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Further record of the Deep-Sea Euphausiid, *Thysanopoda Cristata* G. O. Sars, 1883 (Euphausiacea, Euphausiidae) from the Southwestern Atlantic: with comments on morphological variations

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ABSTRACT

Euphausiids are a diverse order of crustaceans that play a key role in pelagic food webs. The genus *Thysanopoda* H. Milne Edwards, 1830 is composed of 14 valid species, widely distributed in all oceans. However, some gaps remain in our knowledge of the geographic distribution of *Thysanopoda cristata* G. O. Sars, 1883, and its actual occurrence in Brazil. This study aims to expand the knowledge on krill diversity in Brazilian waters, confirming the occurrence of *T. cristata* and providing illustrations of its morphological variations. Four specimens, two males and two females, were collected on board R/V “Antea” in October 2015, using a micronekton net with 1 mm mesh size, at depths ranging between 10 and 1660 m. Before this study, reports of *T. cristata* from Brazil were provided only in species lists or unpublished data. Our study confirms the presence of the species from the southwestern Atlantic and brings new information on its morphology.

Key words. — Krill, Brazil, zooplankton, pelagic habitat, Abraços Project

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RESUMO

Eufausiáceos constituem uma diversificada ordem de crustáceos que desempenham um papel fundamental nas teias alimentares pelágicas. O gênero *Thysanopoda* H. Milne Edwards, 1830 é composto de 14 espécies válidas, amplamente distribuídas em todos os oceanos. Contudo, algumas lacunas permanecem em nosso conhecimento da distribuição geográfica de *Thysanopoda cristata* G. O. Sars, 1883, e sua atual ocorrência no Brasil. Este estudo tem como objetivo expandir o conhecimento da diversidade de krill em águas brasileiras, confirmando a ocorrência de *T. cristata* e fornecendo ilustrações de suas variações morfológicas. Quatro espécimes, dois machos e duas fêmeas foram coletados a bordo do R/V “Antea” em Outubro de 2015, usando uma rede de micronécton com 1 mm de malha, entre 10 e 1660 m de profundidade. Antes deste estudo, registros de *T. cristata* para o Brasil foram fornecidos apenas em listas de espécies ou em dados não publicados. Nosso estudo confirma a presença da espécie para o Sudoeste do Atlântico e traz novas informações sobre a morfologia da espécie.

Palavras-chave. — Krill, Brasil, zooplâncton, habitat pelágico, projeto Abraços

INTRODUCTION

Zooplanktonic organisms are widely studied worldwide to assess their biodiversity, biology and role in the pelagic energy transport, food webs, carbon and nitrogen flow and indications of environmental conditions (Bonecker et al., 2014). Among these organisms, holoplanktonic crustaceans of the order Euphausiacea Dana, 1852, composed by organisms, commonly known as krill (Ramirez, 1971, 1973, 1977; Montú, 1977), play an important role in the dynamics of pelagic communities, participating in both top-down and bottom-up controls (Rissik et al., 1997; Verity et al., 2002; Champalbert et al., 2005).

Krill is indeed the main prey for a large number of cephalopods, fishes, seabirds, sea lions and whales, due to its great abundance and rich source of energy and nutrients (Mauchline & Fisher, 1969; Gibbons et al., 1999; Letessier et al., 2009; Vereshchaka et al., 2018). Krill is also used in the production of feed for the aquaculture industry, the production of pharmaceuticals, and has been used as human food in some regions of Antarctica, Russia and Japan, due to the high concentration of fatty acids, lipids, vitamin A, Omega-3 and fluorine (Gibbons et al., 1999; Atkinson et al., 2008). For several regions of the world, e.g., subtropical, subpolar and polar regions, krill can be a potential indicator of water masses, associated with their occurrence and migration only in specific masses (Montú & Cordeiro, 1986; Atkinson et al., 2008; Sutton & Beckley, 2017).

