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Morphological anomalies in polychaetes: *Perinereis* species (Polychaeta: Annelida) examples from the Brazilian coast

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Abstract Coutinho, M.C.L. and Santos, C.S.G. 2014. Morphological anomalies in polychaetes: *Perinereis* species (Polychaeta: Annelida) examples from the Brazilian coast. *Memoirs of Museum Victoria* 71: 45–51.

The examination of a large number of specimens in the context of taxonomic and ecological studies may lead to the discovery of morphological anomalies. The aim of this study was to describe the morphological anomalies observed in some individuals of *Perinereis anderssoni* and *Perinereis ponteni* collected in various regions of the Brazilian coast. A total of 290 specimens were analysed from along the northern and southern Brazilian coast, and 21 of these presented morphological anomalies, such as variations in the number of tentacular cirri and eyes, completely or basally fused antennae, chaetigers with three parapodia, and others. *Perinereis anderssoni* presented the highest number of anomalous individuals, and the most frequent morphological anomaly was the presence of a single antenna and nine tentacular cirri. Anomalous individuals of *P. ponteni* with seven tentacular cirri were also commonly collected. Ilha do Mel (PR) was the area with the highest percentage of individuals with anomalies (12.96%), followed by Martim de Sá (SP) (10.31%), São Francisco do Conde (BA) (8.33%), Tambaba (PB) (5.55%) and Itaipu (RJ) (1.92%). Most of the sampling locations have a history of contamination by a diverse array of pollutants. We provide background information for the morphological changes observed in two species that occur along the Brazilian coast, but additional studies are needed to confirm the real cause of these anomalies and their effect on the population structure of these ecologically important species.

Keywords morphology, abnormalities, Nereididae, *Perinereis*, *Ceratonereis*, *Unanereis*

Introduction

The genus *Perinereis* is commonly found in shallow-water environments is composed of approximately 60 described species and is considered polyphyletic (Bakken and Wilson, 2005). The species in this genus are characterised by the presence of a proboscis with conical paragnaths on the maxillary and oral rings, and conical and additional bar-shaped paragnaths on the oral ring, four pairs of tentacular cirri with distinct cirrophores, one pair of biarticulated palps, a pair of frontal antennae, two pairs of eyes, notopodia with homogomph spinigers throughout, neuropodia with homogomph spinigers, heterogomph spinigers and heterogomph falcigers, notopodial ligule present and prechaetal notopodial lobe and postchaetal neuropodial lobe present or absent (De Léon-González and Solís-Weiss, 1998; Bakken and Wilson, 2005).

The examination of a large number of specimens in the context of taxonomic and ecological studies may lead to the discovery of morphological anomalies (Mohammad, 1981). These anomalies may occur within and between populations and can be the result of a range of processes (e.g. genetic, ecophenotypic or ontogenetic) or due to other factors, such as injury. Genetic processes are related to the presence of different genotypes in the same population or different populations of the same species, and are associated with phenotypic (i.e. relating to the external shape, physiological or behavioural character) variations of adaptive value to individuals. Morphological changes with adaptive value have been found in several species of polychaetes, particularly in the Nereididae (Geracitano et al., 2004a). Ecophenotypic factors refer to morphological changes resulting from environmental changes, such as contamination or changes in the concentration of an abiotic factor, and they can also generate genetic alterations (Backmann et al., 1995; Geracitano et al., 2002, 2004b; Bocchetti et al., 2004; Ferreira-Cravo et al., 2009; Mouneyrac et al., 2010; Ahrens et al., 2013). Ontogenetic factors are associated with the changes undergone by organisms during their development (Qian, 1999; Kubal et al., 2012). In the same way, injuries caused by predators may alter the bodies of individuals and result in the reduction or absence of cirri and parapodial structures.

The aim of this study was to describe the morphological anomalies observed in individuals of *Perinereis anderssoni* Kinberg, 1866 and *Perinereis ponteni* Kinberg, 1866, collected from different regions along the Brazilian coast. It is beyond the scope of this study to determine the causes of these anomalies.

