PANAMJAS
Pan-American Journal of Aquatic Sciences

Population structure and dynamics of *Perinereis anderssoni* (Polychaeta: Nereididae) in a subtropical Atlantic Beach

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Abstract: The population dynamics of the nereidid polychaete *Perinereis anderssoni*, Kinberg, 1866 was investigated at Itaipu Beach (22°58'26.6"S 43°02'49.7"W), Niterói, Southeast Brazil. Surveys were taken monthly over two years (from April 2009 to April 2010 and from March 2011 to April 2012) during low tide on the rocky intertidal shore. All specimens were measured for the width of the 10th chaetiger and grouped over 0.5 mm size classes to analyze the population structure and to estimate asymptotic length, growth, growth performance index and mortality rates. Recruitment took place mostly between September and April. The decrease of large-sized individuals, concomitantly with recruitment, strengthens the existence of semelparity on the studied species, as usual for Nereididae and reported on previous works. Estimated parameters were similar among nereidid species, although most studies were performed in the Northern hemisphere. The fast growth and low lifespan (around one year) observed in the studied population suggest a highly ephemeral life strategy.

Keywords: Polychaete, parameters, lifespan, von Bertalanffy

Resumo. Estrutura e dinâmica populacional de *Perinereis anderssoni* (Polychaeta: Nereididae) em uma praia Atlântica subtropical. A dinâmica populacional do poliqueta nereidídeo *Perinereis anderssoni*, Kinberg, 1866 foi estudada na praia de Itaipu (22°58'26.6"S 43°02'49.7"W), Niterói, sudeste do Brasil. Amostras foram coletadas mensalmente ao longo de 2 anos (de Abril de 2009 a Abril de 2010 e de Março de 2011 a Abril de 2012) na região entremarés do costão rochoso, durante a maré baixa. Todos os espécimes foram medidos quanto à largura do 10º setígero e agrupados em classes de tamanho de 0,5 mm para analisar a estrutura populacional e estimar o comprimento assintótico, crescimento, índice de performance de crescimento e taxas de mortalidade. O recrutamento ocorreu principalmente entre os meses de Setembro a Abril. A redução do número indivíduos de tamanho grande, concomitante ao recrutamento, fortalece a existência de semelparidade na espécie estudada, como é comum em Nereididae e relatado em estudos prévios. Os parâmetros estimados foram similares entre espécies de nereidídeos, apesar de que a maior parte dos estudos foram realizados no hemisfério Norte. O crescimento rápido e baixa duração de vida (cerca de um ano) observados na população estudada sugerem uma estratégia de vida altamente efêmera.

Palavras-chave: Poliqueta, parâmetros, duração da vida, von Bertalanffy

Introduction

Polychaetes belonging to the Family Nereididae Blainville, 1818 are common and abundant, being one of the most specious families (Rouse & Pleijel 2001), capable of colonizing diverse habitats, including freshwater and terrestrial (Glasby & Timm 2008). Globally, around 588 nominal species distributed in 50 genera have been described (Read & Glasby 2017).

Population structure and dynamics are better studied in the Northern Atlantic, as there are studies concerning *Perinereis cultrifera* (Grube, 1840) (Rossi 2002, Rouabah & Scaps 2003, Rouabah *et al*. 2008, Rouhi *et al*. 2008), *Nereis falsa* Quatrefages, 1866 (Daas *et al*. 2010), *Hediste diversicolor* (Müller, 1776) (Abrantes *et al*. 1999, Gillet & Torresani 2003) and *Platynereis dumerilii* Audouin & Milne Edwards, 1833 (Giangrande *et al*. 2002). In the Pacific Ocean, better-studied species include *Neanthes acuminata* (Ehlers, 1868) (Reish 1957), *Simplisetia limnetica* (Hutchings & Glasby, 1982) (Glasby 1986) and *Perinereis aibuhitensis* (Grube, 1878) (Choi & Lee 1997). Besides these studies, a large-scale study of the population structure of *Hediste diversicolor* and *Alitta virens* Sars, 1835 was performed in the Northern hemisphere (Breton *et al*. 2003). Northern hemisphere species commonly possess reproductive seasons restricted to the Spring and/or Summer, due to higher temperatures and increased availability of food sources and, most importantly, exhibits seasonal growth, with markedly different growth rates throughout the life cycle (Fischer 1999).

