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Squids caught by shrimp trawlers off the coast of Sergipe, northeastern Brazil

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ABSTRACT

The objective of this study was to identify the squids caught by shrimp trawlers in Sergipe and to describe their populational structure. Four samples were obtained monthly from commercial trawlers based in Pirambu-Sergipe (May/2015-May/2016). Each squid found was separated, identified, weighed individually (wet weight – WW in g) and had its mantle length (ML; cm) and total length (TL, including tentacles; cm) measured. One specimen of *Doryteuthis pleii* was captured (23.3 cm ML mature male), as well as 152 specimens of *Lolliguncula brevis* (1.5-6.7 cm ML). The linear relation between TL and ML of *L. brevis* was TL=5.1173+2.6190ML (positive allometry) and the power relation between WW and ML was $WW=0.1453ML^{2.5353}$ (negative allometry). For *L. brevis*, there were two cohorts in the area during the period analyzed. Studies on the biology of cephalopods are scarce in northeastern Brazil, especially considering that these species are present in the bycatch of shrimp fishing and that the global conservation status of *L. brevis* is data deficient (DD) according to the International Union for Conservation of Nature (IUCN).

Keywords: Bycatch, Cephalopoda, *Doryteuthis pleii*, *Lolliguncula brevis*

Shrimps are one of the main fishery resources caught in waters off the state of Sergipe and accounted for about 32.3% of the total catch in 2013 (Thomé-Souza et al., 2014). One of the main problems associated with shrimp trawlers is the impact of repetitive bottom trawling (Meenakumari et al., 2008) and the capture of a high number of juveniles of fish species of commercial interest, but also gastropods, sea stars, crabs, and cephalopods (Alverson et al., 1994; Keunecke et al., 2007; Silva Júnior et al., 2019).

Cephalopods are not economically exploited in the waters off Sergipe (Thomé-Souza et al., 2014). However, there are a few localities in northeastern Brazil where cephalopods, especially octopuses, are targeted by commercial fisheries (Haimovici et al., 2014; Lima et al., 2021). In the southeastern and southern regions of Brazil, cephalopods have a considerable fishing production when compared to the northeastern region. Previous efforts, such as the REVIZEE program (*Programa de Avaliação do Potencial Sustentável de Recursos Vivos na Zona Econômica Exclusiva do Brasil* - Program for the Assessment of the Sustainable Potential of Living Resources in the Brazilian Exclusive Economic

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Zone), have sought to understand the population dynamics and fishery production of squid species exploited in the region: *Doryteuthis pleii* (Blainville, 1823) and *Doryteuthis sanpaulensis* (Brakoniecki, 1984) (Gasalla et al., 2005; Perez et al., 2005).

The occurrence of squids had been already reported in Sergipe by Lima and Couto (2001) and Carneiro and Arguelho (2018), specifically: *Lolliguncula brevis* (Blainville, 1823), *Doryteuthis pleii* and *Doryteuthis* spp. Naef, 1912. Nevertheless, no information other than the occurrence was found. Thus, this study aimed at determining if any other squid species were caught by shrimp trawlers in Sergipe and to describe their population structure.

Four complete samples (target shrimps and bycatch), weighing about six kilograms each, were obtained monthly from four commercial shrimp trawlers based in Pirambu, on the northern coast of Sergipe, northeastern Brazil (11°S; 36°W). The samples were collected from May 2015 to May 2016 and preserved on ice onboard and when landed in the port. No samples were collected during the closed season for the shrimp fishery: from April 1st to May 15th and from December 1st to January 15th (MMA, 2004). The samples were then transported to the Laboratório de Ecologia Pesqueira at the Universidade Federal de Sergipe, where they were kept frozen until processing. Each squid found was separated, identified using Jereb and Roper (2010), weighed individually with an electronic scale (wet weight – WW in g; precision: 0.1 g) and had its mantle length (ML; cm) and total length (TL, including tentacles; cm) measured using an ichthyometer (precision: 0.1 cm).

