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Length–weight relationships of eleven mesopelagic fishes from oceanic islands of the Southwestern Tropical Atlantic

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ABSTRACT

This study provides the length-weight relationship for eleven deep-sea fishes from oceanic islands of the Southwestern Tropical Atlantic: *Bonapartia pedaliota*, *Sigmops elongatus* (Gonostomatidae), *Argyropelecus aculeatus*, *Argyropelecus affinis*, *Argyropelecus sladeni*, *Sternoptyx diaphana*, *Sternoptyx pseudobscura* (Sternoptychidae), *Malacosteus niger*, *Thysanactis dentex* (Stomiidae), *Melanonus zugmayeri* (Melanonidae), and *Ectreposebastes imus* (Setarchidae). Data were collected during a scientific survey (2017) around Rocas Atoll, Fernando de Noronha Archipelago and adjacent seamounts, using a micronekton trawl (side length of body mesh: 40 mm, side length of cod-end mesh: 10 mm) at 35 stations from 0 to 1113 m depth. A new maximum standard length for *Bonapartia pedaliota* and *Ectreposebastes imus* are also provided.

INTRODUCTION

In the western Tropical Atlantic, the Fernando de Noronha Archipelago, Rocas Atoll and adjacent seamounts host a remarkable biodiversity (Fiedler et al., 2016; Hazin et al, 1998). For this reason, the marine ichthyofauna of this large biogeographic unit categorized as Ecologically or Biologically Significant Marine Areas - EBSA (CBD, 2014) has been studied by many authors (Dominguez et al., 2016; Kikuchi & Schobbenhaus, 2002; Oliveira et al., 2011). However, most efforts focused on fishes living near to the surface (0-200 m) and few studies described the mesopelagic zone (200-1000 m depth) of this region, which is considered as one of the most understudied of the world ocean (St. John et al., 2016).

The mesopelagic community is a key resource for higher trophic levels, maintaining part of the marine biodiversity and playing an important role in carbon sequestration and thus on the biological carbon pump (Proud et al, 2017; St. John et al., 2016). To better account for the role of this community in the ecosystem structure and function, a prerequisite is to have the necessary biological information. One of such key basic knowledge concerns the length-weight relationships (LWR) that are one of the requisites for fisheries management and conservation (Froese, 2006; Froese et al., 2011). Indeed, LWRs are used to estimate body weight by length measurements, assess the condition factor or well-being of species of interest, as well as for the calculation of production and biomass of a fish stock (Froese, 2006). Despite this, information on LWRs are still lacking for many deep-sea fishes. Here, we provide new LWRs for eleven mesopelagic fish species collected along the northeast Brazilian oceanic islands, in order to increase the biological data and general knowledge of these species.

MATERIAL AND METHODS

The study area comprises the northeast Brazilian oceanic islands, including Rocas Atoll (3°52'S, 33°49'W), Fernando de Noronha Archipelago (3°50'S, 32°25'W) and adjacent seamounts. Data were collected during the scientific survey ABRACOS (Acoustics along the BRAzilian COaSt) conducted on board the RV *Antea*, from 9th April to 6th May 2017. Mesopelagic sampling was conducted using a micronekton trawl (side length of body mesh: 40 mm, side length of cod-end mesh: 10 mm) at 35 stations from 0 to 1113 m depth. After capture, the material was fixed in a 4% formalin solution for one month and then preserved in a 70% alcohol solution for proximally six months before processing for length and weight. At the laboratory, species were identified,

measured (nearest 0.1 cm of standard length, SL) and weighed (nearest 0.01 g of total weight, TW). All specimens were deposited in the Fish Collection of the Núcleo em Ecologia e Desenvolvimento Socioambiental de Macaé (NPM), Universidade Federal do Rio de Janeiro (NUPEM/UFRJ).

The parameters of the LWR were estimated through the equation: $TW = a \times SL^b$, where *TW* is the total weight (g), *SL* is the standard length (cm), *a* is a constant being the initial growth index and *b* is the slope of the regression. Prior to the calculation of LWRs, the relationship plots were executed for visual inspection and removal of outliers (Froese & Binohlan, 2000). The significance of the regression was tested by ANOVA and the degree of association between *TW* and *SL* was calculated by the determination coefficient (r^2). We only included LWRs for species with n > 30, except for three species for which a wide fish-length range was available.