Comparisons and pattern descriptions among Northern and Southern hemisphere species should be made with caution, as species are subject to different conditions, such as temperature and day length, which directly affects biological processes, like reproduction, growth (including the occurrence of season growth) and longevity.

In the Southern Atlantic, studies are scarce, focusing in *Nereis oligohalina* Rioja, 1946 in Paraná State (Pagliosa & Lana 2000), *Laeonereis culveri* in São Paulo (Omena & Amaral 2000, MacCord 2005) and Pernambuco States (Santos *et. al*. 2002), *Laeonereis culveri* (Webster, 1879) (Martin & Bastida 2006) in Argentina and *Alitta succinea* Leuckart, 1847 in Pernambuco State (Sette *et al*. 2013). In tropical and subtropical areas, seasonal growth peaks as seen in temperate species may be absent and reproduction may occur throughout most of the year (Florêncio 2000, Sette *et al*. 2013). According to Omena & Amaral (2000), population studies concerning polychaetes are hindered due to the absence of hard structures, as well as body elasticity and fragility. Despite this, the dynamics of most species remains poorly known, as most articles are reproductive studies coupled with population structure studies.

Among *Perinereis* species, *Perinereis anderssoni* Kinberg, 1866, described from Rio de Janeiro, Brazil, is common, Amphi-American and considered widely distributed along the western Atlantic, mainly occurring on rocky shores (de León-González & Solís-Weiss 1998, Santos & Steiner 2006) (Fig. 1). A previous study about the species reproductive biology was performed by Peixoto & Santos (2016), which reported that reproduction occurs throughout most of the year and that the species undergo epitokal modifications, which were divided into stages and characterized. As in most nereidid species, modifications were more pronounced in males, which also developed a pygidial rosette, which might spawn sperm plates, thus avoiding rupture of the body wall (Reish 1957, Baoling *et al*. 1985, Ong 1996, de León González & Solis-Weiss 1998).

The main goal of the present study is to investigate the life strategy of *P. anderssoni*. To achieve this goal, population structure, lifespan, growth and mortality rates were estimated in a population from Itaipu Beach, Southeast Brazil. Results were also compared with available data of other nereidid species from different latitudes.

Materials and Methods

Study Area: Itaipu Beach is a dissipative beach delimited on the East by Andorinhas Hill and on the West by Itaipu Channel. The rocky shore where the samples were collected is located on the East, being partially covered by algae (mainly *Ulva* sp. Linnaeus, 1753) and mussels (*Perna perna* (Linnaeus, 1758) and *Brachidontes* sp. (Swainson, 1840).

Field work and laboratory procedures: Specimens used in this work are the same collected by Peixoto & Santos (2016). Monthly samples were randomly collected during low tide at intertidal zone in Itaipu Beach, Niterói Rio de Janeiro State, Brazil (22°58'26.6"S 43°02'49.7"W) (Fig. 2) between April 2009 and April 2010 and between March 2011 and April 2012 by means of scraping of the rocky shore. Due to weather and tide conditions,

