





Length-weight relationship of commercial fish species caught on the central coast of Espírito Santo, Southeastern Brazil

Clara de Oliveira Xavier^{1*} , Patrick Lopes Serrão Leal¹ , Joelson Musiello-Fernandes² ,
Mauricio Hostim-Silva² , Natalia Priscila Alves Bezerra¹ 

¹Universidade Federal do Espírito Santo  – Departamento de Oceanografia e Ecologia – Laboratório de Bioecologia Marinha – Vitória (ES), Brazil.

²Universidade Federal do Espírito Santo  – Departamento de Ciências Agrárias e Biológicas – Laboratório de Pesca e Aquicultura – São Mateus (ES), Brazil.

*Corresponding author: clara.olixavier@gmail.com

ABSTRACT

This study aimed to establish length–weight relationships (LWR) for fish species captured by the artisanal fleet on the central coast of Espírito Santo, Brazil. Although the landing site was specific, the fish were caught across various areas along the central coast, indicating a broader spatial range than the collection point suggests. Data were collected from February 2023 to July 2024, including fishing gear used, capture location, total length (TL), and total weight (TW) of the specimens. A total of 1,484 individuals were measured, representing 12 species from six orders and 10 families. Haemulidae was the most represented family, and *Haemulon aurolineatum* was the most abundant species. *Caranx crysos* and *Balistes capriscus* showed the highest mean lengths (35.50 and 34.59 cm), while *H. aurolineatum* and *Cynoscion jamaicensis* had the lowest (20.39 and 22.99 cm). *Caranx crysos* and *Cephalopholis fulva* were the only species exhibiting isometric and positive allometric growth, respectively ($b = 2.94$; $b = 3.08$). The remaining species showed negative allometric growth, with a ranging from 0.006 to 3.798, b from 1.152 to 3.08, and r^2 from 0.4758 to 0.9636. These results provide valuable biological information for key commercial species and support future actions for sustainable fisheries management and conservation in Espírito Santo.

Keywords: Artisanal fisheries; Allometry; Population dynamics; Marine environments; Fisheries management.

Relação comprimento-peso de espécies de peixes comerciais capturadas na costa central do Espírito Santo, sudeste do Brasil

RESUMO

Este estudo teve como objetivo estabelecer relações de comprimento–peso (LWR) para espécies de peixes capturadas pela frota artesanal na costa central do Espírito Santo, Brasil. Embora o ponto de desembarque fosse específico, os peixes foram capturados em diversas áreas ao longo da costa central, indicando uma abrangência espacial maior do que o local de coleta sugere. Os dados foram coletados entre fevereiro de 2023 e julho de 2024, incluindo o petrecho de pesca utilizado, o local de captura, o comprimento total (CT) e o peso total (PT) dos espécimes. Foram medidos 1.484 indivíduos, representando 12 espécies distribuídas em seis ordens e 10 famílias. Haemulidae foi a família mais representada, e *Haemulon aurolineatum* foi a espécie mais abundante. *Caranx crysos* e *Balistes capriscus* apresentaram os maiores comprimentos médios (35,50 e 34,59 cm), enquanto *H. aurolineatum* e *Cynoscion jamaicensis* apresentaram os menores (20,39 e 22,99 cm). *C. crysos* e *Cephalopholis fulva* foram as únicas espécies que apresentaram crescimento isométrico e alométrico positivo, respectivamente ($b = 2,94$; $b = 3,08$). As demais espécies apresentaram crescimento alométrico negativo, com a variando de 0,006 a 3,798, b de 1,152 a 3,08 e r^2 de 0,4758 a 0,9636. Esses resultados fornecem informações biológicas valiosas para espécies comerciais importantes e subsidiam futuras ações voltadas ao manejo sustentável da pesca e à conservação no Espírito Santo.

Palavras-chave: Pesca artesanal; Alometria; Dinâmica populacional; Ambientes marinhos; Gestão pesqueira.

