Acta Limnologica Brasiliensia

Publication of the Brazilian Association of Limnology

Original Article
Acta Limnologica Brasiliensia, 2023, vol. 35, e22
https://doi.org/10.1590/S2179-975X4423
ISSN 2179-975X on-line version

Length-weight relationship of fishes from an estuary of Abrolhos Bank, Brazil

Relações peso-comprimento de peixes de um estuário do Banco dos Abrolhos, Brasil

Matheus Oliveira Freitas[1*], Fernando Conceição Fontes[1], Jonison Vieira Pinheiro[2] and Vinicius José Giglio[3]

[1]Instituto Meros do Brasil, Rua Benjamin Constant, 67, CEP 80060-020, Curitiba, PR, Brasil

[2]Programa de Pós Graduação em Biodiversidade, Universidade Federal do Oeste do Pará, Rua Vera Paz, S/N, CEP 68040-255, Santarém, PA, Brasil

[3]Universidade Federal do Oeste do Pará, PA-439, Km 4, 257, CEP 68270-000, Oriximiná, PA, Brasil

*e-mail: serranidae@gmail.com

Cite as: Freitas, M.O., et al. Length-weight relationship of fishes from an estuary of Abrolhos Bank, Brazil. *Acta Limnologica Brasiliensia*, 2023, vol. 35, e22.

Abstract: Aim: We investigate the length-weight relationship estimates of seventeen species caught using an artisanal purse seine in the Abrolhos Bank, a tropical estuarine complex in eastern Brazil. **Methods:** From February 2012 to November 2013, fish were collected monthly using an artisanal small purse seine with a total of 84 fish landings. The fish were captured in mangrove margins during high tide and retrieved after six hours at depths ranging from 1.2 to 3 meters. **Results:** A total of 4433 fish specimens from 17 species and nine families were sampled. The coefficient of determination ranged from 0.904 for *Centropomus parallelus* to 0.987 for *Lutjanus cyanopterus*. Species presented allometric growing, with *Caranx latus*, *Lutjanus cyanopterus* and *M. curema* exhibing negative allometric while all the other species presented positive allometric growing. We present first data in Brazil to *L. cyanopterus* and first data in the literature to *Lutjanus alexandrei*. **Conclusions:** Our results provide novel data of biological attributes for 17 species. By understanding the length-weight relationships and growth patterns of these species, data at stock level may subside proper management initiatives such as fishing restrictions in fishing sites or seasons and mesh size limits.

Keywords: artisanal fishing; Abrolhos Bank; fish ecology; fisheries management; fisheries biology.

Resumo: Objetivo: Investigamos as estimativas da relação peso-comprimento de dezessete espécies capturadas utilizando uma rede de cerco artesanal no Banco dos Abrolhos, um complexo estuarino tropical no leste do Brasil. **Métodos:** De fevereiro de 2012 a novembro de 2013, peixes foram coletados mensalmente utilizando uma rede de cerco artesanal de pequeno porte, totalizando 84 desembarques de peixes. Os peixes foram capturados nas margens de manguezais durante a maré alta e despescados após seis horas a profundidades variando de 1,2 a 3 metros. **Resultados:** Um total de 4433 espécimes de peixes de 17 espécies e nove famílias foram amostrados. O coeficiente de determinação variou de 0,904 para *Centropomus parallelus* a 0,987 para *Lutjanus cyanopterus*. As espécies apresentaram crescimento alométrico, com *Caranx latus*, *Lutjanus cyanopterus* e *M. curema* exibindo crescimento alométrico negativo, enquanto todas as outras espécies apresentaram crescimento alométrico positivo. Apresentamos os primeiros dados no Brasil para *L. cyanopterus* e os primeiros dados na literatura para *Lutjanus alexandrei*. **Conclusões:** Nossos resultados fornecem novos dados sobre atributos biológicos de 17 espécies. Ao compreender as relações peso-comprimento e padrões de crescimento dessas espécies, os dados em nível de estoque podem subsidiar iniciativas adequadas de manejo, como restrições de pesca em áreas ou épocas específicas e limites de tamanho de malha.