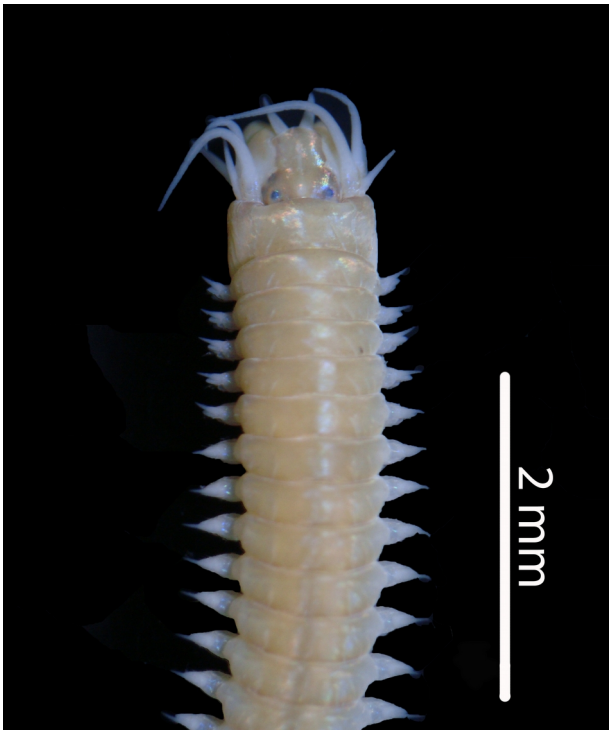

Figure 1.- *Perinereis anderssoni*, anterior end, dorsal view.

sampling was not possible on all months. Specimens were narcotized with menthol crystals and taken alive to the laboratory, fixed with 4% formalin and then transferred to 70% alcohol.

In the laboratory, all specimens had their width measured at 10th chaetiger (W10), excluding parapodia, following Peixoto & Santos (2016).

Data analysis: Based on the width of the 10th chaetiger, all specimens were grouped in 10 size classes (Table I), with intervals of 0.5 mm, and monthly histograms of size frequency were performed. The smallest size class (0 to 0.5 mm) corresponds to newly recruited specimens. The number and interval of size classes were determined by simulations in the software FiSAT II V. 1.2.2 (Gayanilo-Jr *et al*. 2005) searching for the best fit for the size distribution.

The von Bertalanffy growth function (Ricker 1975) was adjusted based on the 10th chaetiger frequency distributions. Munro's phi prima / growth performance index (ϕ) (Pauly & Munro 1984) was calculated to compare the growth rates (K) with data available in the literature for other *P. anderssoni* populations and nereidid species. For some studies, the growth performance index estimative was not readily available and needed to be calculated. Length-converted catch curves (Sparre & Venema 1997) were used to calculate total mortality rates (Z)

Table I.- Size-Class intervals based on the width of 10th chaetiger to *P. anderssoni* in Itaipu Beach, Niteroi, RJ.

Class	Interval (mm)
1	0 ⊣ 0.5
2	0.5⊣ 1.0
3	1.0⊣ 1.5
4	1.5⊣ 2.0
5	2.0⊣ 2.5
6	2.5⊣ 3.0
7	3.0 ⊣ 3.5
8	3.5⊣ 4.0
9	4.0 ⊣ 4.5
10	4.5 ⊣ 5.0

based on monthly sampling data. The maximum longevity (Tmax) was calculated by the 95% asymptotic size estimate (Taylor 1959). All calculations were performed with FiSAT II V. 1.2.2.

Results

A total of 1669 specimens were examined. The specimen's size ranges from 0.3 to 4.7 mm of W10. Monthly size frequency distribution is shown in Fig. 3. The smallest size class (0⊣ 0.5 mm), which corresponds to newly recruited specimens, was present on most months from April 2009 to September 2009, April 2010 and from December 2011 to March 2012 (Fig.3). Class 2 (0.5⊣ 1 mm), corresponding to juveniles, was present on most months, frequently corresponding to the most representative class.

From April 2009 to September 2009 and in April 2010, the smallest size class (0⊣ 0.5 mm), corresponding to newly recruited specimens, were present (Fig.3).

From April to November 2009, histograms showed population growth, since larger size-classes became more common. Although these specimens were abundant from September to December 2009, they were not found in the following months, reappearing on the population only in April 2010 (Fig.3).

From March to November 2011 there was a population size increase, as larger size-classes became more common. From December 2011 to February 2012, these larger size-class were not found, reappearing on the population only in March 2012, when the population started another size increase (Fig. 3).