A frequency distribution for the mantle length and the wet weight was calculated for the main species caught. Additionally, the relation between total and mantle length was estimated using a linear model ($TL = a + bML$) (Zar, 2010). A logarithmic form of the power model ($WW = aML^b$) was fitted to the relation between wet weight and mantle length. Confidence intervals were estimated for both parameters in both models and the isometry was tested ($b = 1$ for the length-length relation and $b = 3$ for the weight-length relation) using confidence intervals (Zar, 2010). The significance of each parameter was tested using a significance level of 5%. All analyses were performed in R software version 4.2.1 (R Core Team, 2023).

Two squid species were found in the bycatch of shrimp trawlers off Sergipe in 2015-2016: *Doryteuthis pleii* and *Lolliguncula brevis*. Only one specimen of *D. pleii* was captured: a male with 23.3 cm ML (137.7 g WW), caught in November 2015. Its size corresponded to 67% of the maximum size registered for this species (Vaske Júnior and Costa, 2011) and was larger than the size at first maturity (L_m) for males, which corresponds to 8.7 cm ML in southeastern-southern Brazil (Martins and Juanicó, 2018) and to 14.7 cm ML in southern Brazil (Martins and Perez, 2007).

Conversely, 152 specimens of *Lolliguncula brevis* were caught during the same period, with 1.5-6.7 cm ML (3.65 ± 1.12 cm; mean ± standard deviation) and 0.2-18.8 g WW (4.88 ± 4.28 g). Most specimens were smaller than the L_m of 5 cm ML for females and males, as estimated for São Paulo (southeastern Brazil, Vaske-Júnior et al., 2014) (Figure 1A). This species is not commercially exploited in Sergipe due to its small size. The distribution of WW was asymmetrical, with 63.2% of the specimens falling into the first two classes (< 4 g) (Figure 1B). This species reproduces at approximately the same size, regardless of where it occurs. Thus, its reproduction is more related to size than age. The difference among areas is related to the rate at which individuals reach this specific size, which is faster in warmer waters (Jackson et al., 1997).

The linear relation fitted between the total length (including tentacles) and mantle length of *L. brevis* was statistically significant and indicated a positive allometry (slope >1; Table 1). The relation between the wet weight and mantle length indicated a negative allometry of the growth in weight ($b < 3$; Table 1), as was also found in São Paulo (southeastern Brazil, Vaske Júnior et al., 2014) and Santa Catarina (southern Brazil, Martins and Perez, 2007).