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INTRODUCTION

Artisanal fishing represents half of the world's fishing effort and is often defined as low-yield fishing conducted with small- and medium-sized vessels with low autonomy that operate close to the coast (FAO, 2012; Rousseau et al., 2019). In Brazil, this traditional activity typically depends on family labor, has been practiced for generations, and accounts for the largest share of national fish production (Knox & Trigueiro, 2015; Silva, 2014), primarily in inland and coastal waters. Artisanal fishing spans the entire Brazilian coastline, displaying a wide range of characteristics shaped by local and regional contexts and by the diversity of fishing communities (MPA, 2019). Furthermore, many fishers rely on this activity as their main source of income or subsistence (FAO, 2012).

Despite its socioeconomic and cultural importance, artisanal fishing in Brazil suffers from a chronic lack of data regarding catch volumes and fishing effort, which hinders effective fisheries management and compromises the sustainability of marine resources (Viana, 2013). The absence of reliable and consistent monitoring data results in environmental, social, and economic impacts (Musiello-Fernandes et al., 2021). In the state of Espírito Santo, Brazil, fishing plays a significant role in the local economy and culture, generating employment and income for communities (Abreu et al., 2020). Consequently, the concurrent monitoring of fish landings, combined with biometric measurements and sex determination of the landed catch, is imperative for understanding the population structure of the captured species, thereby providing a foundation for the management of fishery resources.

The length-weight relationship is a widely used tool in fisheries science to estimate one metric (length or weight) from the other and to assess the growth patterns of fish species. It helps understand population conditions across time and space and contributes to evaluating fishery yields (Wang et al., 2024). This relationship also provides insights into fish condition and somatic growth, which may be isometric or allometric (Mehanna & Farouk, 2021). Biometric data such as length and weight are essential for stock assessment, for understanding population structure and ecology, and for implementing management measures like minimum catch sizes and closed seasons (Santos & Santos, 2005).

In this context, the study aimed to provide new biometric data for species caught by the local artisanal fishing fleet operating in the municipality of Vila Velha, Espírito Santo, through

the estimation of length-weight relationships, contributing to the sustainability of local fisheries.

MATERIAL AND METHODS

Data collection was conducted in the Prainha region, in the municipality of Vila Velha (20°19'40.09"S; 40°17'29.16"W), located on the central coast of Espírito Santo state, from February 2023 to July 2024 (Fig. 1). Fish samples were obtained from artisanal fisheries conducted by local fishermen using bottom longlines, surface longlines, gillnets, and cast nets. Landings were monitored weekly at the Prainha landing site to collect specimens and record fishery data.

During landing events, specimens were identified to the lowest possible taxonomic level based on specialized literature, weighed (g), and measured for total, standard, and fork lengths (cm). Although sampling was conducted exclusively at the Prainha landing site, the catches originated from multiple fishing grounds along the central coast of Espírito Santo, including Jacaraípe, Vila Velha, Carapebus, Praia da Costa, Prainha, and Vitória. Taxa with fewer than 10 sampled individuals were not included in the length-weight relationship analyses.

The length-weight relationship (LWR) was estimated using the power equation (Eq. 1):

$$W = a \times L^b \quad (1)$$

Where: W: the total weight (g); L: the fish length (cm); a: the intercept of the regression (initial growth coefficient); b: the slope of the regression (Froese, 2006; Froese et al., 2011).

Total length (TL) was used in all analyses to ensure standardization, including the detection and treatment of outliers. The first equation was logarithmically transformed into Eq. 2:

$$\log(W) = \log(a) + b \times \log(TL) \quad (2)$$

Values of $b = 3$ indicate isometric growth, $b > 3$ indicate positive allometric growth, and $b < 3$ indicate negative allometric growth. Before calculating the LWR, outliers for each species were identified through standard length (SL) versus total weight (TW) plots (Froese & Binohlan, 2000) and subsequently removed (Xavier et al., 2026). The coefficient of determination (Pearson r-squared, r^2) and the confidence limits (95%CL) were used as indicators of the quality of the parameters a and b in R software (Froese, 2006; Froese et al., 2011).