Size-classes and cohort overlapped on most months. The individuals were most frequent in the size-class of 1⊣ 1.5 mm (Fig.4). In March 2012, the largest specimen was found, a mature female 4.7

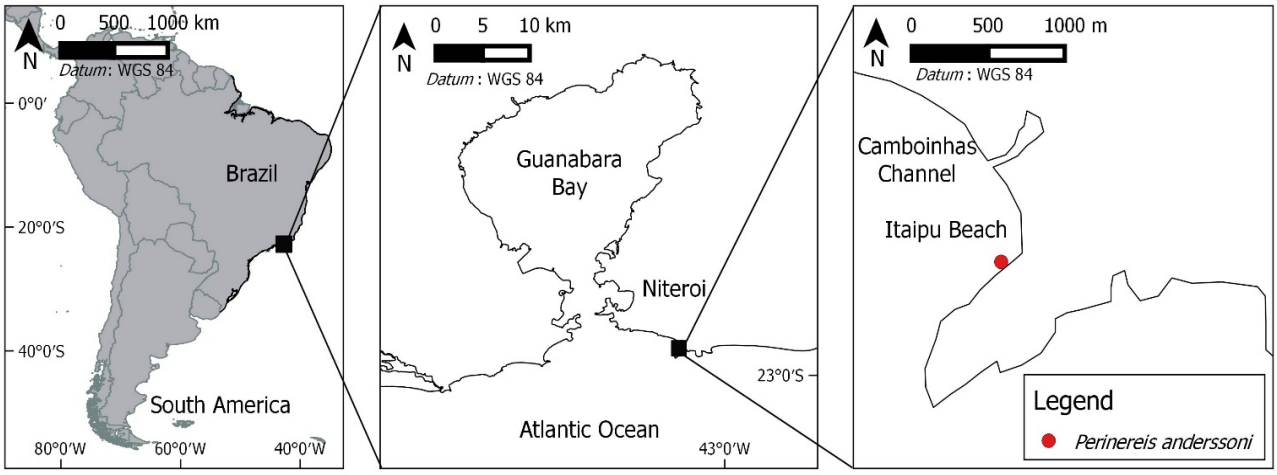

Figure 2.- Sampling location (marked) of *Perinereis anderssoni* specimens collected in Itaipu Beach, Niterói, Southeast Brazil.

mm wide at 10th chaetiger. This specimen was the only class 10 specimen found during all study.

The growth rate (K) was estimated at 2.36 and the asymptotic size was 5.5 mm of W10. (Fig. 5). Growth performance index (φ) was 1.83. Mortality was estimated in 9.99/year and longevity was 1.2 years.

Discussion

In the present study, the width of the 10th chaetiger was used, due to a previously known high correlation to total length (Peixoto & Santos 2016). The 10th chaetiger is not affected by proboscis contraction on fixed specimens, thus being a reliable measure for populational studies (Oliveira *et al*. 2010). The width of specific chaetigers is frequently used in nereidid populational studies, being commonly measured in *Laeonereis culveri*, as Martin & Bastida (2006) in a study in Rio da Prata, Argentina, used the width of the 1st chaetiger, Florêncio (2000) in Praia de Enseada dos Corais used the width of the 5th chaetiger and Omena & Amaral (2000), in São Sebastião, São Paulo State used the width of the 6th chaetiger.

During January 2010 and December 2011 there was a sudden decrease in larger size-classes, which could be related to the end of reproductive peaks, as *P. anderssoni*, in accordance with other species belonging to Nereididae, might be semelparous (Wilson 2000), dying after the release of gametes (Fischer & Dorresteijn 2004).

Between July and December 2009 and July and October 2011 histograms showed population growth, which was greatly reduced in the following months, that may correspond to the reproductive peaks observed by Peixoto & Santos (2016). The growth was greatly reduced during the reproductive peaks because most nutrients and energy are used for gametes maturation and development of epitokal modifications (Fischer 1999, Olive *et al*. 2000). This decrease was also observed by Daas *et al*. (2010) for *Nereis falsa* and Rouabah & Scaps (2003) for *Perinereis cultrifera*, following reproductive peaks, although during different time periods, as both articles studied Northern hemisphere species. To the Southern hemisphere, this decrease on larger size-classes occurred during a similar time period, rightly after a reproductive peak, in *Laeonereis culveri* (Omena & Amaral 2000, Martin & Bastida 2006) and *Nereis oligohalina* (Pagliosa & Lana 2000).