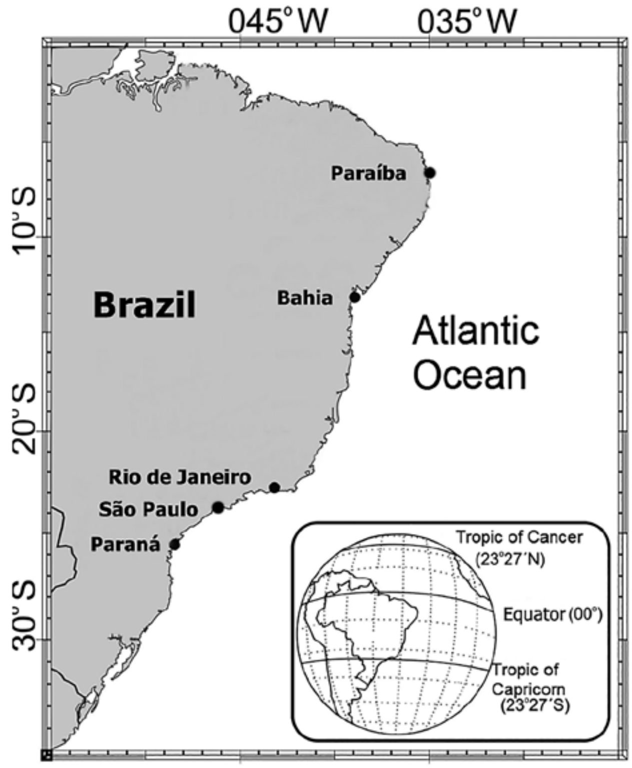


Figure 1. Location of sampling sites in states of Brazil.

Materials and methods

A total of 119 atokous individuals of *P. ponteni* (7.00–77.50 mm) and 171 of *P. anderssoni* (4.50–58.12 mm) from different states along the northern and southern Brazilian coast were analysed. Specimens of *P. anderssoni* were collected from four populations in the following localities: Ilha do Mel, Paraná (PR) (July to August 2012); Itaipu, Rio de Janeiro (RJ) (April 2009 to April 2010); Tambaba, Paraíba (PB) (February 2009); Martim de Sá, São Paulo (SP) (March, April, August and September 2001). Specimens of *P. ponteni* were collected from four populations in the following localities: Ilha do Mel, Paraná (PR) (July 2012); Itaipu, Rio de Janeiro (RJ) (August 2009 to March 2012); São Francisco do Conde, Bahia (BA) (July 2011) and Martim de Sá, São Paulo (SP) (March and September 2001) (fig. 1).

All specimens were collected from rocky shores by scraping small areas covered by the bivalve *Brachidontes* sp. and the green alga *Ulva* sp. and mixed with coarse sediment grains. Specimens were anesthetized with menthol, fixed in 10% formalin (except for the populations of Itaipu, which were fixed in 4% formalin) and preserved in 70% ethanol. The specimens were examined with a stereomicroscope and photographed with a Sony CyberShot 13MP digital camera. Photographs were edited with PhotoScape v.3.6.2.

Results

A total of five specimens of *P. ponteni* (9.8–20.6 mm long) and 16 specimens of *P. anderssoni* (6.0–41.9 mm long) from a number of populations presented morphological anomalies (figs 2 and 3). Based on descriptions of *P. anderssoni* and *P. ponteni* by Lana (1984), De Leon-González (1999) and Santos and Steiner (2006), the differences were considered anomalies and not intraspecific or interspecific variations as they did not follow a pattern of occurrence (table 1). It is also notable that the cirri and parapodial anomalies were never symmetrical, nor did they occur in the same parapodia or body region.

Of the two species, *P. anderssoni* had the most observed anomalies, and this may be partly explained by the greater number of individuals examined. Among the sampling localities, Ilha do Mel (PR) was the locality with the highest percentage of anomalous individuals (12.96%), followed by Martim de Sá (SP) (10.31%), São Francisco do Conde (BA) (8.33%), Tambaba (PB) (5.55%) and Itaipu (RJ) (1.92%) (fig. 4).