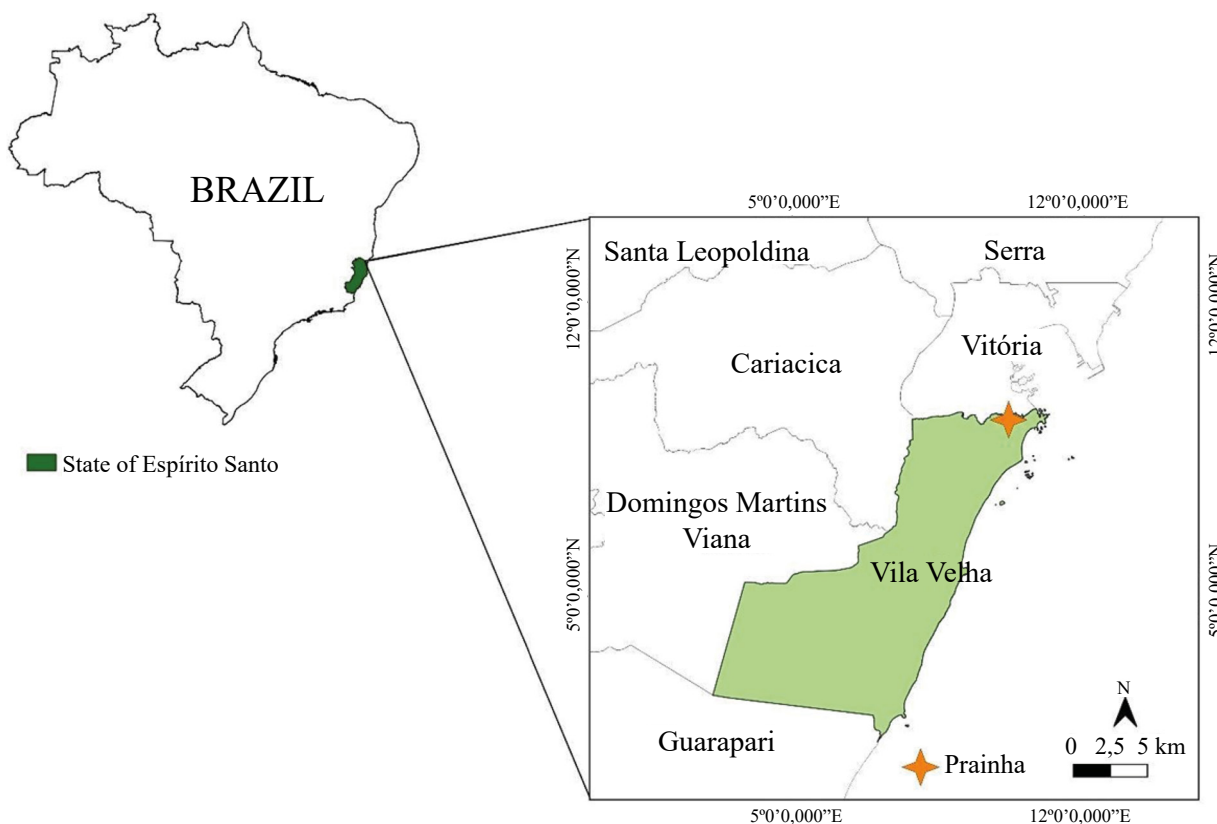


Figure 1. Location of the Prainha region in the municipality of Vila Velha, Espírito Santo state, Brazil, with data collection conducted from February 2023 to July 2024.

