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# Length–weight relationships of five selected demersal fishes from the Cabo Verde Islands (eastern-central Atlantic)

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## Abstract

The length–weight relationships (LWR) were estimated for five selected demersal marine fishes from the relatively undisturbed shelves and slopes of the Cabo Verde Islands. Most of them were of ecological and/or commercial interest. Occasional sampling was carried out during different fisheries research projects. LWRs were taken for the following bycatch species for which no such estimates exists in the science literature: *Myroconger compressus*, *Synaphobranchus affinis*, *Physiculus cyanostrophus*, *Physiculus caboverdensis* and *Canthidermis maculata*. Total length and fork length (to the nearest 0.1 cm) and total weight (to the nearest 0.1 g) were determined. The resulting length–weight equations are characterized by a high accompanying coefficient of correlation. The present data help improving the knowledge base needed for further fish biology studies and fisheries management.

**KEYWORDS**

by-catch, Cape Verde, East Atlantic, growth, Osteichthyes

## 1 | INTRODUCTION

The archipelago of Cabo Verde (eastern-central Atlantic) biogeographically forms its own ecoregion within the West African Transition province of the Tropical Atlantic realm (Spalding et al., 2007). A recent marine multi-taxon approach has proposed that these islands should be given the status of a biogeographic sub-province within the above-mentioned province (Freitas et al., 2019).

The benthic ecosystem around these arid subtropical islands can be considered as moderately human-altered; there is no bottom trawling in this area and the fishing effort with bottom longlines is anecdotal (González et al., 2020; Pajuelo et al., 2018). The zone within 3 n.m. is reserved exclusively for national subsistence and small-scale fishing, while the 12 n.m. zone is restricted to the national semi-industrial fleet, which targets mainly small pelagic fish, tunas, and sharks using purse seines, handlines and gill nets, and the endemic Cape Verde lobster (*Palinurus charlestoni* Forest & Postel, 1964) with traps (González et al., 2009, 2020).

Length–weight relationships (LWRs) of fish are usefulness to fish biology and for fisheries and conservation management (Andrade & Campos, 2002; Ecoutin et al., 2005; Froese et al., 2011), provided they are supplemented by additional population data and environmental parameters. LWRs provide information on fish condition and their types of growth, to estimate biomass from length data by underwater visual census, compare life histories and morphological differentiations of species across different regions (Morato et al., 2001; Verdiell-Cubedo et al., 2006; Vieira et al., 2014).

Most data available for LWRs of fish species from the Cabo Verde archipelago were reported in technical reports, except for 27 demersal

fish species (Pereira et al., 2012). This paper estimates LWRs for five selected demersal by-catch fishes from Cabo Verde Islands for which such estimates do not exist anywhere in the science literature. The present results (being tentative or not) increase basic knowledge on population ecology and fisheries of the studied species.

## 2 | MATERIALS AND METHODS

### 2.1 | Sample collection

Fishes sampled were obtained as by-catch of four exploratory trapping surveys and from one targeted fishery, but there was no specific and standardized sampling design specifically addressing the issue of species-specific LWRs.

Key information for each studied species concerning research project, cruise, vessel, fishing ground, dates of collection, collecting gear used and depth interval covered was summarised in Table 1, and explained as follows. Individuals of deep-water species *Myroconger compressus* Günther, 1,870 and *Synaphobranchus affinis* Günther, 1877 were caught with bottom traps in 2005. Fishing operations during cruise covered a depth range between 437 m and 1,060 m, in search of new living resources off the islands of Boa Vista –which is characterized by a sediment-covered broad shelf and slope– and Santiago –with a narrow shelf and slope dominated by hard substrata. Specimens of semi-deep species *Physiculus cyanostrophus* Anderson & Tweddle, 2002 and *P. caboverdensis* González et al., 2018 were mainly obtained with multiple semi-floating shrimp traps in 2011–2012. These cruises were mainly directed towards exploration and stock assessment of the striped soldier shrimp (*Plesionika edwardsii* (J.F. Brandt in von Middendorf, 1851)) between 66 m and 458 m depth, covering four islands. In all these research cruises, bottom traps (BT) and semi-floating shrimp traps (SFST, operated around 2.4 m above the seafloor) (González et al., 1992, 2004, 2014; Pajuelo et al., 2018) were used as fishing gear. At last, individuals of the reef-associated species *Canthidermis maculata* (Bloch, 1786) were caught from the domestic small-scale fisheries with purse seine in 2017, in the frame of an ongoing biological and phylogenetic research on Balistidae from Macaronesia (Table 1).