To date, the order Euphausiacea is composed of two families: (i) Benteuphausiidae Colosi, 1917, which is monospecific, comprising only the genus *Benteuphausia* G. O. Sars, 1885, represented by *B. amblyops* G. O. Sars, 1885; and (ii) the family Euphausiidae Dana, 1852, comprising 11 genera and 86 valid species (WoRMS, 2022), which is widely distributed in all oceans including

high latitudes, occurring in pelagic habitats from the surface to the deep ocean (>5000 m) (Boden et al., 1955; Antezana & Brinton, 1981; Gibbons et al., 1999; Vereshchaka et al., 2018).

Around 60 species of krill are reported in the South Atlantic, from neritic to oceanic zones, including islands, archipelagos and atolls (Montú, 1977; Muxagata et al., 2019). In Brazilian waters, 22 species are currently recorded, distributed among *Euphausia* Dana, 1850 (6 species), *Nematobranchion* Calman, 1905 (3 species), *Nematoscelis* G. O. Sars, 1883 (4 species), *Stylocheiron* G. O. Sars, 1883 (4 species) and *Thysanopoda* (5 species) (Ramirez, 1971; Antezana & Brinton, 1981; Montú & Cordeiro, 1986; Gibbons et al., 1999; Lansac-Tôha & Freire, 1999). Large parts of these records are concentrated in only a few regions of Brazil, such as: the Saint Peter and Saint Paul as well as the Fernando de Noronha archipelagos and in the states of Espírito Santo, Rio de Janeiro (Campos Basin), São Paulo, Paraná and Rio Grande do Sul (Ramirez, 1971; Gibbons et al., 1999).

Regarding Euphausiidae, the genus *Thysanopoda* H. Milne Edwards, 1830 is composed of 14 valid species with a broad distribution in all oceans (including Arctic and Antarctic regions), especially in meso- and bathypelagic zones (~200 to 4000 m) (Brinton, 1962; Baker et al., 1990; Gibbons et al., 1999). According to Lansac-Tôha & Freire (1999) and Muxagata et al. (2019), only five species of *Thysanopoda* have been recorded in the South Atlantic (*T. aequalis* Hansen, 1905; *T. monacantha* Ortmann, 1893; *T. obtusifrons* G. O. Sars, 1883; *T. orientalis* Hansen, 1910; and *T. tricuspidata* H. Milne Edwards, 1837). However, reports of *T. cristata* G. O. Sars, 1883 from the South Atlantic can only be found as elements in species lists in grey literature, and in Silva et al. (2019). In view of that surprisingly basic condition, this study aims to improve knowledge on krill diversity in Brazilian waters with the confirmation of *T. cristata* collected during the Acoustic Along the Brazilian Coast 1 (Abraços 1) survey in 2015, providing illustrations, morphological variations and deposited material.

MATERIAL AND METHODS

The specimens of *Thysanopoda cristata* were collected in October 2015 during the Abraços 1 survey, covering Northeastern Brazil between the states of Alagoas and Rio Grande do Norte and encompassing the Fernando de Noronha Archipelago, Rocas Atoll and the Fernando de Noronha Chain (Bertrand, 2015). Sampling was performed in the water column, using a micronekton trawl net with a 1 mm mesh at depths ranging between 10 and 1170 m.

After sampling, specimens were sorted out. In the laboratory, all individuals were measured with a digital calliper (0.01 mm) for total length (TL) and carapace

width (CW), and were next preserved in formalin 4% and thereafter identified to species level according to Boden et al. (1955) and Lozano Soldevilla & Lozano Soldevilla (1991). The appendages were dissected and mounted on semi-permanent excavated glass slides with glycerin and observed under an optical microscope Leica DM E and a stereomicroscope Nikon SMZ 800, both with camera lucida, for illustration. The drawings were digitized with CorelDRAW® Graphics Suite 2018. All specimens examined were deposited in the Museum of Oceanography Prof. Petrônio Alves Coelho of the Federal University of Pernambuco, Recife, Brazil (MOUFPE).