From October 2009 to April 2010 and December 2011 to April 2012, smaller size-classes, which corresponds to newly settled larvae and juveniles, were common, although class 2 (0.5⊣ 1.0 mm) occurred on most samples, suggesting a semi-continuous reproduction, which is supported by Peixoto & Santos (2016) for the same species and Santos *et al*. (2002) for *Laeonereis culveri*.

Cohort and size-class overlap were common on most months, due to a semi-continuous reproductive cycle in *Perinereis anderssoni* as noted by Peixoto & Santos (2016), which, in many cases, made cohort recognition problematic or impossible.

On months that smaller size-classes were not observed, this could have been caused by lack of sampling of scraped material using 250-µm mesh sieves, or these smaller classes may indeed be absent, as reproduction seems to be semi-continuous or it is possible that larvae metamorphose and settle on the sublittoral, migrating to the intertidal zone, particularly when sexually mature, as described to *Perinereis nuntia brevicirris* (Ong 1996).

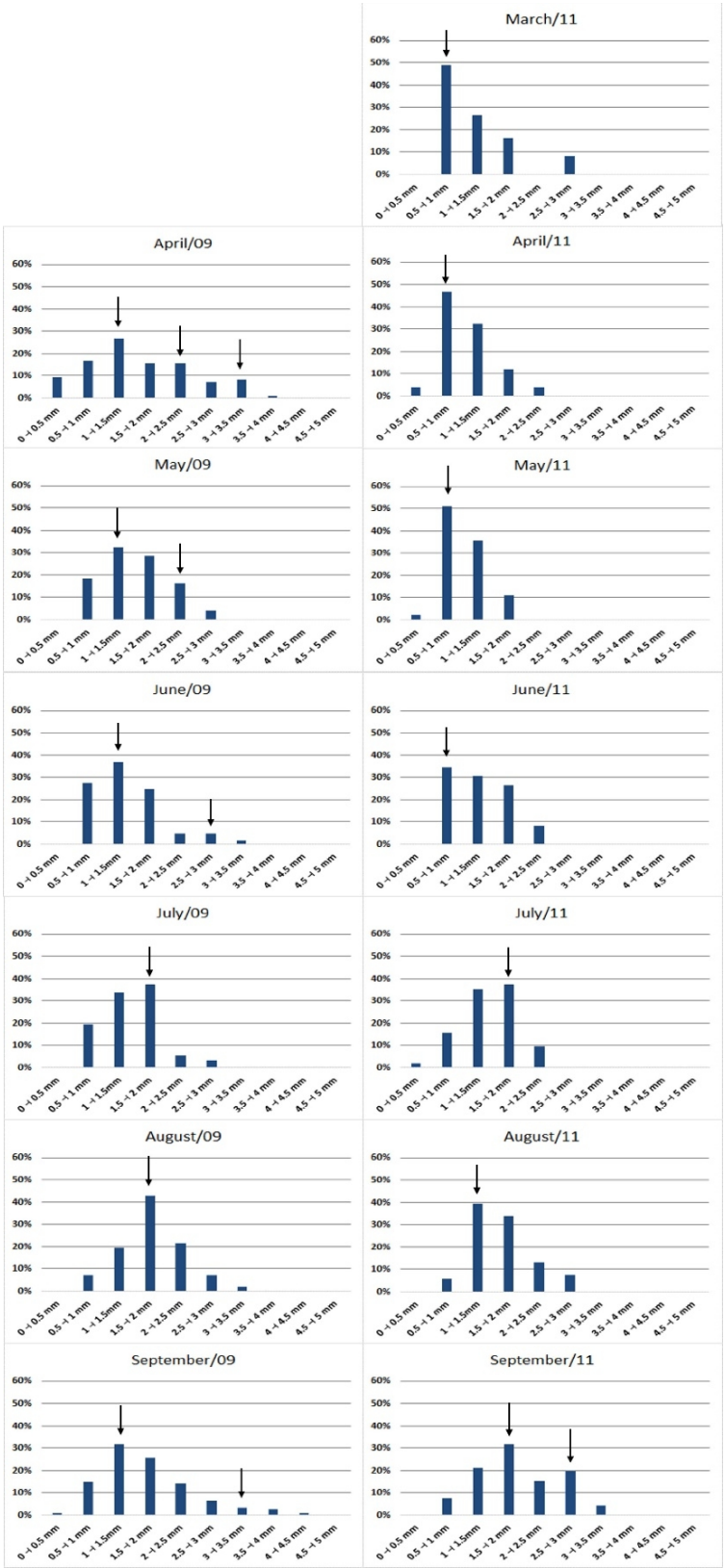

Figure 3.- Monthly size-class histograms of *Perinereis anderssoni* specimens collected in Itaipu Beach, Niterói, Southeast Brazil. Arrows pointing down (↓) indicate different cohorts.

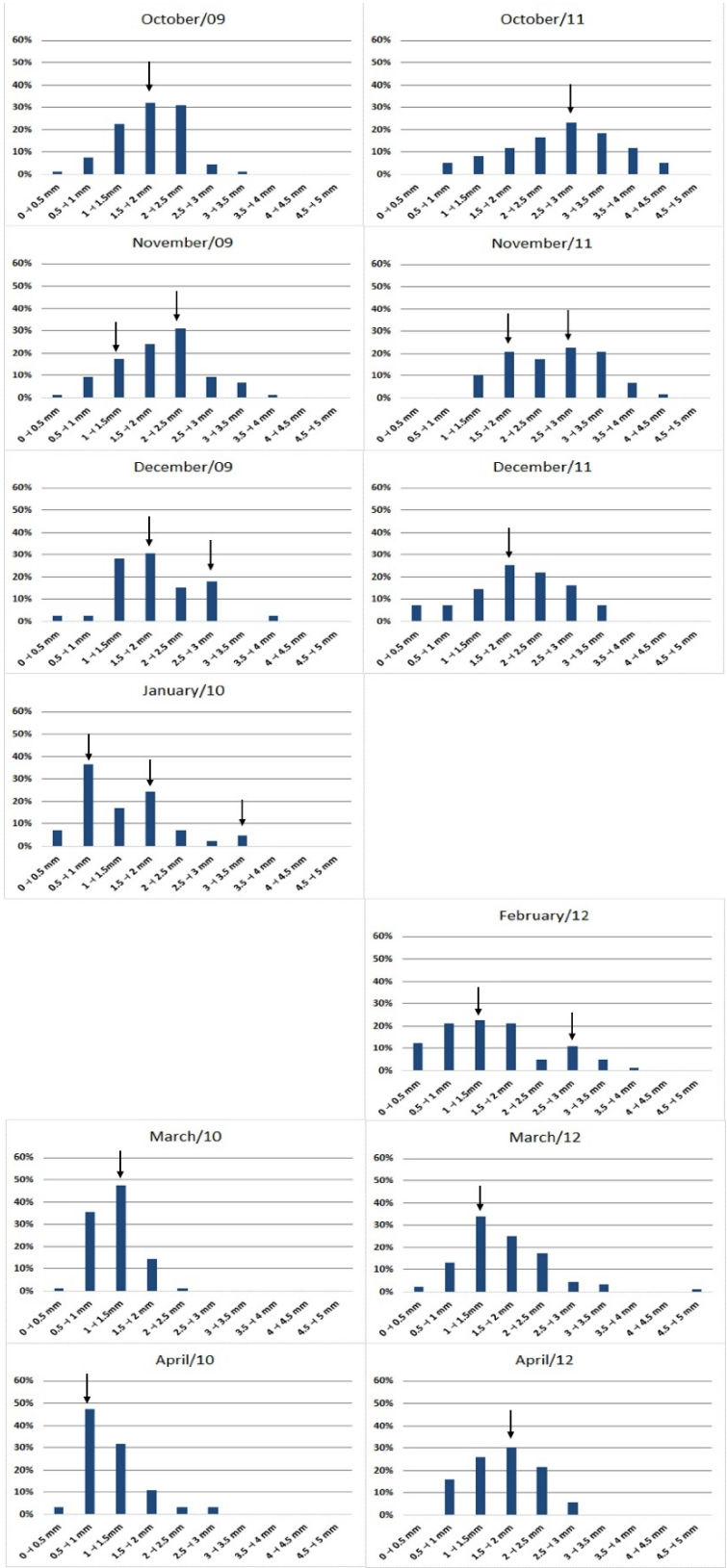

Figure 3 (Cont.).- Monthly size-class histograms of *Perinereis anderssoni* specimens collected in Itaipu Beach, Niterói. Arrows pointing down (↓) indicate different cohorts.

