Received: 22 September 2017 | Accepted: 16 November 2017

DOI: 10.1111/jai.13585

TECHNICAL CONTRIBUTION

WILEY Journal of Applied Ichthyology DWK

Length-weight and length-length relationships of three tidepool fish species in the Amazon Coastal Zone of Brazil

C. M. C. Lobato[1,2] | B. E. Soares[3,4] | A. C. C. Santos[1] | T. O. Begot[1,2] | L. F. A. Montag[1]

[1]Laboratório de Ecologia e Conservação (LABECO), Universidade Federal do Pará (UFPA), Belém, Brazil

[2]Programa de Pós-Graduação em Zoologia (PPGZOOL), Universidade Federal do Pará (UFPA), Belém, Brazil

[3]Laboratório de Ecologia de Peixes (LABECO), Universidade Federal do Rio de Janeiro (UFRJ), Rio de Janeiro, Brazil

[4]Programa de Pós-Graduação em Ecologia (PPGE), Universidade Federal do Rio de Janeiro (UFRJ), Rio de Janeiro, Brazil

Correspondence
Cleonice Maria C. Lobato, Programa de Pós-Graduação em Zoologia (PPGZOOL), Laboratório de Ecologia e Conservação (LABECO), Universidade Federal do Pará (UFPA), Belém, Brazil.
Email: lobatocmc@gmail.com

Funding information
Coordenação de Aperfeiçoamento de Pessoal de Nível Superior; Fundação Amazônia Paraense de Amparo à Pesquisa; Conselho Nacional de Desenvolvimento Científico e Tecnológico; PROPESP/UFPA, Grant/Award Number: (#05/2009)

Summary

Length-weight relationships (LWR) and length-length relationships (LLR) were analyzed for three species inhabiting tidepools in the Amazon Coastal Zone, two of them non-native. Tidepools were sampled in five beaches along the Amazon Coastal Zone in 2011, and samplings were carried out using hand nets. The coefficients of allometry and proportionality were within the ranges estimated for fishes. All three species exhibited coefficients of allometry (b) higher than 3 in the LWR.

1 | INTRODUCTION

The Amazon Coastal Zone exhibit high diversity of habitats and is under constant pressure of tide regime. Tidepools are habitats linked with tide regime, and are characterized as depressions in the intertidal zone that retain water during the low tide (Fangue et al., 2001; Metaxas & Scheibling, 1993). Numerous fishes inhabit tidepools and are adapted to the environmental variation, as permanent resident fishes or juveniles of larger fish species that use tidepools as nursery areas (Begot, Soares, Juen, & Montag, 2017; Horn, Martin, & Chotkowski, 1999). In the Amazon Coastal Zone, these tidepools are inhabited by native species and also by two non-native species with broad geographical range in Brazil, which invasion processes are commonly linked to ballast water (Soares, Raiol, & Montag, 2011; Soares, Ruffeil, & Montag, 2012).

Length-weight relationship (LWR) and the length-length relationship (LLR) information are useful for the management of fishery stocks, environmental monitoring and assessment of population dynamics (Froese, 2006; Froese, Tsikliras, & Stergiou, 2011). Therefore, this study aims to contribute with technical information about the growth patterns of three tidepool fish species, including native and non-native species inhabiting the tidepools of the Amazon Coastal Zone.

2 | MATERIALS AND METHODS

Specimens were sampled during an ichthyofaunistic survey carried out in five rocky outcrops in the Amazon Coastal Zone (see Begot et al., 2017 for details) in 2011, comprising: Areuá Island (00°35′06.8″S; 47°50′45.0″W); Algodoal Beach (00°35′32.9″S; 47°35′27.6″W); Fortalezinha Beach (00°37′54.7″S; 47°32′11.1″W); Marieta Beach (00°36′04.7″S; 47°28′39.6″W); and Maçarico Beach (00°36′32.5″S; 47°21′27.4″W).