Palavras-chave: pesca artesanal; Banco dos Abrolhos; ecologia de peixes; gestão da pesca; biologia pesqueira.

1. Introduction

Biometric data like length-weight relationship (LWR) is basic information in fishery biology (Froese, 2006). These parameters are essential for fisheries, being used to calculate the weight of the individual from length-frequency data, estimation of biomass, growth pattern, general health, habitat conditions, fish fatness, morphological characteristic of the fish and fish condition factor in studies where weighing the fish is not possible (Ritcher et al., 2000; Froese, 2006; Macieira & Joyeux, 2009). For instance, LWR data is commonly used to calculate biomass of fish to analyze fish stock or verifying the fish density. The examination of the length-weight data is basic in fisheries research, providing information that informs stock assessments and aid in making informed decisions for sustainable exploitation.

Although there were LWR studies for many places along the Brazilian coast (Frota et al., 2004; Joyeux et al., 2009), there needs to be more data on LWR for fish stocks caught in the estuarine environments of eastern Brazil. Obtaining LWR data from local fish stocks, instead of from other stocks, is important for informing local management as it ensures that strategies are tailored to the specific characteristics and dynamics of the local fish populations, thereby increasing the accuracy and effectiveness of harvest regulations (Froese, 2006). Herein, we investigated the LWR of 17 fish species caught in an estuary off the Abrolhos Bank. The Abrolhos Bank extends ~ 200 km offshore and is Southwestern Atlantic's most biodiverse region, encompassing a large mid to outer shelf hard bottom domain with reefs and rhodolith beds (~20,900 km2) (Leão et al., 2003; Moura et al., 2013). Moreover, it is an ancient and important fishing area in Brazil (Cordel, 2006; Fogliarini et al., 2022), with fish being the primary income source of thousands of families. Fisheries in estuarine environments support the livelihood of hundreds of families, providing animal protein and generating income.

2. Material and Methods

2.1. Study area and sampling

The study was conducted at the Caravelas-Nova Viçosa estuarine complex, located on the extreme south coast of the state of Bahia and mid portion of Abrolhos Bank, eastern Brazil (17° 38' 08.89" S; 39°15'41.87" W; Figure 1). The Cassurubá Extractive Reserve has an area of 100.767 ha in total, being created in 2009, aiming to assign exclusive fishing rights to local fishers and guarantee the maintenance of fish stocks at sustainable fishing levels (Nobre & Schiavetti, 2013).

Fishes were collected monthly from February 2012 to November 2013. We sampled the fish catches during 84 fish landings of a small-scale fisher using an artisanal small purse seine fishing named "*camboa*" [see details in Giglio & Freitas (2013)]. The net contained on the purse net had 400 meters in length, 3 meters in height, and 40 millimeters in mesh size. Specimens were entangled in the mangrove margins during the high tide and collected after six hours in the low tide, at depths of 1.2 to 3 meters.