RESULTS

The analyses included a total of 1,484 individuals, representing one class, six orders, 10 families, and 12 species, with only the species with a sample size greater than 10 being considered (Xavier et al., 2026). The family Haemulidae was the most representative in this study, with two species. The *Caranx crysos* and *Balistes capriscus* stood out for having the highest average lengths of 35.5 (min = 26, max = 54.39) and 34.59 cm (min = 23.5, max = 48), respectively. In contrast, the *Haemulon aurolineatum* and *Cynoscion jamaicensis* had the lowest average lengths, with 20.39 (min = 14, max = 24) and 22.99 cm (min = 16, max = 27) (Table 1). The species *Pagrus pagrus* (n = 534), *H. aurolineatum* (n = 368), *B. capriscus* (n = 153), *Trichiurus lepturus* (n = 128), and *C. jamaicensis* (n = 123) were the most representative taxa (Table 1).

The LWR calculations revealed that *Cephalopholis fulva* exhibited positive allometric growth ($b = 3.087$), while *C. crysos* displayed isometric growth ($b = 2.94$), both within the limits proposed by Froese (2006). The intercept (a) varied between 0.006 and 3.798, whereas the slope (b)

varied from 1.152 to 3.08. The coefficient of determination (r^2) ranged from 0.4758 to 0.9636 (Table 2). The remaining 10 species showed negative allometric growth ($b < 3$). Among them, *H. aurolineatum* presented the lowest b value (1.1552), followed by *Dactylopterus volitans* (1.662) and *B. capriscus* (1.873) (Table 2).

DISCUSSION

The absence of fishery data is a pervasive issue on a global scale, with Brazil being a notable example of a nation grappling with this challenge. The most recent official fisheries statistics report was published 13 years ago, in 2011 (MPA, 2011). The availability of detailed fishery data remains limited, particularly regarding species-specific biometric information at regional scales. Despite the availability of national statistics, length and weight data are frequently inadequate for conducting population-level assessments. This situation is further compounded by the absence of long-term monitoring programs, which restricts data continuity and undermines effective fisheries management. Thus, our results contribute with data from 1,484 specimens

Table 1. Taxonomic classification (order, family, and species with authorship presented in a single column), abundance (number of individuals), and descriptive statistics (mean, minimum and maximum) of total length (cm) and weight (g) of 12 commercial fish species collected in Prainha region, Vila Velha, Espírito Santo, Brazil, between February 2023 and July 2024.

Taxonomic classification (order/family/taxon)	Brazilian common name	Total number of individuals	Mean length (cm)	Min length (cm)	Max length (cm)	Mean weight (g)	Min weight (g)	Max weight (g)
Carangiformes/Carangidae/ <i>Caranx crysos</i> (Mitchill, 1815)	Chicharro	20	35.55	26	54.39	557.25	215	1.465
Pleuronectiformes/Cyclopsettidae/ <i>Syacium papillosum</i> (Linnaeus, 1758)	Linguado	18	21.22	14	27	102.22	30	180
Mugiliformes/Mugilidae/ <i>Mugil liza</i> Valenciennes, 1836	Tainha	15	30.4	27.5	37	283	200	485
Perciformes/Haemulidae/ <i>Haemulon aurolineatum</i> Cuvier, 1830	Cutinga	368	20.39	14	24	132.87	105	205
Perciformes/Haemulidae/ <i>Haemulon plumierii</i> (Lacepède, 1801)	Boca-de-velho	22	30.15	25	34	470.77	290	670
Perciformes/Sciaenidae/ <i>Larimus breviceps</i> Cuvier, 1830	Cabeça-dura	14	16.66	15	19.5	77.14	55	120
Perciformes/Sciaenidae/ <i>Cynoscion jamaicensis</i> (Vaillant & Bocourt, 1883)	Pescadinha	123	22.99	16	27	170.61	105	295
Perciformes/Serranidae/ <i>Cephalopholis fulva</i> (Linnaeus, 1758)	Catuá	78	25.01	16	36	288.12	23	780
Perciformes/Trichiuridae/ <i>Trichiurus lepturus</i> Linnaeus, 1758	Espada	128	129.58	89	160	1,557.85	860	3.025
Perciformes/Dactylopteridae/ <i>Dactylopterus volitans</i> (Linnaeus, 1758)	Falso-voador	11	33.36	28	36	397.72	280	460
Acanthuriformes/Sparidae/ <i>Pagrus pagrus</i> (Linnaeus, 1758)	Pargo-rosa	534	25.05	18	41	279.69	105	1.105
Tetraodontiformes/Balistidae/ <i>Balistes caprisus</i> Gmelin, 1789	Peroá-branco	153	34.59	23.5	48	525.55	205	1.000