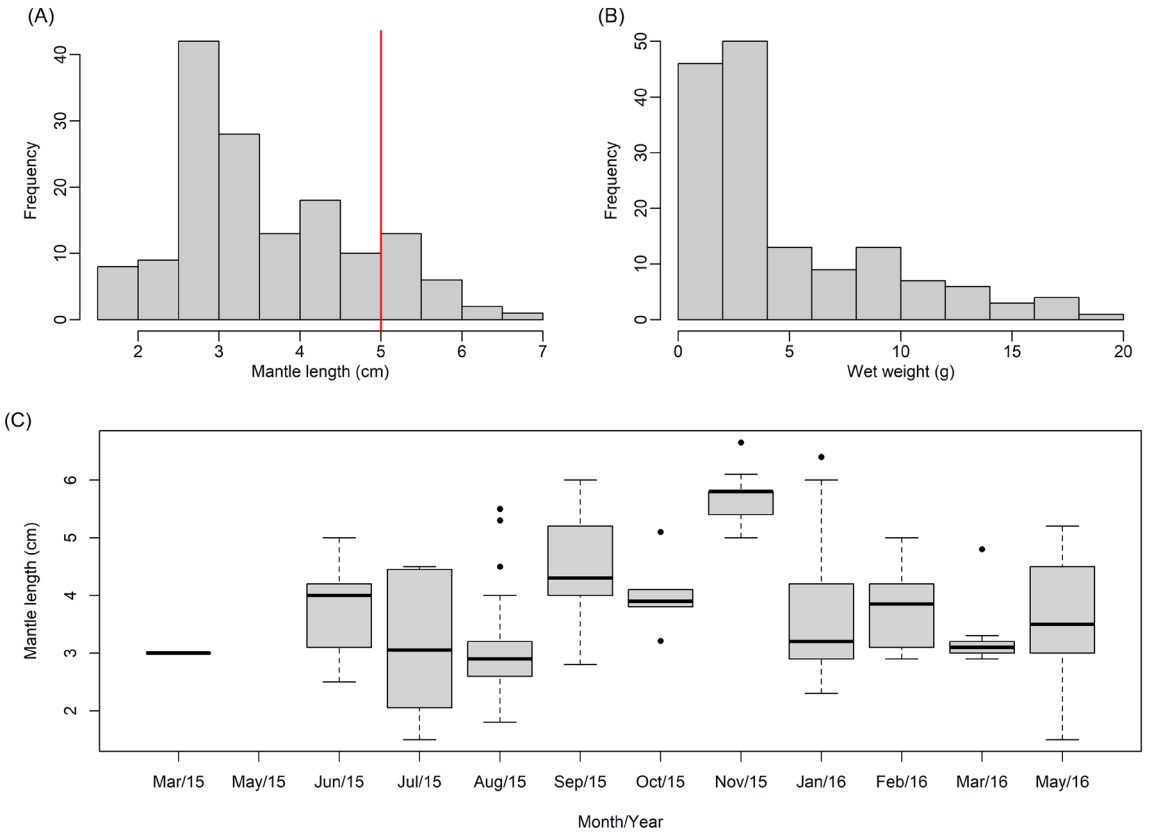

Figure 1. Histogram for the mantle length (A) and wet weight (B) of *Lolliguncula brevis* caught by shrimp trawlers along the coast of Sergipe in northeastern Brazil (2015-2016). The red line corresponds to the length at first maturity for females and males for the state of São Paulo (Vaske Júnior et al., 2014). (C) Boxplot indicating median, 1st and 3rd quartiles of the mantle length per month for *L. brevis* caught by shrimp trawlers along the coast of Sergipe (2015-2016). Black circles indicate outliers.

Table 1. Parameters estimated for the linear relation between the total length (cm) and mantle length (cm), and between the wet weight (g) and mantle length (cm) for *Lolliguncula brevis* caught by shrimp trawlers along the coast of Sergipe (2015-2016). TL = total length (including tentacles; cm); ML = mantle length (cm); WW = wet weight (g); SE = standard error; r^2 = coefficient of determination; n = sample size (which differs between relations, as total length could not be measured in all specimens); Lower and Upper represent the limits of the confidence interval for each parameter.

Relation between total length and mantle length: TL = a + b ML								
	Estimate	SE	t-value	p-value	r^2	n	Lower	Upper
a	5.1173	0.9325	5.488	< 0.001*	0.696	65	3.2538	6.9808
b	2.6190	0.2178	12.025	< 0.001*	0.696	65	2.1838	3.0542
Relation between wet weight and mantle length: $\log_{10}WW = \log_{10}a + b \log_{10}ML$								
$\log_{10}$ a	-0.8377	0.0512	16.360	< 0.001*	0.837	150	-0.9389	-0.7365
b	2.5353	0.0917	27.650	< 0.001*	0.837	150	2.3541	2.7165

* Indicates statistical significance ($\alpha = 0.05$).