RESULTS AND DISCUSSION

Specimens collected

Four specimens of *Thysanopoda cristata*, 2 females and 2 males, were collected from Rocas Atoll, “Abraços 1” Station 22/ Leg. 1, initial trawl coordinates: 4°07'S 33°47'W, final trawl coordinates: 4°07'S 33°48'W, 8 October 2015, at a depth of 525 m, MOUFPE 20050.

Descriptive notes

The specimens' size (TL) ranged from 51.5 to 67.8 mm, while the carapace width (CW) ranged between 15 and 21 mm. *T. cristata* is characterized by a rostrum with an acute main spine and a shorter one above it (fig. 1A); carapace with a longitudinal groove above the inferior margin and a posterolateral denticle on the inferior margin (fig. 1A); first segment of the peduncle of first antenna bearing a hood-like lappet with dorsal setae, second segment dorsally produced as an acute spine (fig. 1B, C); fourth and fifth abdominal somites with a dorsal spine (fig. 1D, E); sixth abdominal somite slightly longer than fifth (fig. 1F); petasma with spinous process almost straight to curved, terminal process curved, proximal process longer than terminal and tapering distally, lateral process long and very curved distally, additional process short and somewhat rounded (fig. 1G); uropod extending beyond distal end of telson, protopod bearing short lateral plumose setae, with a produced dorsal spine, exopod with plumose setae, smooth on the lateral margin and slightly serrate on medial margin, bearing a distolateral projection forming an acute spine, endopod shorter than exopod, with plumose setae, margins slightly crenulate (fig. 1H); telson with up to 10 pairs of stout dorsal setae (fig. 1I). Thoracopods 1-8 with regular shape and structurally similar, bearing plumose, pectinate and/or serrate setae on the endopods and densely plumose setae on exopods (fig. 2A-H); seventh thoracopod (fig. 2G) like the sixth thoracopod (fig. 2F); eighth thoracopod (fig. 2G) with rudimentary endopod.

