paraná state (Southern Brazil). Check list. 2(3):30–63. https://doi.org/10.15560/2.3.30.

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.D.; Barroso, R.; Rizzo, A.E. & Fukuda, M.V. 2021. Polychaetes in Brazil: people and places, past, present and future. Boletín del Instituto Oceanográfico de Venezuela. 2017:24–50.

Lopez, G. & Levinton, J. 1987. Ecology of deposit-feeding animals in marine sediments. The Quarterly Review of Biology. 62(3):235–260.

Mann, H.B. & Whitney, D.R. 1947. On a test of whether one of two random variables is stochastically larger than the other. The Annals of Mathematical Statistics. 18(1): 50–60.

Mattos, P.R. & Almeida, T.C.M.D. 2016. Spatiotemporal distribution of the benthic macrofauna in an urbanized subtropical estuary: environmental variations and anthropogenic impacts. Brazilian Journal of Oceanography. 64:227–238. https://doi.org/10.1590/S1679-87592016111306403.

Müller, F. 1858. Einiges uber die Anneliden Fauna der Insel Sta. Catarina an der Brasilianischen Kuste. Arch. Naturg. 24:211–220.

Netto, S.A. & Gallucci, F. 2003. Meiofauna and macrofauna communities in a mangrove from the Island of Santa Catarina, South Brazil. Hydrobiologia. 505:159–170.

Nonato, E.F. 1965. Anelídeos poliquetas. In: História natural dos organismos aquáticos do Brasil. FAPESP, Brasil. 133–137 pp.

Nonato, E.F. & Luna, J.A.C. 1970. Anelídeos poliquetas do nordeste do Brasil: I-poliquetas bentônicos da costa de Alagoas e Sergipe. Boletim do Instituto Oceanográfico. 19:57–130 pp.

Olivier, S.R.; Escofet, A.; Penchaszadeh, P. & Orensanz, J.M. 1972a. Estúdios ecológicos en la region estuarial de Mar Chiquita (Buenos Aires, Argentina). I: Las comunidades bentônicas. Anales de la Sociedad Científica Argentina. 93:237–261.

Olivier, S.R.; Escofet, A.; Penchaszadeh, P. & Orensanz, J.M. 1972b. Estúdios ecológicos en la region estuarial de Mar Chiquita (Buenos Aires, Argentina). II: Relaciones tróficas inter-especificas. Anales de la Sociedad Científica Argentina. 94:89–104.

Olsgard, F.; Brattegard, T. & Holthe, T. 2003. Polychaetes as surrogates for marine biodiversity: lower taxonomic resolution and indicator groups. Biodiversity and Conservation. 12:1033–1049. https://doi.org/10.1023/A:1022800405253.

Ortega, I.; Colling, L.A. & Dumont, L.F.C. 2018. Response of soft-bottom macrobenthic assemblages to artisanal trawling fisheries in a subtropical estuary. Estuarine, Coastal and Shelf Science. 207:142–153. https://doi.org/10.1016/j.ecss.2018.04.007.

Pagliosa, P.R.J.G.; Doria, G.F.A.; Almeida, T.M.C.; Lorenzi, L.; Netto. A.S. & Lana, P.C. 2012. Polychaetes from Santa Catarina State (southern Brazil): checklist and remarks on species distribution. Zootaxa. 3486:1–49. https://doi.org/10.11646/zootaxa.3486.1.1.

Pritchard, D.W. 1967. Observations of circulation in coastal plain estuaries. In: Estuaries. AAAS, Washington, p. 37–44.

Porto de Itajaí. https://www.portoitajai.com.br/. Apresentação, Itajaí, Brasil (last access in 05/05/2023)

Rao, D.S. 1980. Ecology of Heteromastus Similis Southern 1921 (Polychaeta, Capitellidae) in the Vasishta Godavari Estuary. Proceedings of the Indian National Science Academy. 89:407–414.