There is discussion among scientists about differences between the populations of *L. brevis* inhabiting the northernmost areas of its distribution (e.g., the population in the Caribbean and the USA) and the southernmost areas (e.g., the population in Brazil) (Simone, 1997; Vaske Júnior et al., 2014). In fact, the northernmost specimens reach larger sizes (maximum of 8.3 to 12.0 cm ML, Haefner-Júnior, 1964; Jackson et al., 1997; Bartol et al., 2002) when compared to the specimens in Brazil (maximum of 5.0 to 7.6 cm ML, Berry, 1911; Simone, 1997; Martins and Perez, 2007; Coelho et al., 2010; Zaleski et al., 2012; Vaske Júnior et al., 2014). Other morphological characteristics also strengthen this hypothesis, such as the shape of the mantle and fins, and a few modified suckers, suggesting that these two populations could actually be two species (Simone, 1997; Zaleski et al., 2012).

The ML of *L. brevis* off Sergipe remained approximately stable from January to May and increased from September to November (Figure 1C). Both periods correspond to the dry season in Sergipe (Carneiro and Arguelho, 2018). According to Jackson et al. (1997), the life span of *L. brevis* is less than 200 days, which corresponds to approximately six months. Thus, Figure 1C may be showing the presence of two different cohorts in the waters of Sergipe, as also observed in Chesapeake Bay (USA) (Bartol et al., 2002). The highest number of *L. brevis* specimens was found in August 2015 (38 specimens), at the end of the rainy season, and in January 2016 (37 specimens), during the dry season in Sergipe. In all other months, the number was lower than 50% of that observed in January and August. Here again, there is an indication of the presence of two squid cohorts in the area.

The distribution of loliginid paralarvae was assessed at latitudes 22°-25°S in the Western Atlantic, where upwelling events and oceanographic conditions linked to water temperature and salinity control the distribution and abundance of squid species over time (Araujo and Gasalla, 2018). According to these authors, *L. brevis* paralarvae were more abundant in shallow, coastal and low salinity waters close to estuaries. This information may partly explain the large quantity of this species in bycatch samples in Sergipe, as shrimp trawling is concentrated on the muddy bottom, in 10-30 m deep waters (Pennino et al., 2016).

Cephalopods are known for their physiological limitations preventing them from occupying shallow, highly variable, and euryhaline habitats. However, *L. brevis* is one exception, inhabiting areas with salinity ranging from 17.9 to 35.0 (Bartol et al., 2002), but also being able to live in waters with salinity down to 8 (Vaske Júnior and Costa, 2011). According to Coelho et al. (2010), this species prefers to use the inner shelf and feed on crustaceans. However, the samples collected in Sergipe could not be georeferenced, sex was not identified, and their gut content was not analyzed, three issues that should be addressed in future studies with *L. brevis*, which are still scarce in northeastern Brazil. Finally, it would be important to assess the role of *L. brevis* in the region using ecosystem models. According to the International Union for Conservation of Nature (IUCN), the global status of this species is data deficient - DD (Allcock and Taite, 2019), which demonstrates the importance of making more data available on this species in different regions.

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AUTHOR CONTRIBUTIONS

K.M.F.F.: Conceptualization; Methodology; Software; Formal Analysis; Investigation; Writing – Original draft.

J.R.J.: Investigation; Methodology; Software; Formal Analysis; Writing – Review & editing.

R.A.S.: Investigation; Writing – Review & editing.

REFERENCES

Allcock, A. L. & Taite, M. 2019. *Lolliguncula brevis*. The IUCN Red List of Threatened Species 2019: e.T163081A970763. DOI: https://doi.org/10.2305/IUCN.UK.2019-2.RLTS.T163081A970763.en

Alverson, D. L., Freeberg, M. H., Murawski, S. A. & Pope, J. G. 1994. A global assessment of fisheries bycatch and discards. Rome, FAO Fisheries Technical Paper, No. 339

Araujo, C. C. & Gasalla, M. A. 2017. Distribution patterns of loliginid squid paralarvae in relation to the oceanographic features off the South Brazil Bight (22°-25°S). Fisheries Oceanography, 27, 63-75. DOI: https://doi.org/10.1111/fog.12238

Bartol, I. K., Mann, R. & Vecchione, M. 2002. Distribution of the euryhaline squid *Lolliguncula brevis* in Chesapeake Bay: effects of selected abiotic factors. Marine Ecology Progress Series, 226, 235–247. DOI: https://doi.org/10.3354/meps226235

Berry, S. S. 1911. A note on the genus *Lolliguncula*. Proceedings of the Academy of Natural Sciences of Philadelphia, 63(1), 100–105.