Once taxonomically identified, each fresh individual was measured for total length (TL, to the nearest 0.1 cm) and weighed for total weight (TW, to the nearest 0.1 g) on board or in laboratory. Fork length (FL, to the nearest 0.1 cm) was also registered for individuals belonging to *C. maculata*.

### 2.2 | Data analysis

The relationship between TW and TL was calculated by applying a non-linear regression to the exponential equation $TW = a \times TL^b$, where *a* and *b* are the parameters to be estimated. The function was fitted by means of the Levenberg-Marquardt algorithm for non-linear parameter estimation. The goodness of fit to the exponential model was estimated by $r^2$, calculated as 1 – (Residual sum of squares) / (Corrected sum of squares) by ANOVA analysis, which indicates the degree of fit of the values of sample to the selected non-linear model, and the *b*-value for each fish species was tested by *t*-test to verify whether it was significantly different from isometric growth ($b = 3$) (Sokal & Rohlf, 1987). For *C. maculata* an LWR was also calculated as TW versus FL.

## 3 | RESULTS

Key parameters of the LWRs estimated for the five selected by-catch fish species – *C. maculata*, *P. caboverdensis*, *P. cyanostrophus*, *M. compressus*, and *S. affinis* – from waters of the Cabo Verde Islands are presented in Table 2. Almost all correlations reached the preferred significant level ($r^2 > 0.95$), which is needed for a reliable LWR. Only two estimates reached an $r^2$ value slightly below but still above 0.9.

## 4 | DISCUSSION

*Physiculus caboverdensis* has recently been described (González et al., 2018) and no biometrical data have so far been published on this species. However, the species is listed in Eschemeyer's Catalogue of Fishes.

Regarding *P. cyanostrophus* and *C. maculata*, the size ranges covered by this study are limited (the smaller size classes are missing) and a sampling effort should be done in the future to improve these estimates.

Apart of being a reef-associated species, *C. maculata* is also an epipelagic species almost throughout life, often associated with drifting objects (Fedoryako, 1980). The low *b*-values (between 2.2964 and

**TABLE 1** List of cruises, locations, gear used and sampling depth from which fish specimens were obtained

| Project | Cruise/Fishery | Vessel | Islands | Dates | Collecting gear | Depth interval (m) |
|---|---|---|---|---|---|---|
| Hydrocarpo | Cabo Verde 2005–06 | R/V "Pixape II" | Boa Vista and Santiago | Jun. 4–16, 2005 | BT | 447–1060 |
| Marprof-CV | Camarão–1 | R/V "Prof. I. Lozano" | Santiago | Nov. 17–30, 2011 | SFST, BT | 66–364 |
| Marprof-CV | Camarão–2 | R/V "Prof. I. Lozano" | Boa Vista | Mar. 3–15, 2012 | SFST, BT | 94–289 |
| Marprof-CV | Camarão–3 | R/V "Prof. I. Lozano" | Sal and São Nicolau | Jul. 10–25, 2012 | SFST, BT | 74–458 |
| Macarofood | Small-scale fisheries | Cabo Verde boat | Bancona Bank, Santiago | Jul. 14, 2017 | PS | 15–20 |

*Note:* BT, bottom traps; SFST, semi-floating shrimp traps; PS, purse seine.