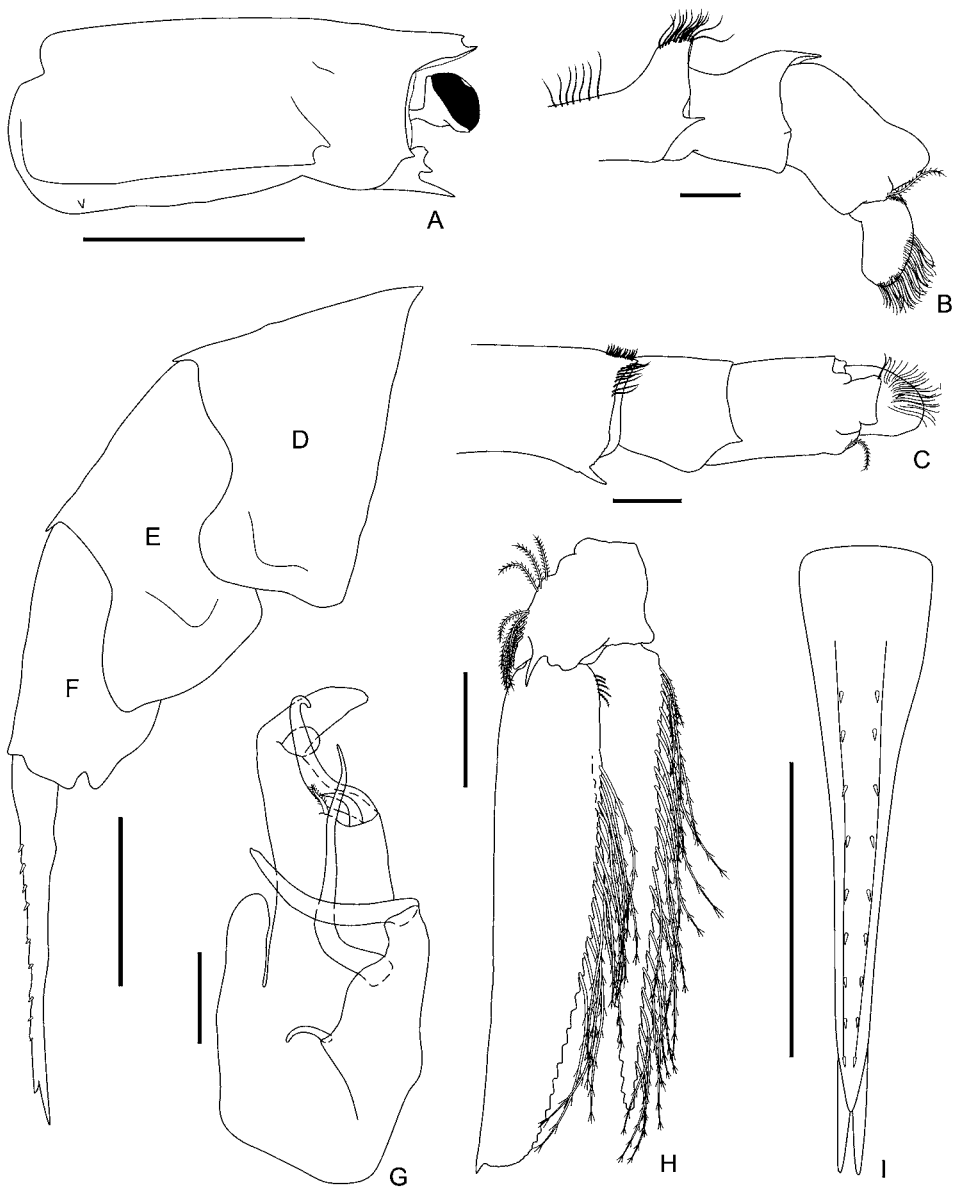


Fig. 1. *Thysanopoda cristata* G. O. Sars, 1883, (MOUFPE 20050). Female, 67.8 mm in length: A, carapace; D, fourth abdominal somite; E, fifth abdominal somite; F, sixth abdominal somite; H, uropod; I, telson. Male, 52.1 mm in length: B, first antennal peduncle in lateral view; C, first antennal peduncle in dorsal view; G, petasma. Scale bars = 10 mm for A; 1 mm for B-C; 5 mm for D-F and I; 0.5 mm for G; 2 mm for H.



Fig. 2. *Thysanopoda cristata* G. O. Sars, 1883, (MOUFPE 20050). Female, 67.8 mm in length: A-H, thoracopods 1-8, respectively. Scale bars = 0.05 mm.

Remarks and general discussion

The individuals of *T. cristata* analysed herein present some morphological differences from others described in the literature, such as: inferior margin of carapace with a denticle (vs. carapace without inferior denticle in G. O. Sars’

(1883) original description). Boden et al. (1955) and Lozano Soldevilla & Lozano Soldevilla (1991) provided an identification key in which the denticle is present, leading us to suppose that this character was overlooked by Sars (1883) as it can be often shortened. Additionally, the denticle does not exceed the carapace inferior margin, while it does in the illustration by Boden et al. (1955). The rostrum in our individuals has the main spine slightly longer than the shorter one and is weakly curved upwards, whereas it seems to be longer and deflexed in the description by Sars (1883), and straight in that of Boden et al. (1955). The sixth abdominal somite of our individuals presents a strong notch near the posterodistal corner, not observed, nor reported, in other literature. In our specimens, it is also possible to see the telson with up to 10 pairs of stout dorsal setae (vs. 6 pairs and 7 pairs described, respectively, in the works of Sars, 1883, and Boden et al., 1955).