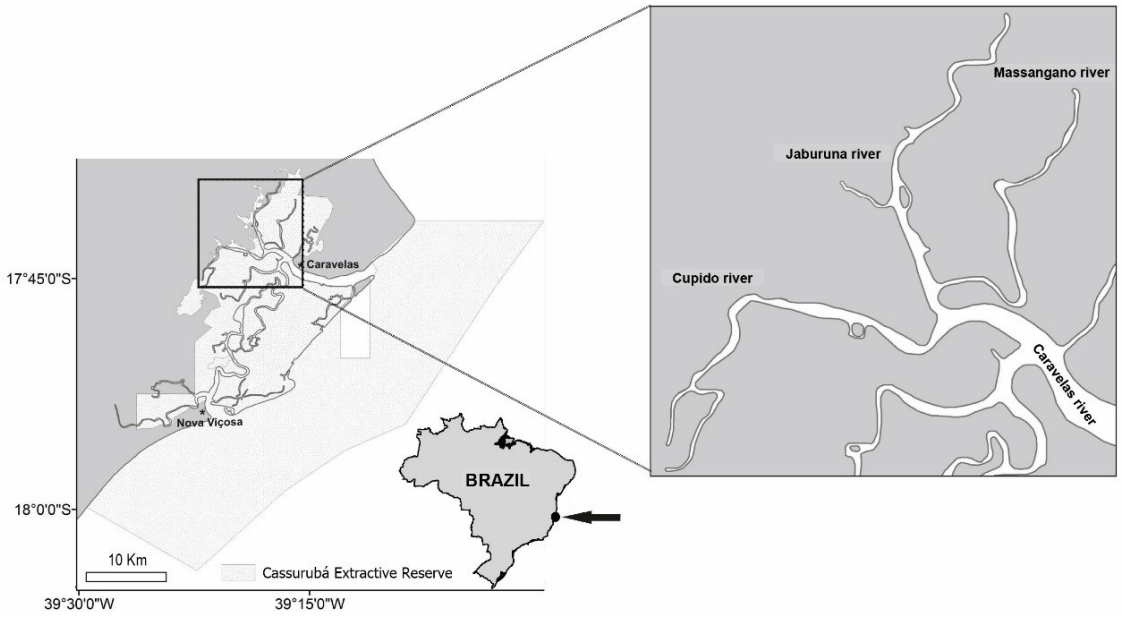

Figure 1. Studied area showing rivers where the data was collected.

After the collection, individuals from each species were immediately photographed and identified with the use of keys and descriptions provided by Cervigón et al. (1992), Carvalho-Filho (1999), and Nelson (2006).

2.2. Statistical analyses

Specimens were individually measured in Total Length (TL) to the nearest millimeter and weighted through Total Weight (TW) at a precision of 0.01g. All measurements were conducted immediately after the fishing in the field. The length-weight relationship ($TW = a\,TL^b$) was determined for all species that had sampled sizes ≥ 13 individuals. The data check for outliers was the determination of the coefficient lower than 0.95 (Barnett & Lewis, 1994). Parameters of the growth model $TW = aTL^b$ were estimated by least squares linear regression on *log*10 transformed data (Froese, 2006), where a is the intercept of the regression, and b is the allometric coefficient. The degree of association between variables was calculated by the determination coefficient (r^2) and confidence interval (95%) of a and b were calculated. The type of growth was determined through a Student t-test where H0: $b = 3$ (isometric growth) and H1: $b \neq 3$ (allometric growth) (Zar, 2010). Metric relationships of all species were plotted using the R software v. 4.1.2 (R Core Team, 2019).

3. Results

We analyzed 4433 fish specimens belonging to 17 species and nine families. Gerreidae and Centropomidae had higher numbers of individuals caught, representing 45% and 24% of the total catches. The number of individuals varied from 13 for green moray, *Gymnothorax funebris* Ranzani (1839) to 1559 for Caitipa mojarra, *Diapterus rhombeus* Cuvier (1829). From the total captures, 1.04% of specimens were listed at some endangered status according to the Brazilian Red List of Endangered Species (Table 1). Largest individuals were of *Gymnothorax funebris* (Ranzani, 1839), with maximum TL of 103.5 cm and smallest from *Diapterus rhombeus* (Cuvier, 1829*)* with minimum TL of 8.5 cm. The most captured endangered species was *Epinephelus itajara* Lichtenstein (1822), listed as critically endangered (CR), representing 0.6% of the catches. Coefficients of determination (r^2) ranged from 0.904 for the fat snook, *Centropomus parallelus* Poey (1860), to 0.987 for Cubera snapper, *Lutjanus cyanopterus* Cuvier (1828). The estimated value of parameter b ranged from 2.472 for *G. funebris* Ranzani (1839) to 3.164 for white mullet, *Mugil curema* Valenciennes (1836) (Table 1). The b parameter ranged from 2.46 for *G. funebris* to 3.16 for *M. Curema*. Concerning the type of growth, all species presented allometric growth (t-test, $P < 0.05$, $b \neq 3$).