Ren, W.; Zhong, Y.; Meligrana, J.; Anderson, B.; Watt, We.; Chen, J. & Leung, H.L. 2003. Urbanization, land use, and water quality in Shanghai: 1947–1996. Environment international. 29(5):649–659. https://doi.org/10.1016/S0160-4120(03)00051-5.

Ren, L.; Cui, E. & Sun, H. 2014. Temporal and spatial variations in the relationship between urbanization and water quality. Environmental science and pollution Research. 21(23):13646–13655. https://doi.org/10.1007/s11356-014-3242-8.

Reyes-Rojas, J.; Panesso-Guevara, M. & Duque, G. 2022. Influence of maintenance dredging on polychaete community composition in an estuary (Tropical Eastern Pacific). International Journal of Environmental Science and Technology. 1–12 pp. https://doi.org/10.1007/s13762-022-04722-7.

Ribeiro, R.P. & Almeida, Z.D.S. 2014. Anelídeos Poliquetas do estado do Maranhão, Brasil: síntese do conhecimento. Bioikos. 28(1):45–55.

Rizzo, A.E. & Amaral, A.C.Z. 2007. Nephtyidae (Annelida: Polychaeta) from São Paulo State, Brazil, including a new record for the Brazilian coast. Biota Neotropica. 7(3):253–263. https://doi.org/10.1590/S1676-06032007000300028.

Rouse, G.W. & Pleijel, F. 2006. Annelid Phylogeny and Systematics. In: Reproductive Biology and Phylogeny of Annelida. Enfiel, Science Publishers, p. 42.

Salazar-Vallejo, S.I. 1990. Redescriptions of Sigambra grubii Müller, 1858 and Hermundura tricuspis Müller, 1858 from Brazil and designation of neotypes (Polychaeta: Pilargidae). Journal of Natural History. 24(2):507–517. https://doi.org/10.1080/00222939000770351.

Salazar-Vallejo, S.I. & Orensanz, J.M. 1991. Pilárgidos (Annelida: Polychaeta) de Uruguay y Argentina. Cahiers de Biologie Marine. 32:267–279.

Salazar-Vallejo, S.I.; Rizzo, A.E.; León-González, J.Á. & Brauko, K.M. 2019. Four new Caribbean Sigambra species (Annelida, Pilargidae), and clarifications of three other Sigambra species. ZooKeys. 893:21. https://doi.org/10.3897/zookeys.893.39594.

Sandgaard, M.H.; Syberg, K.; Grønlund, S.N.; Riisgaard, E.K.; Rishøj, C. & Palmqvist, A. 2023. Small Butt Harmful: Individual-and Population-Level Impacts of Cigarette Filter Particles on the Deposit-Feeding Polychaete Capitella teleta. Environmental Science & Technology. 57(8):3218–3227. https://doi.org/10.1021/acs.est.2c06117.

Santana, M.P.; Resende, M.L.; Clara, F.T.; Zandonà, E.; Mazzoni, R. & El-Sabaawi, R. 2020. Urbanization can increase the invasive potential of alien species. Journal of Animal Ecology. 89(10):2345–2355. https://doi.org/10.1111/1365-2656.13293.

Sato, M. 2013. Resurrection of the genus Nectoneanthes Imajima, (Nereididae: Polychaeta), with redescription of Nectoneanthes oxypoda (Marenzeller,) and description of a new species, comparing them to Neanthes succinea (Leuckart). Journal of Natural History. 47(1–2):1–50. https://doi.org/10.1080/00222933.2012.743609.

Schettini, C.A.F. 2002. Caracterização física do estuário do Rio Itajaí-Açu, SC. Revista Brasileira de Recursos Hídricos. 7(1):123–142.

Schettini, C.A.F. & Carvalho, J.L.B., Jabor, P. 1996. Comparative hydrology and suspended matter distribution of four estuaries in Santa Catarina State – Southern Brazil. Workshop on Comparative Studies of Temperate Coast Estuaries, Bahia Blanca, Proceedings, IADO. 29–32 pp.