across 12 taxa, measured and weighed in the city of Vila Velha, in Espírito Santo state, a previously undocumented location for these parameters.

The negative allometry ($b < 3$) observed in the species of *S. papillosum*, *D. volitans*, and *L. breviceps* in the present study contrasts with findings from other studies conducted in the Southeast region (Dias et al., 2014; Joyeux et al., 2008), possibly due to differences in habitat type (Ruiz-Campos et al., 2010), food availability, condition factor (Froese et al., 2011), gonadal maturity, sex, and growth phase (Froese, 2006), effects of formalin on specimens

(Teixeira-de-Mello et al. 2011), or other uncontrolled factors such as seasonal variations or extreme environments effects (Costa et al., 2014; Wang et al., 2016).

The b value (2.94) for *C. crysos* observed in this study is similar to the value recorded in the Northeast region (2.94) (Ferreira et al., 1998), and in the Southeast region (3.14) (Costa et al., 2018). This similarity may be explained by the fact that all studies were conducted in coastal areas, which generally offer favorable environmental conditions for fish growth, including greater food availability, habitat complexity, and protected spawning grounds (Goodridge Gaines et al., 2020).

Table 2. Descriptive statistics and parameters of length–weight relationships (LWR) for 10 commercial fish species from Prainha, municipality of Vila Velha, central coast of Espírito Santo, Brazil, from February 2023 to July 2024*.

Taxon	Regression parameters						Allometric
	a	b	r ²	95%CI of a	95%CI of b	P (t-test) b compared to 3	
<i>Caranx crysos</i> (Mitchill, 1815)	0.0133	2.943	0.9636	(-5.299), (-3.341)	2.667–3.218	1.29e-11	Isometric
<i>Syacium papillosum</i> (Ranzani, 1842)	0.0597	2.431	0.8363	(-4.436225), (-1.198539)	1.899233– 2.963369	2.64e-2	Negative
<i>Mugil liza</i> (Valenciennes, 1836)	0.0205	2.76	0.902	(-5.684620), (-2.080731)	2.257766– 3.313834	3.87e-2	Negative
<i>Haemulon aurolineatum</i> (Cuvier, 1829)	3.798	1.152	0.4758	0.9533852– 1.7157635	1.050245– 1.303433	< 2.2e-16	Negative
<i>Haemulon plumierii</i> (Lacepède, 1801)	0.6633	2.67	0.5044	(-3.217952), 2.397058	1.089926– 2.734157	8.82e-2	Negative
<i>Larimus breviceps</i> (Cuvier, 1830)	0.1419	2.233	0.5443	(-5.313149), 1.409152	1.036601– 3.430783	0.001566	Negative
<i>Cephalopholis fulva</i> (Linnaeus, 1758)	0.0120	3.087	0.8676	(-5.297191), (-3.532137)	2.811839– 3.362446	< 2.2e-16	Positive
<i>Trichiurus lepturus</i> (Linnaeus, 1758)	0.0318	2.213	0.6677	(-4.777003), (-2.117070)	1.939619– 2.486988	< 2.2e-16	Negative
<i>Dactylopterus volitans</i> (Linnaeus, 1758)	1.968	1.662	0.5299	(-2.558210), 3.912482	0.593874– 2.441415	0.004385	Negative
<i>Cynoscion jamaicensis</i> (Vaillant & Bocourt, 1883)	0.06314	2.514	0.7056	(-3.672065), (-1.852602)	2.223566– 2.804675	< 2.2e-16	Negative
<i>Pagrus pagrus</i> (Linnaeus, 1758)	0.006	2.570	0.792	(-3.069124), (-2.348146)	2.45884– 2.68303	< 2.2e-16	Negative
<i>Balistes capriscus</i> (Gmelin, 1789)	0.5989	1.873	0.4938	(-1.5982224), 0.5731853	1.597004– 2.210752	< 2.2e-16	Negative