Table 1. Morphological characteristics and anomalies described in P. ponteni and P. anderssoni

Morphological characters/ Species	Normal characters	Anomalies	
		P. ponteni	*P. anderssoni*
Antennae	A pair of frontal antennae		Single antenna, two antennae completely fused, two antennae basally fused
Tentacular cirri (number)	Eight tentacular cirri	Seven or nine tentacular cirri	Six, seven or nine tentacular cirri
Number of parapodia	Chaetiger with two parapodia		Chaetiger with three parapodia
Number of eyes	Two pairs of eyes		Five eyes

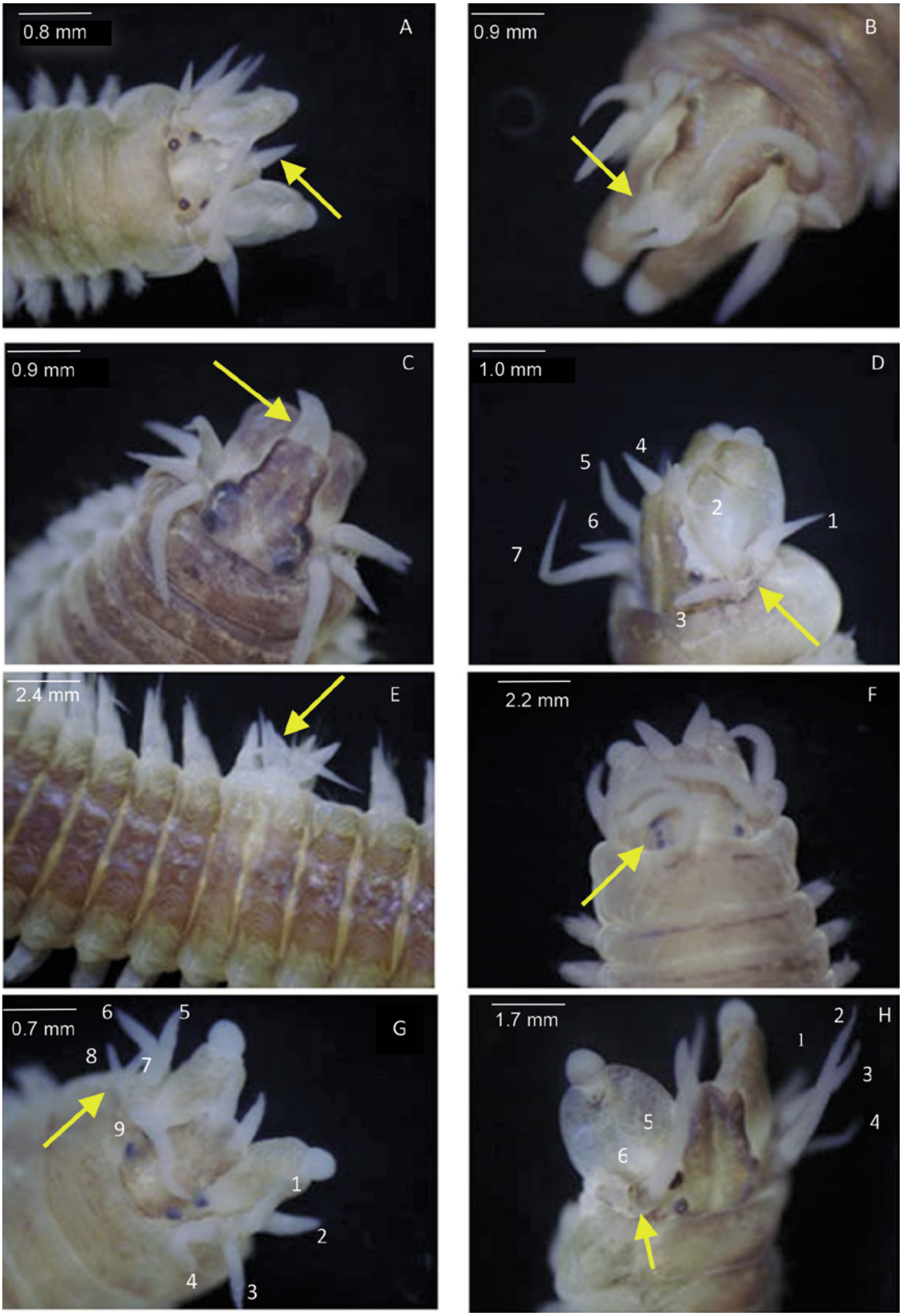
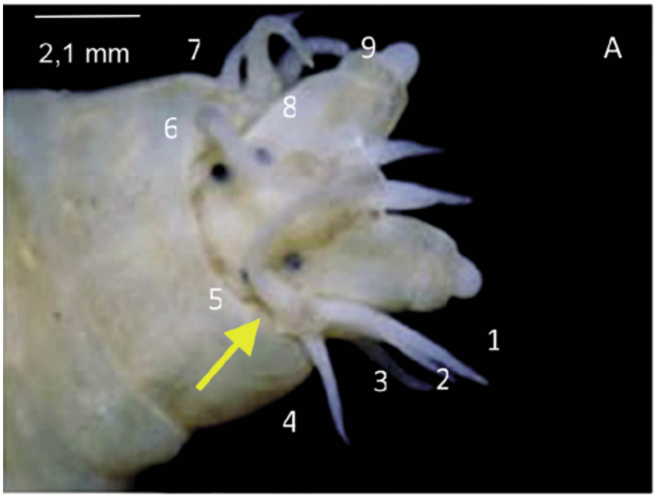