Carneiro, M. E. R. & Arguelho, M. L. P. M. 2018. Plataforma continental de Alagoas e Sergipe: geoquímica sedimentar e comunidade bêntica. São Cristóvão, Editora da UFS.

Coelho, L. I., Muto, E. Y., Marian, J. E. A. R. & Soares, L. S. H. 2010. Contribuição ao conhecimento da dieta, atividade alimentar e reprodução de *Lolliguncula brevis* (Blainville, 1823) na região costeira de Santos (estado de São Paulo). Boletim do Instituto de Pesca, 36, 225–236.

Gasalla, M. A., Perez, J. A. A., Marques, C. A, Tomás, A. R. G., Aguiar, D. C. & Oliveira, U. C. 2005. *Loligo sanpaulensis* (Brakoniecki, 1984). In: Cergole, M. C., Ávila-Da-Silva, A. O. & Rossi-Wongtschowski, C. (eds.) Análise das principais pescarias comerciais do sudeste-sul do Brasil: Dinâmica populacional das espécies em explotação (Série documentos REVIZEE: Score Sul). São Paulo: Instituto Oceanográfico da USP.

Haefner-Júnior, P. A. 1964. Morphometry of the common Atlantic squid, Loligo pealei, and the brief squid, *Lolliguncula brevis* in Delaware Bay. Chesapeake Science, 5(3), 138–144.

Haimovici, M., Leite, T. S., Marinho, R. A., Batista, B. B., Madrid, R. M., Lins-Oliveira, J. E., Lima, F. D. & Candice, L. 2014. As pescarias de polvos do nordeste do Brasil. In: Haimovici, M., Andriguetto-Filho, J. M. & Sunyé, P. S. (eds.) A pesca marinha e estuarina no Brasil: estudos de caso multidisciplinares. Rio Grande: Editora da FURG.

Jackson, G. D., Forsythe, J. W., Hixon, R. F. & Hanlon, R. T. 1997. Age, growth, and maturation of *Lolliguncula brevis* (Cephalopoda: Loliginidae) in the northwestern Gulf of Mexico with a comparison of length-frequency versus statolith age analysis. Canadian Journal of Fisheries and Aquatic Sciences, 54, 2907–2919. DOI: https://doi.org/10.1139/f97-192

Jereb, P. & Roper, C. F. E. 2010. Cephalopods of the world: An annotated and illustrated catalogue of cephalopod species known to date (vol. 2. Myopsid and Oegopsid Squids). Rome, FAO, Fisheries and Aquaculture Resources Use and Conservation Division.

Keunecke, K. A., Vianna, M., Fonseca, D. B. & D'incao, F. 2007. The pink-shrimp trawling bycatch in the northern coast of São Paulo, Brazil, with emphasis on crustaceans. Nauplius, 15, 49–55.

Lima, F. D., Andrade, L. C. A. & Medeiros, S. L. S. 2021. Cefalópodes No Nordeste Brasileiro. In: Viana, D. L., Lins-Oliveira, J. E., Hazin, F. H. V. & Souza, M. A. C. (eds.) Ciências do Mar: dos oceanos do mundo ao Nordeste do Brasil: Bioecologia, Pesca e Aquicultura. Recife, Via Design Publicações.

Lima, G. C. & Couto, E. C. G. 2001. Malacofauna da costa sergipana: classe Polyplacophora Blainwille, 1816; classe Scaphoda Bronn, 1862 e classe Cephalopoda Cuvier, 1798. Revista Nordestina de Biologia, 15(2), 91–98.