Table 1. The length-weight relationship of fishes from Abrolhos Bank Estuary, Brazil. Status = conservation status of the species at national level (ICMBio, 2018; Brasil, 2022), LC = Least Concern, CR = Critically Endangered, VU = Vulnerable, NT = Near Threatened, and DD = Data Deficient. N = number of individuals sampled; TL = Total Length; W = Weight; a = intercept of the relationship; b = slope of the relationship; CI = confidence interval; r2 = coefficient of determination. A+ = positive allometric and A- = negative allometric.

Species	Status	N	TL range	W range (g)	*a*	95% CI of *a*	*b*	95% CI of *b*	r^2	Growth type
Caranx hippos	LC	33	21–40	28–537	0.038	0.014–0.095	2.67	2.39–2.95	0.925	A-
Caranx latus	LC	53	16.8-35	51–1015	0.010	0.003–0.028	3.08	2.76–3.40	0.878	A+
Selene vomer	DD	197	16–44.5	549–2725	0.033	0.023–0.046	2.68	2.58–2.79	0.925	A-
Centropomus parallelus	LC	54	21.5–58	105–1494	0.036	0.015–0.081	2.56	2.32–2.79	0.904	A-
Centropomus pectinatus	LC	847	17–63.7	35–2060	0.022	0.017–0.026	2.77	2.70–2.83	0.896	A-
Centropomus undecimalis	LC	157	26.5–84	161–4960	0.011	0.006–0.019	2.89	2.74–3.04	0.906	A-
Chaetodipterus faber	LC	346	15.5–37.5	113–1285	0.115	0.090–0.145	2.57	2.49–2.64	0.931	A-
Epinephelus itajara	LC	28	33–98.5	32–862	0.020	0.006–0.041	2.99	2.76–3.22	0.967	A-
Diapterus rhombeus	CR	1559	8.5–39.5	564–15510	0.028	0.023–0.032	2.77	2.72–2.82	0.887	A-
Eugerres brasilianus	LC	453	16.8–42.2	70–1060	0.020	0.016–0.025	2.87	2.80–2.93	0.941	A-
Lutjanus alexandrei **	VU	19	16.5–30.8	254–4370	0.019	0.008–0.043	2.92	2.65–3.19	0.972	A-
Lutjanus cyanopterus *	NT	18	26.2–69	66–490	0.012	0.006–0.022	3.03	2.86–3.19	0.987	A+
Lutjanus jocu	DD	286	17–32.6	527–2173	0.023	0.015–0.033	2.87	2.74–3.00	0.877	A-
Mugil curema	NT	14	42–63	106–1014	0.004	0.0008–0.019	3.16	2.75–3.57	0.951	A+
Mugil liza	DD	338	11–46.5	1200–2450	0.025	0.015–0.038	2.72	2.59–2.85	0.843	A-
Gymnothorax funebris	LC	13	78–103.3	65–416	0.027	0.0004–1.699	2.46	1.54–3.38	0.670	A-
Archosargus probatocephalus	LC	18	29–49	130–730	0.053	0.010–0.262	2.75	2.31–3.19	0.900	A-

*First LWR record described in Brazil. **First LWR record described in the literature.

Three species presented positive allometric growth ($b > 3$): *C. latus*, *L. cyanopterus* and *M. curema* while all others presented negative allometric growth ($b < 3$) (Table 1).

4. Discussion

Our result provides an adequate estimation of the LWR according to the guidelines for data collection and analysis of length-weight relationships described by Froese (2006). The calculated b values of the regression for all species are within the acceptable range of ~2.5–3.5 (Froese, 2006). Variations in length-weight relationship parameters may be related to multiple environmental, biological and fishing conditions such as habitat, season, sex, maturation, growth phase, temperature, salinity, food availability and fishing gear (Froese, 2006; Hossain et al., 2019). However, these characteristics were not considered in our study.

This study provide novel data on LWR for fishes in an estuary from the most biodiverse reef complex in south Atlantic, the Abrolhos Bank. We provided the first of length-weight relationship published for Brazil to the Cubera Snapper, *Lutjanus cyanopterus*, and Brazilian Snapper, *L. alexandrei*. Such species are commercially important and data from local stocks are basic to understanding specific characteristics and dynamics of the local fish populations. This local level data informing proper management initiatives such as fishing gear of mesh size restrictions using accurate biological attributes information. *Lutjanus cyanopterus* is listed as endangered (EN), being overexploited since the 2000s, with no sign of population recovery (Motta et al., 2022). For Brazilian Snapper *L. alexandrei* we also provide the first reference available in the literature for LWR. Such species was described in 2007 (Moura & Lindeman, 2007), and show few biological data available.