Figure 2. Morphological anomalies in *P. anderssoni*: A. single antenna; B. basally fused antennae; C. completely fused antennae; D. seven tentacular cirri; E. two parapodia on the same side of chaetiger; F. five eyes; G. nine tentacular cirri; H. six tentacular cirri.



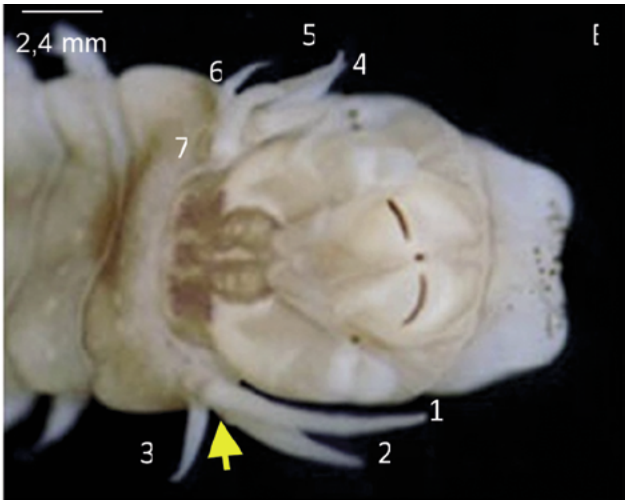


Figure 3. Morphological anomalies in *P. ponteni*: A. nine tentacular cirri; B. seven tentacular cirri.

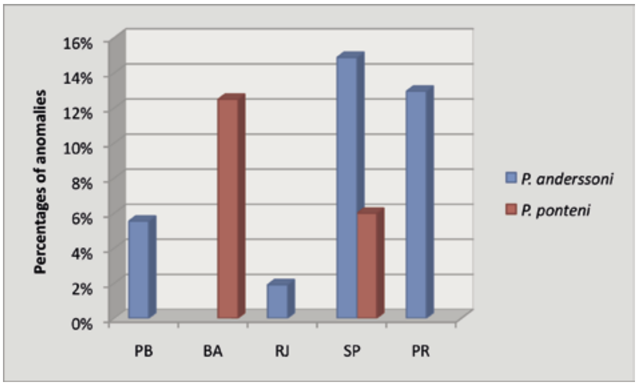


Figure 4. Percentage of morphological anomalies found in the species *P. anderssoni* and *P. ponteni*.