TABLE 1 Descriptive statistics and length–weight relationship (LWR) parameters for three tidepool fish species in the Amazon Coastal Zone

Order/Family/Species	*N*	SL range (cm)	W range (g)	*a* (95% CI)	*b* (95% CI)	R^2	*a* (Fishbase)	*b* (Fishbase)
Gobiesociformes								
Gobiesocidae								
Gobiesox barbatulus Starks, 1913	13	2.3–5.1	0.28–4.66	0.018 (0.013–0.024)	3.322 (3.082–3.562)	.987	0.002–0.013[B]	2.91–3.31[B]
Perciformes								
Blenniidae								
Omobranchus punctatus[E] (Valenciennes, 1836)	99	2.9–7.5	0.24–3.73	0.009 (0.007–0.012)	3.056 (2.897–3.216)	.937	0.003–0.012[B]	2.85–3.25[B]
Eleotridae								
Butis koilomatodon[E] (Bleeker, 1849)	33	1.4–5.1	0.05–3.18	0.014 (0.012–0.017)	3.26 (3.106–3.417)	.983	0.004–0.024[B]	2.34–3.26[B]

Codes: [B] (FishBase Bayesian analysis); [E] (Non-native species); *N* (sample size); SL (standard length); W (Weight); a (coefficient of proportionality); b (coefficient of allometry); R^2 (coefficient of determination).

TABLE 2 Descriptive statistics and length-length relationship (LLR) parameters for three tidepool fish species in the Amazon Coastal Zone

Order/Family/Species	*N*	TL range (cm)	SL range (cm)	*a* (95% CI)	*b* (95% CI)	R^2	*a* (Fishbase.se)	*b* (Fishbase.se)
Gobiesociformes								
Gobiesocidae								
Gobiesox barbatulus	13	2.8–6.4	2.3–5.1	0.033 (−0.218–0.284)	1.237 (1.170–1.305)	.99		
Perciformes								
Blenniidae								
Omobranchus punctatus[E]	99	3.3–8.3	2.9–7.5	0.052 (−0.099–0.202)	1.141 (1.110–1.172)	.98	−0.131	0.884–1.149
Eleotridae								
Butis koilomatodon[E]	33	1.7–6.4	1.4–5.1	−0.139 (−0.266–0.012)	1.257 (1.222–1.292)	1	0	0.830–1.205

Codes: [E] (Non-native Specie); *N* (sample size); TL (total length); SL (standard length); a (coefficient of proportionality); b (coefficient of allometry); R^2 (coefficient of determination).

Fishes were sampled in tidepools during the low tide in two expeditions during the year 2011, one in the rainy season (February to April) and another in the dry season (September to November). Samplings in the tidepools were carried out with hand nets with mesh size of 5 mm between knots. Specimens were fixed in formaldehyde 10% and posteriorly conserved in alcohol 70%, and then deposited in the ichthyological collection of the Museu Paraense Emílio Goeldi (MPEG), Brazil. At laboratory, all specimens of three species had their total length (TL), standard length (SL) measured with a caliper (precision = 0.1 cm) and their total weight (TW) recorded in grams (precision = 0.01 g).

Outliers were identified using a data dispersion plot and excluded from analysis. LWR and LLR were calculated applying linear equations of logarithmized data. Parameters and their confidence intervals (*a*—coefficient of proportionality; *b*—coefficient of allometry; R^2—coefficient of determination) were estimated in the R software (R Core Team, 2017).

3 | RESULTS

Three species from three different families and two orders were analyzed. Number of sampled individuals and parameters for the LWR and LLR are summarized in the Tables 1 and 2, respectively.

4 | DISCUSSION

Estimated parameters for LWR are within the ranges for most fish species (Froese, 2006). All the three species exhibited coefficients *b* higher

than 3. *Gobiesox barbatulus* presented *b* higher than it was predicted by the FishBase Bayesian analysis, while *B. koilomatodon* and *O. punctatus* showed coefficients *b* within the confidence interval of the FishBase Bayesian analysis (Froese & Pauly, 2017). These bayesian predictions of FishBase were calculated using subfamily LWR data and further information may be found in Froese, Thorson, and Reyes (2014).