Fishes presented allometric growth, and most species had negative allometric growth which suggests that the weight of the fish increases at a slower rate compared to its length. However, it is important to acknowledge that our study did not account for potential variations in growth patterns between sexes and different life phases, highlighting the need for further investigation to understand these factors' influence on the length-weight relationship in fishes. For instance, for *Ocyurus chrysurus* in Mexican waters, while young male and female individuals presented negative allometry, adult females presented an isometric pattern (Renán et al., 2015). Such a pattern may be related to gonadal development since females need more energy for gonadal maturation while males have smaller gonads and invest less energy in somatic growth (Lester et al., 2004). In addition, we have a small sample size (less than 30 individuals) to six species which need more samples to inform accurately the biological attributes.

This study provides data on the length-weight relationship and growth mode for 17 species. The biological data presented in this study provided basic data on the biological aspects of commercially important fishes. This can be a useful insight for fisheries management such as fishing gear and mesh size restrictions, especially in Cassurubá estuary who fish stocks are declining.

Acknowledgements

We thank P. Beckenkamp (in memorian) and H. Teixeira for their help in the field and logistic support. This project benefited from grants from Conselho Nacional de Desenvolvimento Científico e Tecnológico (CNPq) grants to MOF. This is a contribution of the Meros do Brasil project (sponsored by Petrobras).

References

Barnett, V. & Lewis, T., 1994. Outliers in statistical data (3rd ed.). Chichester: John Wiley & Sons, 604 p.

Brasil, 8 jun. 2022. Portaria MMA n. 148, de 7 de junho de 2022. Diário Oficial da União [da] República Federativa do Brasil, Poder Executivo, Brasília, DF, Seção 1, pp. 74.

Carvalho-Filho, A., 1999. Peixes da costa brasileira. São Paulo: Melro, 320 p.

Cervigón, F., Cipriani, R., Fischer, W., Garibaldi, L., Hendrickx, M., Lemus, A.J., Marquez, R., Poutiers, J.M., Robaina, G. & Rodriguez, B., 1992. Guia de campo de las especies comerciales marinas y de aguas salobres de la costa septentrional de Sur America. Roma: Organización de las Naciones Unidas para la Alimentación y la Agricultura, 512 p.

Cordel, J., 2006. Brazil: dynamics and challenges of marine protected area development and coastal protection. In: The World Bank, org. Scaling up marine management: the role of marine protected areas. Washington: The World Bank, 58-75.

Fogliarini, C.O., Longo, G.O., Francini-Filho, R.B., Mcclenachan, L. & Bender, M.G., 2022. Sailing into the past: nautical charts reveal changes over 160 years in the largest reef complex in the South Atlantic Ocean. Perspect. Ecol. Conserv., 20(3), 231-239. http://dx.doi.org/10.1016/j.pecon.2022.05.003.

Froese, R., 2006. Cube law, condition factor and weight–length relationships: history, meta-analysis and recommendations. J. Appl. Ichthyology, 22(4), 241-253. http://dx.doi.org/10.1111/j.1439-0426.2006.00805.x.

Frota, L.O., Costa, P.A.S. & Braga, A.C., 2004. Length-weight relationships of marine fishes from the central Brazilian coast. NAGA, 27, 20-26.

Giglio, V.J. & Freitas, M.O., 2013. Caracterização da pesca artesanal com rede de camboa na Reserva Extrativista de Cassurubá, Bahia. Biotemas, 26(2), 249-259. http://dx.doi.org/10.5007/2175-7925.2013v26n2p249.