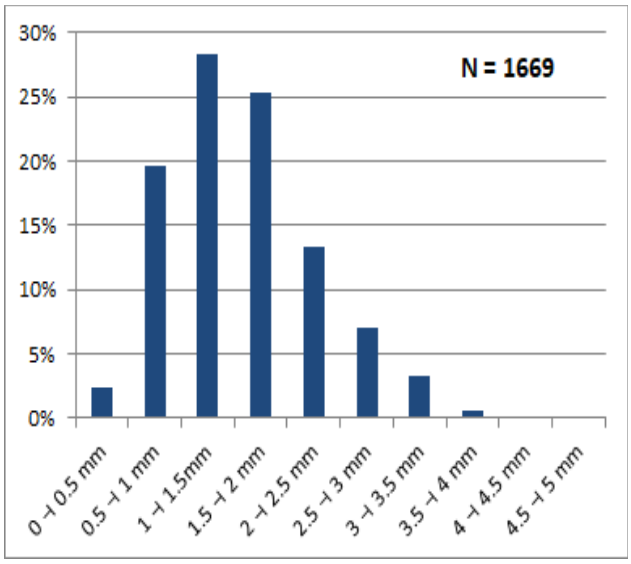

Figure 4.- Distribution frequency of size-classes based on the width of 10th chaetiger from Itaipu Beach, Niterói, Southeast Brazil.

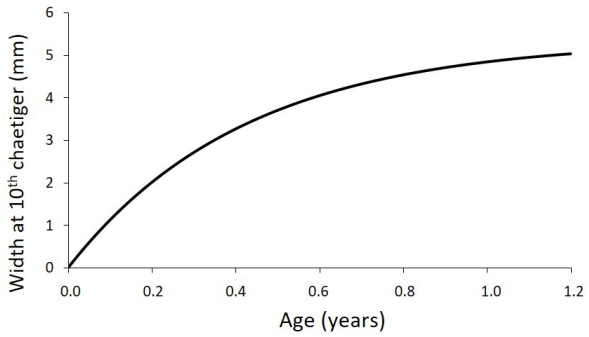

Figure 5.- von Bertalanffy catch curve based on estimated parameters.

Growth performance index was estimated at 1.83, similar to other nereidid species occurring on tropical and subtropical Occidental Atlantic, in which values ranged from 0.485 to *Laeonereis culveri* (Omena & Amaral, 2000) to 3.3 to *Nereis oligohalina* (Pagliosa & Lana 2000).

Longevity, which is determined by the semelparous reproduction, was estimated in 1.2 years, similar to other nereidid species (Table II), in which longevity ranged from 0.25 years in a lab culture of *Platynereis dumerilii* (Fisher & Dorresteijn 2004) to 4 years to *Perinereis cultrifera* (Rouabah & Scaps 2003), although, as reported for most comparative data, these records are from Northern hemisphere species, which are subjected to different conditions that affect growth and survival throughout the year, such as photoperiod and temperature (Fischer 1999).

According to Villalobos-Guerrero (2012), longevity of semelparous species is linked to reproduction, as, soon after spawning, specimens die as a result of body wall rupture to release gametes or exhaustion due to extensive morphological modifications related to epitoky, although semelparity in *P. anderssoni* remains unclear as previously noted by Peixoto & Santos (2016).