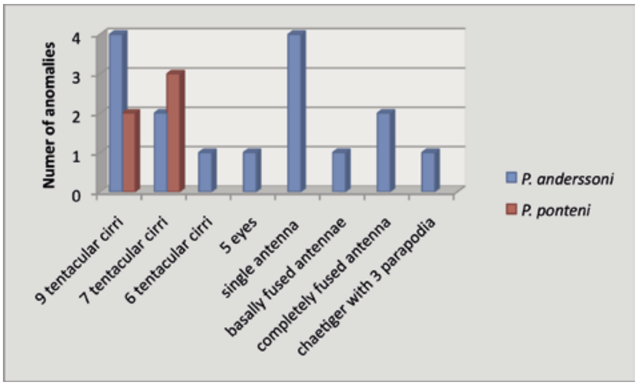


Figure 5. Number and type of morphological anomalies found in the species *P. anderssoni* and *P. ponteni*.

The most frequently observed morphological anomaly shared by both species was the presence of nine tentacular cirri. For *P. anderssoni*, the most frequent anomaly was the presence of a single antenna and nine tentacular cirri, and for *P. ponteni*, it was the presence of seven tentacular cirri (fig. 5). In some specimens, we found alterations in the number of paragnaths, but this was not considered anomalous.

Discussion

It is beyond the scope of this paper to determine the possible causes of the morphological anomalies that were observed. Most studies that report malformations or anomalies in polychaetes relate them to exposure to pollutants and its effects at many levels: individual, specific, population and community. In an earlier study, Reish et al. (1974) observed bifurcation in *Capitella capitata* larvae exposed to copper and zinc. Geracitano et al. (2004b) found morphological and histological anomalies (e.g. curling, protrusions, cuticle separation from the epidermis) in *Laeonereis acuta* that were caused by copper exposure. In addition, Méndez et al. (2009) described changes in colouration, swelling and rupture of the epidermis in *Eurythoe complanata* individuals exposed to mercury. Oliveira (2009) associated the anomalies observed in *Laeonereis* species (such as hypertrophy of the cirri and dorsal lobes, absence of dorsal ligules, and bifurcated cirri, lobes and ligules) with environments polluted by domestic and industrial sewage and harbour activities.

The sampling localities in this study show variation in their degree of 'health'. The economy of Ilha do Mel, for example, is based on tourism, and the region suffers from the influence of Paranaguá Bay, where fishing, urban occupation, tourism and industry are all common activities, and the bay is home to the main South American grain shipping port (Martins et al., 2010; Gonzaga et al., 2013). Prior information about morphological changes in some marine organisms in the area is available in Valdez-Domingos et al. (2007), who recorded histopathological lesions in the gills of *Crassostrea rhizophorae* found in Paranaguá Bay. There was no direct relationship established by the authors between the lesions and a specific contaminant because the study only evaluated the impact of a range of human activities. Among the species we studied, a single antenna was the anomaly most observed in polychaetes from this locality.

Fishing is the main economic activity in Itaipu followed by tourism. However, this locality is adjacent to Guanabara Bay, which is considered one of the most polluted environments of the Brazilian coast. It hosts large municipalities, several industries, shipyards, ports, naval bases, refineries and marine oil terminals (Marques-Júnior et al., 2009). There are already local records of histopathological alterations in a species of commercial fish (Cardoso et al., 2009) contaminated by mercury. The most common morphological anomaly found in polychaete specimens from Itaipu Beach was the presence of a single antenna.

There is one genus in the family, *Unanereis* Day, 1962, with two described species: *U. macgregori* Day, 1962 and *U. zgahli* Ben Amor, 1980, that presents one antenna. The first species description was based on an incomplete specimen, and the second description is poor. Apart from the number of antennae, all of the other *Unanereis* characteristics are similar to *Ceratonereis* species, including long tentacular and notopodial cirri. The second species description is also based on one specimen, and apart from noting the presence of one antenna, it is similar to *Composetia* Hartmann-Schröder, 1985, which was previously considered a subgenus of *Ceratonereis*. The author mentioned that the species is similar to *Ceratonereis costae* Grube, 1840 in all other features. Bakken and Wilson (2005) and Santos et al. (2005) nested both genera, *Unanereis* and *Ceratonereis*, in a polytomy. They did not make any decisions about nomenclature, and that is not our intention here, even though it deserves attention. We suggest, based on what we have observed for *Perinereis* species, *Pseudonereis* and *Laeonereis* (Santos and collaborators, pers. obs.), that until more *Unanereis* specimens are found, the presence of one antenna could, in fact, be an anomaly and not a synapomorphy of this taxon.