Hossain, M., Hossen, M., Rahman, M., Islam, M., Khatun, D., Nawer, F. & Ohtomi, J., 2019. Temporal variations of sex ratio and growth pattern of critically endangered catfish *Clupisoma garua* from the Ganges River of north-western Bangladesh. Indian J. Geo-Mar. Sci., 48(5), 647-653.

Instituto Chico Mendes de Conservação da Biodiversidade – ICMBio, 2018. Livro vermelho da fauna brasileira ameaçada de extinção. Brasília: ICMBio, 4162 p.

Joyeux, J.-C., Giarrizzo, T., Macieira, R.M., Spach, H.L. & Vaske Junior, T.J., 2009. Length-weight relationships for Brazilian estuarine fishes along a latitudinal gradient. J. Appl. Ichthyology, 25(3), 350-355. http://dx.doi.org/10.1111/j.1439-0426.2008.01062.x.

Leão, Z.M.A.N., Kikuchi, R.K.P. & Testa, V., 2003. Corals and coral reefs of Brazil. In: Cortes, J., ed. Latin America coral reefs. Oxford: Elsevier, 9-52. http://dx.doi.org/10.1016/B978-044451388-5/50003-5.

Lester, N.P., Shuter, D.J. & Abrams, P.A., 2004. Interpreting the von Bertalanffy model of somatic growth in fishes: the cost of reproduction. Proc. Biol. Sci., 271(1548), 1625-1631. PMid:15306310. http://dx.doi.org/10.1098/rspb.2004.2778.

Macieira, R.M., & Joyeux, J., 2009. Length-weight relationships for rockpool fishes in Brazil. J. Appl. Ichthyology 25(3), 358-359. http://dx.doi.org/10.1111/j.1439-0426.2008.01118.x.

Motta, F.S., Freitas, M.O., Rolim, F.A., Abilhoa, V. & Pereira Filho, G.H., 2022. Direct evidence of a spawning aggregation of cubera snapper (*Lutjanus cyanopterus*) in southeastern Brazil and its management implications. Fish. Res., 252, 106339. http://dx.doi.org/10.1016/j.fishres.2022.106339.

Moura, R.L. & Lindeman, K.C., 2007. A new species of snapper (Perciformes: Lutjanidae) from Brazil, with comments on the distribution of *Lutjanus griseus* and *L. apodus.* Zootaxa, 1422(1), 31-43. http://dx.doi.org/10.11646/zootaxa.1422.1.2.

Moura, R.L., Secchin, N.A., Amado-Filho, G.M., Francini-Filho, R.B., Freitas, M.O., Minte-Vera, C.V., Teixeira, J.B., Thompson, F.L., Dutra, G.F., Sumida, P.Y.G., Guth, A.Z., Lopes, R.M., & Bastos, A.C., 2013. Spatial patterns of benthic megahabitats and conservation planning in the Abrolhos Bank. Cont. Shelf Res. 70, 109-117. http://dx.doi.org/10.1016/j.csr.2013.04.036.

Nelson, J.S., 2006 Fishes of the world (4th ed.). Hoboken: John Wiley & Sons, 601 p.

Nobre, D.M. & Schiavetti, A., 2013. Acordos de pesca, governança e conselho deliberativo de reserva extrativista: caso da Resex de Cassurubá, Caravelas, Bahia, Brasil. Bol. Inst. Pesca, 39(4), 445-455.

R Core Team, 2019. A language and environment for statistical computing . Vienna: The R Project for Statistical Computing.

Renán, X., Trejo-Martínez, J., Caballero-Arango, D., & Brulé, T., 2015. Growth stanzas in an Epinephelidae-Lutjanidae complex: considerations to length-weight relationships. Rev. Biol. Trop. 63(1), 175-187. http://dx.doi.org/10.15517/rbt.v63i1.14948.

Ritcher, H.C., Luckstadt, C., Focken, U. & Becker, K., 2000. An improved procedure to assess fish condition on the basis of length-weight relationships. Arch. Fisch. Meeresforsch., 48, 255-264.

Zar, J.H., 2010. Biostatistical analysis. London: Prentice-Hall, 944 p.

Received: 23 May 2023
Accepted: 17 July 2023

Associate Editor: Ronaldo Angelini.