Martins, R. S. & Juanicó, M. 2018. Biology, distribution and geographic variation of loliginid squids (Mollusca: Cephalopoda) off southwestern Atlantic. Zoologia, 35, e23176. DOI: https://doi.org/10.3897/zoologia.35.e23176

Martins, R. S. & Perez, J. A. A. 2007. The ecology of loliginid squid in shallow waters around Santa Catarina Island, southern Brazil. Bulletin of Marine Science, 80(1), 125–145.

Meenakumari, B., Bhagirathan, U. & Pravin, P. 2008. Impact of bottom trawling on benthic communities: A review. Fishery Technology, 45(1), 1–22.

MMA (Ministério do Meio Ambiente). 2004. Instrução Normativa MMA N. 14, 14 de outubro de 2004. Brasília, DF, Ministério do Meio Ambiente. Available from: https://www.icmbio.gov.br/cepsul/images/stories/legislacao/Instrucao_normativa/2004/in_mma_14_2004_regulamentapescacamaroesregiao_ne.pdf. Accessed: 1 May 2023.

Pennino, M. G., Thomé-Souza, M. J. F., Carvalho, A. R., Fontes, L. C. S., Parente, C. & Lopes, P. F. M. 2016. A spatial multivariate approach to understand what controls species catch composition in small-scale fisheries. Fisheries Research, 175, 132–141. DOI: http://dx.doi.org/10.1016/j.fishres.2015.11.028

Perez, J. A. A., Gasalla, M. A., Aguiar, D. C., Oliveira, U. C., Marques, C. A. & Tomás, A. R. G. 2005. *Loligo plei* (Blainville, 1823). In: Cergole, M. C., Ávila-Da-Silva, A. O. & Rossi-Wongtschowski, C. (eds.) Análise das principais pescarias comerciais do sudeste-sul do Brasil: dinâmica populacional das espécies em explotação (Série documentos REVIZEE: Score Sul). São Paulo: Instituto Oceanográfico da USP.

R Core Team. 2023. R: A language and environment for statistical computing. Vienna – Austria, R Foundation for Statistical Computing. Available from: https://www.r-project.org/ Accessed: December 2023.

Silva Júnior, C. A. B., Lira, A. S., Eduardo, L. N., Viana, A. P., Lucena-Frédou, F. & Frédou, T. 2019. Ichthyofauna bycatch of the artisanal fishery of penaeid shrimps in Pernambuco, northeastern Brazil. Boletim do Instituto de Pesca, 45(1), e435. DOI: https://doi.org/10.20950/1678-2305.2019.45.1.435

Simone, L. R. L. 1997. Redescription of *Lolliguncula brevis* (Blainville) (Myopsida, Loliginidae) from southeastern Brazil. Iheringia, 82, 141–150.

Thomé-Souza, M. J. F., Carvalho, B. L. F., Garciov Filho, E. B., Silva, C. O., Deda, M. S., Félix, D. C. F. & Santos, J. C. 2014. Estatística pesqueira da costa do estado de Sergipe e extremo norte da Bahia 2013. São Cristóvão, Editora da UFS.

Vaske Júnior, T. & Costa, F. A. P. 2011. Lulas e polvos da costa brasileira (Coleção Habitat 5). Fortaleza, UFC/LABOMAR/NAVE.

Vaske Júnior, T., Knoeller, J. M. S. & Viliod, M. C. L. 2014. Ocorrência e aspectos da biologia da lula Atlântica *Lolliguncula brevis* no estuário de São Vicente-SP, Sudeste do Brasil. Unisanta BioScience, 3(2), 66–77.

Zaleski, T., Perez, J. A. A., Gandara-Martins, A. L. 2012. Morphological and morphometric variability of the squid *Lolliguncula brevis* (Mollusca: Cephalopoda) in Brazilian waters: evidence for two species in the Western Atlantic? Anais da Academia Brasileira de Ciências, 84(4), 1015–1028.

Zar, J. H. 2010. Biostatistical analysis (5th ed.). New Jersey, Pearson Prentice Hall.