Thysanopoda cristata was described by Sars (1883) based only on one adult male from off Mindanao in the Philippines (Pacific Ocean) (Station 213 at 3750 m), but it is known to be widely distributed in the Indo-Pacific (between 30°N and 40°S), South Africa (Natal coast), Baja California in Mexico, and in the Polar Arctic and Antarctic oceans (Boden, 1955; Brinton, 1962; Grindley & Penrith, 1965; Taniguchi, 1974; Youngbluth, 1975). For the Atlantic Ocean, this species was reported only in the Sargasso Sea, Azores and possible observations in the tropical western Atlantic (covering the North and South Atlantic) (Gibbons et al., 1999; Lansac-Tôha & Freire, 1999; Muxagata et al., 2019). However, several of these records were provided in unpublished reports (dissertations and theses) containing only species lists, without taxonomic descriptions, and specimens not deposited in a zoological collection, nor included an estimate of a possible region of occurrence for the *T. cristata* found. Based on those data, some geographic information included in the literature may contain dubious records from some marine areas around the world.

According to Vereshchaka et al. (2018), *T. cristata* is reported from mesopelagic zones, performing nictemeral migration between the depths of 800 and 2000 m, in addition, the occurrence of this species in shallow waters can be associated with upwelling regions, especially around oceanic islands. In this context, many species of krill are used as indicators of fish stocks, due to their direct predation by commercial fish (Champalbert et al., 2005). For example, in oceanic waters near the Saint Peter and Saint Paul Archipelago, the distribution of *T. cristata* displays seasonal movements that are indicative of the presence of *Thunnus albacares* (Bonnaterre, 1788) and *T. obesus* (Lowe, 1839) (Silva et al., 2019).

In Brazil, knowledge on krill diversity is still far from complete, with the main papers published between 1971 and 1999 (Ramirez, 1971, 1973, 1977; Antezana & Brinton, 1981; Montú & Cordeiro, 1986; Gibbons et al., 1999; Lansac-Tôha & Freire, 1999). However, new surveys along the Brazilian oceanic waters are

providing new materials for new records of known species. Thus, the new record of *T. cristata* increases the knowledge on krill diversity in the southwestern Atlantic, thereby providing an insight that the species might be widespread in the region.

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REFERENCES

- ANTEZANA, T. & E. BRINTON, 1981. Euphausiacea. In: D. BOLTOVSKOY (ed.), Atlas del zooplankton del Atlántico sudoccidental y métodos de trabajo con zooplankton marino: 681-698. (Publicación INIDEP, Ministerio de Comercio e Intereses Marítimos, Mar del Plata, Argentina).
- ATKINSON, A., V. SIEGEL, E. A. PAKHOMOV, P. ROTHERY, P. LOEB, R. M. ROSS, L. B. QUETIN, K. SCHMIDT, P. FRETWELL, E. J. MURPHY, G. A. TARLING & A. H. FLEMING, 2008. Oceanic circumpolar habitats of Antarctic krill. *Marine Ecology Progress Series*, **362**: 1-23.
- BAKER, A. C., P. BODEN & E. BRINTON, 1990. A practical guide to euphausiids of the world: 1-96. (Natural History Museum, London, United Kingdom).
- BERTRAND, A., 2015. ABRACOS cruise, R.V. Antea. Available from: <http://doi.org/10.17600/15005600>.
- BODEN, B. P., 1955. Euphausiacea of the Benguela Current. First Survey, R.R.S. “William Scoresby”, March 1950. *Discovery Reports*, **82**: 337-376.
- BODEN, B. P., M. W. JOHNSON & E. BRINTON, 1955. The Euphausiacea (Crustacea) of the North Pacific. *Bulletin of the Scripps Institution of Oceanography of the University of California*, **6**: 287-400.
- BONECKER, S. L. C., A. V. ARAUJO, P. F. CARVALHO, C. O. DIAS, L. F. L. FERNANDES, A. E. MIGOTTO & O. M. P. OLIVEIRA, 2014. Horizontal and vertical distribution of mesozooplankton species richness and composition down to 2,300 m in the southwest Atlantic Ocean. *Zoologia*, **31**(5): 445-462.
- BONNATERRE, J. P., 1788. *Tableau encyclopédique et méthodique des trois règnes de la nature. Ichthyologie*. *Ichthyologie*, **56**: 1-215. (Panckoucke, Paris).
- BRINTON, E., 1962. The distribution of Pacific euphausiids. *Bulletin of the Scripps Institution of Oceanography of the University of California*, **8**: 51-269.
- CALMAN, W. T., 1905. Note on a genus of euphausiid crustacean. *Fisheries Ireland, Scientific Investigation*, **1902**(03): 153-155.