Silva, C.F.; Seixas, V.C.; Barroso, R.; Di Domenico, M.; Amaral, A.C. & Paiva, P.C. 2017. Demystifying the Capitella capitata complex (Annelida, Capitellidae) diversity by morphological and molecular data along the Brazilian coast. PLoS One. 12(5):1–32. https://doi.org/10.1371/journal.pone.0177760.

Skilleter, G.A.; Pryor, A.; Miller, S. & Cameron, B. 2006. Detecting the effects of physical disturbance on benthic assemblages in a subtropical estuary: a beyond BACI approach. Journal of Experimental Marine Biology and Ecology. 338(2):271–287. https://doi.org/10.1016/j.jembe.2006.06.016.

Southward, E.C. 1957. The distribution of polychaota in off-shore deposits in the Irish sea. Jour. Mar. Biol. Assoc. UK. 36: 49–75.

Steiner, T.M.; Amaral, A.C.Z. & Borges, M. 2021. Manual de Identificação dos Invertebrados Marinhos da Região Sudeste-Sul do Brasil, Vol. 2. Edusp, São Paulo. 287 p.

Tawanggian, Y.; Hanafiah, Z. & Priadi, D.P. 2022. Structure of Polychaeta Community in Banyuasin Mangrove Coast Waters, South Sumatera. Sriwijaya Journal of Environment. 7(1):1–9. http://dx.doi.org/10.22135/sje.2022.7.1.1-9.

Teodoro, N.M.S. & Costa, K.G.D. 2018. Checklist of polychaetes (Annelida: Polychaeta) from a sandstone reef of Southeastern Brazil. Revista Brasileira de Gestão Ambiental e Sustentabilidade. 5(10):779–787. https://doi.org/10.21438/rbgas.051026.

Tenore, K.R. 1972. Macrobenthos of the Pamlico river estuary, North Carolina. Ecological Monographs. 42:51–59.

Tovar-Hernández, M.A.; Salazar-Silva, P.; León-González, J.Á.; Carrera-Parra, L.F. & Salazar-Vallejo, S.I. 2021. Biodiversidad de Polychaeta (Annelida) en México. Editorial Universitaria, p. 1–1054.

Villalobos-Guerrero, T.F. & Carrera-Parra, L.F. 2015. Redescription of Alitta succinea (Leuckart, 1847) and reinstatement of A. acutifolia (Ehlers, 1901) n. comb. based upon morphological and molecular data (Polychaeta: Nereididae). Zootaxa. 3919(1):157–178. https://doi.org/10.11646/zootaxa.3919.1.7.

Villarmarzo, J.; Kandratavicius, N.; Venturini, N.; Giménez, L.; Brugnoli, E. & Muniz, P. 2021. Estructura funcional de la macrofauna bentónica en sistemas estuarinos uruguayos. Boletín de la Sociedad Zoológica del Uruguay. 30(2):30–2. https://doi.org/10.26462/30.2.4.

Vivan, J.M.; Di Domenico, M. & Almeida, T.C.M. 2009. Effects of dredged material disposal on benthic macrofauna near Itajaí Harbour (Santa Catarina, South Brazil). Ecological Engineering. 35(10):1435–1443. https://doi.org/10.1016/j.ecoleng.2009.06.005.

Zanol, J.; Halanych, K.M.; Struck, T.H. & Fauchald, K. 2010. Phylogeny of the bristle worm family Eunicidae (Eunicida, Annelida) and the phylogenetic utility of noncongruent 16S, COI and 18S in combined analyses. Molecular Phylogenetics and Evolution. 55(2):660–676. https://doi.org/10.1016/j.ympev.2009.12.024.

WoRMS. World Register of Marine Species. https://www.marinespecies.org/ (last access in 10/05/2023).