Mortality was estimated in 9.99/year. This parameter was rarely estimated in previous studies, although Pagliosa & Lana (2000), in a study of *Nereis oligohalina* in Paranaguá Bay, Southern Brazil, estimated values from 5.66 to 8.61, while Sette et al. (2013) in a study of *Alitta succinea* in Pina Basin estuary, estimated values from 1.53 to 4.53, depending on the sampling site. Mortality estimates are affected by longevity, since it is estimated as mortality/ year, meaning species with a shorter lifespan are expected to exhibit high mortality estimates.

Very few studies have tried to explain mortality, although Pagliosa & Lana (2000) have hypothesized that sudden changes in salinity are responsible for the mortality, since the studied species inhabits salt marshes. In the present study, mortality could be explained by semelparity, as most specimens die just after reproduction, caused by the rupture of the body wall and exhaustion or a few days later, due to irreversible morphological and metabolic changes (Chatelain *et al*. 2008). Semelparity is the most common reproductive strategy in Nereididae (Fischer 1999).

In conclusion, though *P. anderssoni* shows epitokal changes, modified natatory chaetae were not observed and despite our large dataset, some aspects remain unclear about species' life cycle. Most articles studied Northern hemisphere species, so more studies on Southern species should be performed for a better understanding of the population dynamics of tropical and subtropical invertebrates, as species from lower latitudes frequently does not exhibit seasonal differences in growth rates. Reproductive studies are also advised, as reproduction can interfere with population dynamics and many tropical and subtropical species does not have well-defined reproductive peaks.

Acknowledgments

The authors would like to thank Wilson Malafaia for the English review. The first author also would like to thank "Conselho Nacional de Desenvolvimento Científico e Tecnológico" for his master's degree grant. We are grateful to Rômulo

Table II.- Estimated longevity, growth performance index (Φ) and growth rate (K) values among nereidid species. NA – Not applicable, NE – Northern hemisphere, SE – Southern hemisphere.

Species	Longevity	Locality/ Latitude	Φ	K	Reference
Perinereis anderssoni	1.2 years	22º 52' 30"S	1.83	2.36	Present study
Perinereis cultrifera	2 years	Bay of Algiers (NE)	-	-	Rouabah *et al*. (2008)
Perinereis cultrifera	1.5 – 4 years	Algeria (NE)	-	-	Rouabah & Scaps (2003)
Laeonereis culveri	0.83 - 1.16 years	São Sebastião (SE)	0.485 – 0.872	1.4-2.2	Omena & Amaral (2000)
Laeonereis culveri	-	08º18'05" S	0.574	1.3	Florêncio (2000)
Laeonereis culveri	-	São Sebastião (SE)	0.841	2.4	MacCord (2005)
Laeonereis culveri	0.79 - 1.41 years	Argentina (SE)	0.61 - 0.88	1.8-3.3	Martin & Bastida (2006)
Nereis oligohalina	0.5 years	Paranaguá Bay (SE)	3.11 – 3.33	4-4.5	Pagliosa & Lana (2000)
Nereis falsa	1 year	Algeria (NE)		-	Daas *et al*. (2010)
Nereis grubei (Kinberg 1866)	2 years	California (NE)	-	-	Schroeder (1968)
Hediste diadroma Sato & Nakashima, 2003	1 year	Japan (NE)	-	-	Sato (1999)
Hediste diadroma	1 year	38°15′ N	-	-	Kikuchi & Yasuda (2006)
Hediste atoka Sato & Nakashima, 2003	1 year	Japan (NE)	-	-	Sato (1999)
Hediste atoka	0.5 years	38°15′ N	-	-	Kikuchi & Yasuda (2006)
Alitta succinea	2 years	California (NE)	-	-	Schroeder (1968).
Alitta succinea	1.6-2.6 years	8º5'S	2.86	1.68-2.72	Sette *et al*. (2013)
Platynereis dumerilii	0.25-1.5 years	NA (Lab culture)	-	-	Fisher & Dorresteijn (2004)
Neanthes arenaceodentata (Moore 1903)	1.08 years	NA (Lab culture)	-	-	Reish *et al*. (2009)

Barroso and one anonymous reviewer for helpful comments on the manuscript.

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Received: February 2018
Accepted: June 2018
Published: December 2018