**TABLE 2** Length–weight relationships for five selected demersal fish species from the Cabo Verde Islands (eastern-central Atlantic)

| Species | *n* | TLmin–TLmax (cm) | FLmin–FLmax (cm) | TWmin–TWmax (g) | *a* 95% CI | *b* 95% CI | $r^2$ | *p* | GT |
|---|---|---|---|---|---|---|---|---|---|
| *Canthidermis maculata* | 22 | 25.8–43.9 | - | 373–1325 | 0.2269 | 2.2964 | 0.928 | .00015 | A- |
| (Bloch, 1786)[a] | | | | | −0.0349–0.4887 | 1.9776–2.6153 | | | |
| | 22 | - | 26.0–43.3 | | 0.2296 | 2.3044 | 0.930 | .00013 | A- |
| | | | | | −0.0270–0.4864 | 1.9940–2.6148 | | | |
| *Physiculus caboverdensis* | 25 | 16.2–25.4 | - | 24.0–126.0 | 0.0015 | 3.4899 | 0.976 | .00021 | A+ |
| González et al., 2018 | | | | | 0.0004–0.0026 | 3.2577–3.7220 | | | |
| *Physiculus cyanostrophus* | 325 | 12.9–38.4 | - | 11.8–287.5 | 0.0068 | 2.9628 | 0.964 | .45080 | I |
| Anderson & Tweddle, 2002[a] | | | | | 0.0045–0.0090 | 2.8655–3.0600 | | | |
| *Myroconger compressus* | 91 | 30.3–62.1 | - | 54.7–598.8 | 1.7631 | 3.4063 | 0.952 | .00005 | A+ |
| Günther, 1,870 | | | | | −3.3664–3.8629 | 3.2160–3.5966 | | | |
| *Synaphobranchus affinis* | 193 | 22.0–66.6 | - | 13.6–446.0 | 0.0003 | 3.3961 | 0.965 | .00083 | A+ |
| Günther, 1877 | | | | | 0.0002–0.0003 | 3.3087–3.4834 | | | |

*Note*: *n*: sample size; TLmin and TLmax: minimum and maximum total length (cm); FLmin and FLmax: minimum and maximum fork length (cm); *a* and *b*: relationship parameters; CI: 95% confidence interval; $r^2$: determination coefficient; *p*: *p*-value for *t*-test testing departures from isometric growth (b = 3).

[a]Tentative estimate.

2.3044) could result from the well-developed caudal region for a given individual weight (with caudal-fin rays of adults prolonged above and below), and also due to its laterally compressed body.

The present regressions for *P. caboverdensis* and *P. cyanostrophus* were significant and gave suitable adjustments. However, much more long-term and sex-specific data are needed before any decision on allometry can be made. Possible differences between these congeneric species could be explained by the frequent caudal region regeneration observed in the Cabo Verde population of the later morid (Triay-Portella et al., 2019).

In the case of *S. affinis* a LWR is available in the literature covering a similar TLmax (Froese & Pauly, 2019). Also, the values for parameters *a* and *b* are very similar to those obtained in the present study. Thus, no new science insights on this species-specific LWR are gained except that present data confirm existing knowledge. However, since present sample size is much larger, this estimate offers this confirmation of previous estimate as a quasi-assurance that we do have now a fairly acceptable species-specific estimate. This regression gave a very good adjustment and positive allometric growth. Pereira et al. (2012) reported a similar growth pattern, very probably misidentified as *Synaphobranchus kaupii* Johnson, 1862 (fide Almeida et al., 2010).

The LWRs estimated in this study should be used with caution (especially when the regression included a low number of individuals) and considered as representative of the study period. Additionally, factors such as habitat, seasonal effects, stomach fullness (mainly due to bait used with fishing gear), maturity stage and age are known to affect length–weight relationships (e.g., Ozaydin et al., 2007; Ricker, 1975). Provided they will be supplemented with suitable additional population data and environmental parameters, LWRs estimated in this study are usefulness for fisheries and conservation management.

## 5 | NO DATA AVAILABILITY STATEMENT

Present data are part of specific databases that, over the next few years, will support biological studies (with different authors) that will include aspects of the growth and reproduction of such species.

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### CONFLICT OF INTEREST

MS: Length-weight relationships of twenty selected marine fishes from Cabo Verde Islands (eastern-central Atlantic), by:

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