RESULTS

A total of 11 species belonging to five families and three orders were analysed (Table 1). All regressions were highly significant ($P < 0.01$), with the coefficient of determination (r^2) ranging from 0.9511 to 0.9862. The value of *b* varied between 2.66 for *Sternoptyx pseudobscura* and 3.22 for *Sigmops elongatus*, while the parameter *a* ranged between 0.0012 for *Thysanactis dentex* and 0.0250 for *Ectreposebastes imus.*

DISCUSSION

This work provides the first LWR for six species: *S. pseudobscura*, *B. pedaliota*, *S. elongatus*, *T. dentex*, *M. zugmayeri*, and *E. imus*. LWR information has been previously available for *A. aculeatus*, *A. affinis*, *A. sladeni*, *S. diaphana*, and *M. niger*, but it was based on a small length range, small sample size (<5) and/or without the descriptive statistics of the relationships (Alpoim et al., 2002; Davison et al., 2015). All species presented here but *A. aculeatus* and *M. niger*, have no LWRs available in FishBase. In addition, the highest standard-length values for *Bonapartia pedaliota* and *Ectreposebastes imus* are reported herein.

As established by Froese (2006), the allometric coefficients for all LWRs were within the expected range of 2.5–3.5. These values are reflection of intrinsic characteristics and process of adaptations of each species, as ontogenetic reproductive or environmental variations, mainly between sexes (Froese, 2006). In addition, fixation

in alcohol and formaldehyde can affect length and weight measurements through the shrinking and dehydration of specimens. For that reason, we recommend consider the LWRs presented here as being tentative.

Overall, this study increases the knowledge on mesopelagic fishes, providing basic biological information useful for further studies in ecology, conservation, and fisheries assessment.

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Table 1. Descriptive statistics and parameters of LWRs for 12 deep-sea fishes caught using a micronekton trawl at the northeast Brazilian oceanic islands and seamounts, from 9th April to 6th May 2017. **SL** = Standard Length, **TW** = Total Weight, ***a*** = initial growth index, ***b*** =slope of the regression and **r2** = determination coefficient.

Taxa	**n**	**SL (cm)**		**TW (g)**		**Regression parameters**		**r2**
		Min	**Max**	**Min**	**Max**	**a**	**b (95% CL)**	
Stomiiformes								
Gonostomatidae								
Bonapartia pedaliota Goode & Bean, 1896	85	3.7	7.5	0.4	2.7	0.0074 (0.0058-0.0094)	2.94 (2.80-3.08)	0.9571
Sigmops elongatus (Günther, 1878)	35	4.9	25	0.2	28	0.0015 (0.0009-0.0023)	3.229 (3.07-3.39)	0.9814
Sternoptychidae								
Argyropelecus aculeatus Valenciennes, 1850	49	3	8.2	0.8	20.9	0.0350 (0.0245-0.0496)	2.996 (2.77-3.21)	0.9529
Argyropelecus affinis Garman, 1899	260	2.8	7.8	0.31	6.09	0.0218 (0.0183-0.0258)	2.807 (2.70-3.91)	0.9511
Argyropelecus sladeni Regan, 1908	26	2	6.6	1.15	7.2	0.0425 (0.0257-0.0705)	2.703 (2.39- 3.01)	0.9618
Sternoptyx diaphana Hermann, 1781	600	1.2	4.3	0.1	4.3	0.0570 (0.0370-0.0770)	2.89 (2.79-2.99)	0.9275
Sternoptyx pseudobscura Baird, 1971	51	1.3	5.6	0.24	6.6	0.0754 (0.0582-0.0970)	2.663 (2.45-2.88)	0.9655
Stomiidae								
Malacosteus niger Ayres, 1848	33	6.3	18.1	1.5	34.4	0.0057 (0.0009-0.0030)	2.956 (2.74-3.17)	0.9635
Thysanactis dentex Regan & Trewavas, 1930	35	4.3	14.5	0.1	10.6	0.0012 (0.0009-0.0012)	3.197 (3.07-3.33)	0.9868
Gadiformes								
Melanonidae								
Melanonus zugmayeri Norman, 1930	20	6.4	19.1	1.06	32.31	0.0036 (0.0018-0.0071)	2.973 (2.68-3.26)	0.9623
Scorpaeniformes								
Setarchidae								
Ectreposebastes imus Garman, 1899	25	5.2	23.4	3.43	290.3	0.0250 (0.0138-0.0482)	3.025 (2.81-3.24)	0.9728