a: intercept of the LWR (initial growth coefficient); b: slope of the regression (allometric coefficient); r²: coefficient of determination; 95%CI: 95% confidence interval; P (t-test): probability value of the Student's t-test comparing b to the theoretical value 3; *the growth pattern was classified as isometric (b = 3), negative allometric (b < 3), or positive allometric (b > 3).

The b value (2.76) for *Mugil liza* observed in the coastal Southeast region of Brazil (Frota et al., 2004) is similar to the value found in the present study (b = 2.78). Similarly, the b value (2.56) for *S. papillosum* reported by Dias et al. (2014) is also close to the value found in the present study for this species (b = 2.43). For *C. fulva*, the only species showing positive allometry, previous studies, such as those by Guabiroba and Joyeux (2018), observed similar results in the Southeast region, suggesting that the fast length growth relative to weight is a consistent pattern for this species.

As for *H. plumierii*, there is no previous information on this LWR in the Southeast region, making this the first study to address it for this area. In the Northeast region of Brazil, Viana et al. (2016) found a b value (2.98) close to the one observed in the present study (b = 2.67). However, further studies are needed to better understand the factors influencing the LWR of this species in different regions of Brazil. Finally, this study reports for the first time the LWR for one specie of Haemulidae family in the Southeast region of Brazil (*H. plumierii*).

CONCLUSION

This study provides relevant information that enhances the knowledge of commercially important species in the Central Coast of Espírito Santo, particularly regarding their biological characteristics. Additionally, the data presented can offer essential support for sustainable management aimed at the conservation of these species. However, it is important to note that the limited sample size may have influenced the results. Therefore, it is essential to continue fishery monitoring in Espírito Santo state, with a larger number of samples, to gain a more comprehensive understanding of the population dynamics of these species in the region.

CONFLICT OF INTEREST

Nothing to declare.


DATA AVAILABILITY STATEMENT

The data supporting the findings of this study are available at: <https://doi.org/10.5281/zenodo.19225268>

AUTHORS' CONTRIBUTION

Conceptualization: Xavier, C.O.; **Writing – original draft:** Xavier, C.O., Leal, P.L.S.; **Formal analysis:** Xavier, C.O., Leal, P.L.S.; **Investigation:** Xavier, C.O., Leal, P.L.S.; **Data curation:** Xavier, C.O., Leal, P.L.S.; **Writing – Review & Editing:** Musiello-Fernandes, J., Hostim-Silva, M., Bezerra, N.P.A.; **Resources:** Hostim-Silva, M.; Bezerra, N.P.A.; **Supervision:** Bezerra, N.P.A.; **Final approval:** Xavier, C. O.

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DECLARATION OF USE OF ARTIFICIAL INTELLIGENCE TOOLS

The authors declare that artificial intelligence tools were used exclusively to assist in improving the English language of this manuscript. These tools were employed to enhance grammar, clarity, and readability after the original text had been written

by the authors. The revised text was subsequently reviewed by a professional language editing service prior to submission. No artificial intelligence tools were used to generate scientific content, interpret data, or influence the results and conclusions of this study. All ideas, analyses, and results presented in this manuscript are the sole responsibility of the authors.

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