Our LWR and LLR estimates were based on preserved specimens and the shrinkage effect that fixation procedures lead to was unaccounted for (Kristoffersen & Salvanes,1998). Thus, our estimates must be used with caution and future studies must address the shrinkage effect in LWR and LLR for these species in order to provide a correction factor.

ACKNOWLEDGEMENTS

This study was supported by the PROPESP/UFPA (#05/2009) financial scheme through the PADRC/CAPES/FAPESPA recent-doctor support program. BES, CMCL and TOB are recipients of CNPq, CAPES and FAPESPA fellowships, respectively.

ORCID

C. M. C. Lobato http://orcid.org/0000-0001-7306-2569

REFERENCES

Begot, T. O., Soares, B. E., Juen, L., & Montag, L. F. A. (2017). Rockpool ichthyofauna of Amazon coastal zone: Spatial and environmental effects on species distribution. *Marine and Freshwater Research*, *68*(6), 1137–1143. https://doi.org/10.1071/MF16275

Fangue, N. A., Flaherty, K. E., Runner, J. L., Cole, G., Hansen, K. S., Hinote, R., … Bennett, W. A. (2001). Temperature and hypoxia tolerance of selected fishes from a hyperthermal rockpool in the Dry Tortugas, with notes on diversity and behavior. *Caribbean Journal of Science*, *37*, 81–87.

Froese, R. (2006). Cube law, condition factor and weight-length relationships: History, meta-analysis and recommendations. *Journal of Applied Ichthyology*, *22*, 241–253. https://doi.org/10.1111/j.1439-0426.2006.00805.x

Froese, R., & Pauly, D. (Eds.). (2017). *FishBase*. World Wide Web electronic publication: Retrived from http://www.fishbase.org, version (10/2017).

Froese, R., Thorson, J. T., & Reyes, R. B. (2014). A Bayesian approach for estimating length-weight relationships in fishes. *Journal of Applied Ichthyology*, *30*, 78–85. https://doi.org/10.1111/jai.12299

Froese, R., Tsikliras, A. C., & Stergiou, K. I. (2011). Editorial note on weight–length relations of fishes. *Acta Ichthyologica et Piscatoria*, *41*(4), 261–263. https://doi.org/10.3750/AIP2011.41.4.01

Horn, M. H., Martin, K. L. M., & Chotkowski, M. A. (1999). *Intertidal fishes: Life in two worlds*, 1st ed. San Diego, CA: Academic Press.

Kristoffersen, J. B., & Salvanes, A. G. V. (1998). Effects of formaldehyde and ethanol preservation on body and otoliths of *Maurolicus muelleri* and *Benthosema glaciale*. *Sarsia*, *83*, 95–102. https://doi.org/10.1080/00364827.1998.10413675

Metaxas, A., & Scheibling, R. E. (1993). Community structure and organization o tidepools. *Marine Ecology Progress Series*, *98*, 187–198. https://doi.org/10.3354/meps098187

R Core Team (2017). *R: A language and environment for statistical computing*. Vienna, Austria: R Foundation for Statistical Computing.

Soares, B. E., Raiol, R. D. O., & Montag, L. F. A. (2011). Occurrence of the non-native blenny *Omobranchus punctatus* (Valenciennes, 1836) (Perciformes: Blenniidae) in the Amazon coastal zone, Brazil. *Aquatic Invasions*, *6*(Suppl. 1), 39–43. https://doi.org/10.3391/AI.2011.6.S1.009

Soares, B. E., Ruffeil, T. O. B., & Montag, L. F. A. (2012). Occurrence of the non-native sleeper *Butis koilomatodon* (Bleeker, 1849) (Perciformes: Eleotridae) in the Amazon coastal zone, Brazil. *BioInvasions Records*, *1*, 95–99. https://doi.org/10.3391/BIR.2012.1.2.02

How to cite this article: Lobato CMC, Soares BE, Santos ACC, Begot TO, Montag LFA. Length-weight and length-length relationships of three tidepool fish species in the Amazon Coastal Zone of Brazil. *J Appl Ichthyol*. 2017;00:1–3. https://doi.org/10.1111/jai.13585