- CHAMPALBERT, G., M. PAGANO, B. KOUAMÉ & V. RIANDEY, 2005. Zooplankton spatial and temporal distribution in a tropical oceanic area off West Africa. *Hydrobiologia*, **548**(1): 251-265.
- COLOSI, G., 1917. Crostacei. Part II, Eufausiacei. Raccolte Planctoniche fatte dalla R. Nave 'Liguria', **2**(7): 165-205.
- DANA, J. D., 1850. Synopsis generum Crustaceorum ordinis "Schizopoda". *American Journal of Science*, **9**: 129-133.
- DANA, J. D., 1852. Conspectus of the Crustacea of the exploring expedition under Capt. Wilkers. *Silliman Journal*, **13**(1): 1-685.
- GIBBONS, M. J., V. A. SPIRIDONOV & G. A. TARLING, 1999. Euphausiacea. In: D. BOLTOVSKOY (ed.), *South Atlantic zooplankton: 1241-1279*. (Backhuys Publishers, Leiden, The Netherlands).
- GRINDLEY, J. R. & M. J. PENRITH, 1965. Notes on the bathypelagic fauna of the seas around South Africa. *Zoologica Africana*, **1**(2): 275-295.
- HANSEN, H. J., 1905. Further notes on the Schizopoda. *Bulletin de l'Institut océanographique de Monaco*, **42**: 1-32.
- HANSEN, H. J., 1910. The Schizopoda of the Siboga expedition. *Siboga Expedition Monographs*, **37**: 1-123.
- JAQUEMET, S., M. POTIER & F. MÉNARD, 2011. Do drifting and anchored Fish Aggregating Devices (FADs) similarly influences tuna feeding habits? A case study from the western Indian Ocean. *Fisheries Research*, **107**: 283-290.
- LANSAC-TOHA, F. A. & A. S. FREIRE, 1999. Euphausiacea. In: L. BUCKUP & G. BOND-BUCKUP (eds.), *Os Crustáceos do Rio Grande do Sul (1st ed.)*: 257-274. (Universidade Federal do Rio Grande do Sul, Porto Alegre, RS).
- LETESSIER, T. B., M. J. COX & A. S. BRIERLEY, 2009. Drivers of euphausiid species abundance and numerical abundance in the Atlantic Ocean. *Marine Biology*, **156**(12): 2539-2553.
- LOWE, R. T., 1839. A supplement to a synopsis of the fishes of Madeira. *Proceedings of the Zoological Society of London*, **7**: 76-92.
- LOZANO SOLDEVILLA, F. & I. LOZANO SOLDEVILLA, 1991. A record of the euphausiid *Thysanopoda monacantha* Ortmann, 1893 from the coast of Tenerife (Canary Islands). *Bocagiana*, **153**: 1-7.
- MAUCLINE, J. & L. R. FISCHER, 1969. The biology of euphausiids. *Advances in Marine Biology*, **7**: 1-454.
- MILNE EDWARDS, H., 1830. Mémoire sur une disposition particulière de l'appareil branchial chez quelques Crustacés. *Annales des Sciences Naturelles*, **19**: 451-460.
- MILNE EDWARDS, H., 1837. Histoire naturelle des Crustacés, comprenant l'anatomie, la physiologie et la classification de ces animaux, **2**: 1-534. (Librairie Encyclopédique de Roret, Paris). DOI:10.5962/bhl.title.16170.
- MONTÚ, M., 1977. Eufausidos de la plataforma Argentina y adyacencias I. Distribucion estacional en el sector Patagonico. *Ecosur*, **4**(8): 187-225.
- MONTÚ, M. & T. A. CORDEIRO, 1986. Estudo do zooplâncton coletado durante a primeira expedição brasileira à Antártica pelo NApOc "Barão de Teffé". *Nerítica*, **1**: 85-133.
- MUXAGATA, E., C. N. BARBOSA & V. O. AGOSTINI, 2019. Euphausiacea diversity in a trans-oceanic transect through the South Atlantic Ocean: the first Atlantic record of *Thysanopoda astylata* Brinton, 1975. *Anais da Academia Brasileira de Ciências*, **91**(1): 1-12.
- ORTMANN, A. E., 1893. Decapoden und Schizopoden. *Ergebnisse der Plankton Expedition der Humboldt-Stiftung*, **2**: 1-120.
- RAMIREZ, F. C., 1971. Eufáusidos de algunos sectores del Atlántico sudoccidental. *Physis*, (A, Los Oceanos y sus Organismos) **30**: 105-114.
- RAMIREZ, F. C., 1973. Eufáusidos de la Campaña Oceanográfica "Walter Herwig" 1966. *Physis*, (A) **32**(84): 105-114.