In São Francisco do Conde, oil-related activities are potential sources of pollution in the region (Veiga, 2003). Santos (2011) reported cases of cadmium and lead contamination in fish and shellfish in a number of localities in São Francisco do Conde. Specimens from this locality presented variations in the number of tentacular cirri as their most common anomaly.

Tourism is also the main economic activity in Tambaba and Martim de Sá (Projeto Orla). In Martim de Sá, fishing activities are also important (http://www.caraguatatuba.sp.gov.br). Specimens collected in this region presented variations in the number of tentacular cirri. We believe that genetic or ecophenotypic factors may be responsible for the larger numbers of tentacular cirri because this anomaly was found in both Martim de Sá, where there are no records of severe contamination, and in São Francisco do Conde, an affected site. Lower numbers of tentacular cirri can be explained by injury, such as from predation, but the same cannot be said when a larger number of cirri are observed.

Others anomalies found in this study, such as a variation in the number of eyes, may be due to genetic factors; this anomaly was found in Martim de Sá, which has not experienced high levels of contamination.

Historically, variation in the number of paragnaths is considered important and of taxonomic value as it is a diagnostic trait in some species. Small variations in quantity within or among populations are usually considered normal. According to Ben-Eliahu (1987), the number of paragnaths in proboscidial areas can be size-related. Breton et al. (2004) identified variations in the number of paragnaths in populations of *Nereis virens* from different sites and concluded that the differences were due to intraspecific variation. Garcia-Arberas and Rallo (2000) associated the change in the number of paragnaths in *Hediste diversicolor* with change in environmental conditions, such as sediment grain size. Maltagliati et al. (2006) also studied the paragnaths of *H. diversicolor* and suggested that paragnaths on different rings (oral and maxillary) may have different functions. This species has a variable diet, and one possible cause for variation is heritability of different patterns of paragnaths. However, previous morphometric analysis carried out by Coutinho (2013) (using the same individuals used here) and by Clímaco (2013), for *Allita succinea*, found no relationship between size or age and the number of paragnaths encountered. Silva (2014), in a phylogeographic study of *P. anderssoni* and *P. ponteni* along the Brazilian coast, suggested that *P. ponteni* is the same species found all along the coast and that *P. anderssoni* consists of two, latitudinally separated cryptic species: one species is found in the north-east, and another is distributed in the south and south-east of Brazil. Nevertheless, we found no congruence between the variability in the number of paragnaths and the distribution suggested by Silva (2014). Once, four paragnaths in area V were found in individuals from Itaipu (south-east) and Tambaba (north-east), and individuals from Ilha do Mel (south) presented either five or two paragnaths in area V. Therefore, the variation in the number of paragnaths observed in the specimens studied here is not considered anomalous but normal morphological variability.

It is reasonable to assume that ecophenotypic factors, such as pollution, could be generating the observed morphological changes in these species, because benthic organisms are more sensitive to environmental changes as a result of their limited mobility.

We dismissed ontogenetic factors and methods of fixation as possible causes of the anomalies found in this study. Peixoto (2013) described the reproductive biology and population structure of *P. anderssoni*, and none of these anomalies or morphological alterations was found in the larvae or small size-classes; they were found in adult specimens (Peixoto, pers. com.). For *P. ponteni*, ontogenetic factors may be possible, but this is improbable because this species is morphologically similar to *P. anderssoni*. Until now, no alterations of this magnitude have been linked to methods of fixation, so we also dismiss this factor.

Based on our results and the information discussed above, we suggest that more studies are needed to confirm the real causes of the morphological anomalies found in *P. anderssoni* and *P. ponteni*. Additionally, other localities, including pristine rocky shores, should be investigated along the Brazilian coast, as both species are widely distributed and common in shallow-water environments.

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