- RAMIREZ, F. C., 1977. Planktonic indicators or Argentine shelf and adjacent areas. Proc. Symp. Warm Water Zooplankton. National Institute of Oceanography, **3**: 65-68.
- RISSIK, D., I. M. SUTHERS & C. T. TAGGART, 1977. Enhanced zooplankton abundance in the lee of an isolated reef in the south Coral Sea: the role of flow disturbance. Journal of Plankton Research, **19**: 1347-1368.
- SARS, G. O., 1883. Preliminary notices on the Schizopoda of H.M.S. Challenger Expedition. Forhandl. Vidensk. Selsk. Christiania, **7**: 1-43.
- SARS, G. O., 1885. Report on the Schizopoda collected by H.M.S. Challenger during the years 1873-1876. Report on the Scientific Results of the Voyage of H.M.S. Challenger during the years 1873-76, (Zoology) **13**(37): 1-228.
- SILVA, G. B., H. G. HAZIN, F. H. V. HAZIN & T. VASKE-JÚNIOR, 2019. Diet composition of bigeye tuna (*Thunnus obesus*) and yellowfin tuna (*Thunnus albacares*) caught on aggregated schools in the western equatorial Atlantic Ocean. Journal of Applied Ichthyology, **35**(5): 1111-1118.
- SUTTON, A. L. & L. E. BECKLEY, 2017. Species richness, taxonomic distinctness and environmental influences on euphausiid zoogeography in the Indian Ocean. Diversity, **9**(2): 23.
- TANIGUCHI, A., 1974. Mysids and euphausiids in the eastern Indian Ocean with particular reference to invasion of species from the Banda Sea. Journal of the Marine Biological Association of India, **16**(2): 349-357.
- VERESHCHAKA, A. L., D. N. KULAGIN & A. A. LUNINA, 2018. A phylogenetic study of krill (Crustacea: Euphausiacea) reveals new taxa and co-evolution of morphological characters. Cladistics, **35**(2): 150-172.
- VERITY, P. G., V. SMETACEK & J. J. SMAYDA, 2002. Status, trends and the future of the marine pelagic ecosystem. Environmental Conservation, **29**: 207-237.
- WORMS [WORLD REGISTER OF MARINE SPECIES], 2022. *Thysanopoda* Milne Edwards, 1830. Accessed through: World Register of Marine Species at: <https://www.marinespecies.org/aphia.php?p=taxdetails&id=110680> (accessed 5 January 2022).
- YOUNGBLUTH, M. J., 1975. The vertical distribution and diel migration of euphausiids in the central waters of the eastern South Pacific. Deep-Sea Reserch, **22**: 519-536.