



Successful establishment of the non-native copepod *Temora turbinata* in Uruguayan coastal zooplankton communities

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Abstract: The exotic copepod *Temora turbinata* is reported for the first time as an established species in marine coastal waters of Uruguay. The species was frequently found at high abundance and dominance within the copepod community during routine surveys in Cabo Polonio (2017–2019) and La Paloma – Cabo Santa María (2021–2023). These findings confirm the ongoing southward expansion of its geographical distribution and its successful establishment as a core species in Uruguayan marine coastal assemblages.

Keywords: Copepods, Exotic species, Southwestern Atlantic.

Establecimiento exitoso del copépodo no nativo *Temora turbinata* en las comunidades de zooplankton costero uruguayo. Resumen: Este trabajo reporta por primera vez al copépodo exótico *Temora turbinata* como especie establecida en aguas marinas costeras de Uruguay. La especie fue encontrada frecuentemente en altas abundancias y dominancia dentro de la comunidad de copépodos durante los muestreos de rutina realizados en Cabo Polonio (2017–2019) y La Paloma – Cabo Santa María (2021–2023). Estos hallazgos confirman la continuidad de la expansión de su distribución geográfica hacia el sur, y su establecimiento exitoso como especie central en las comunidades marinas costeras uruguayas.

Palabras clave: Copépodos, Especie exótica, Atlántico Sudoccidental.

Temora turbinata is a small calanoid copepod with wide distribution in neritic subtropical and warm-temperate regions. It was originally described in samples from the Sulu Sea ~8°N 120°E, Philippines, Southeast Asia (Dana 1849-1853). According to the World Register of Marine Species (WoRMS, 2025) *T. turbinata* is widely found in the Western Pacific from Japan (~40°N) and southwards along shallow seas and coastal waters of China, Vietnam, Cambodia, Malaysia, Australia and New Zealand; in the Bay of Bengal and Arabic Sea around India, and

in the gulfs of Oman and Aden (off Oman, Yemen). It has also been more sparsely recorded in the Western Indian Ocean between ca. 5°S off Tanzania to ~30°S, off South Africa. In the Atlantic basin *T. turbinata* seems to be only present along its western margins. In the Northwest Atlantic it is found from ca. 42°N to the South Caribbean Sea off the coasts of Colombia and Venezuela (~11°N). In the Southwest Atlantic it was first recorded in a northern Brazilian estuary in the late 80's (Vasa-Barris River estuary, 11°10'S, 38°52'W; year not specified;

Araujo & Montú, 1993). Subsequent records along the Brazilian coast include Rio de Janeiro and São Paulo (Lopes *et al.*, 1999; Ara, 2002), as well as Santa Catarina and Rio Grande do Sul (Lopes *et al.*, 2006; Resgalla Jr. *et al.*, 2008; Domingos-Nunes & Resgalla Jr., 2012; Becker *et al.*, 2018). Its southernmost record is in the Lagoa dos Patos estuary (Muxagata & Gloeden, 1995; Teixeira-Amaral *et al.*, 2017). All along the Southwest Atlantic coast of Brazil, from the mouth of the Amazon (ca. 0° latitude) to Lagoa dos Patos (~32°S) it is considered a non-indigenous invasive species (WoRMS, 2025; Ferreira *et al.*, 2009; Lopes *et al.*, 2009; Cardoso *et al.*, 2025). Coastal currents systems, ballast water, and maritime transport probably favored its dispersion to new regions (Lopes *et al.*, 2009), where Lagoa dos Patos estuary was the southernmost known location of a *T. turbinata* population so far.

Temora turbinata was recently registered in Uruguay during routine plankton surveys conducted at two coastal sites: Cabo Polonio (34°23'S – 53°46'W) and La Paloma – Cabo Santa María (34°39'S – 54°09'W) (Fig. 1). Quantitative samples were collected using a conical plankton net equipped with a 100 µm mesh and flow meter to estimate zooplankton abundance (ind m⁻³). In Cabo Polonio samples were taken monthly during a four year period between September 2016 and August 2020 at STPCP station, ~2 km offshore in a water column depth of ~12 m. At the current stage the analysis of zooplankton samples is completed for the period December 2017 – August 2019 (21 months, 23 samples). Data from La Paloma covered one full annual cycle, with triplicate plankton samples collected per season (at approximately 10-day intervals) at two

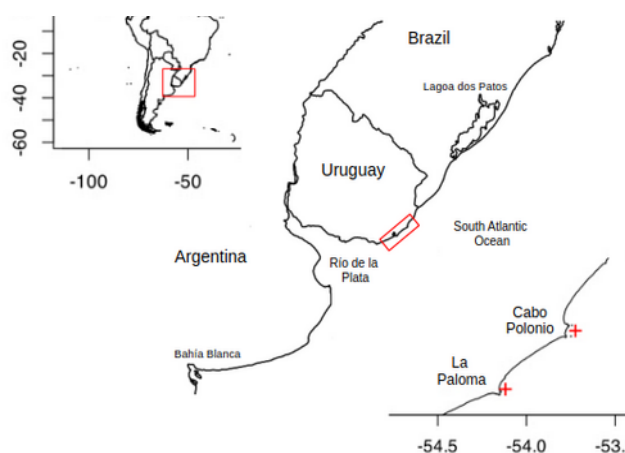


Figure 1. Localities of new records of *Temora turbinata* in Uruguay (indicated by crosses): coastal zone of Cabo Polonio and La Paloma - Cabo Santa María.

stations: one in the surf zone of La Aguada beach, and at the littoral area adjacent to the same beach (~400 m offshore, 6 m water depth). Sampling was conducted during spring 2021 (October), autumn 2022 (April), summer 2023 (February and March) and winter 2023 (July and August), yielding a total of 24 observations. All samples were immediately preserved in 4% (final concentration) of a borax-neutralized formaldehyde seawater solution. On all occasions ancillary environmental data were recorded using an SBE-V2plus oceanographic profiler. The identification of *T. turbinata* was based on taxonomic keys, mainly following Bradford-Grieve (1999). General observation of the specimens were performed under stereomicroscope up to 6.3x magnification: shape of the cephalothorax, posterior corners of the prosome, urosome segments, and caudal ramii. Specific diagnostic characters were also examined under compound microscope up to 40x magnification: the microstructure of caudal ramii and of the fifth pair of cephalothoracic appendages in females and males. Dissection, staining with methylene blue, and mounting of specimens and their parts on slides was done for rigorous analysis of diagnostic characteristics (Fig. 2). A subsample of individuals was photographed and their cephalothoracic length measured using Image-J (Schneider *et al.*, 2012). Spearman correlations were computed to examine relationships between abundance and environmental data. Data analyses and representations were done using the R platform (v4.2.1, R Core Team, 2022) and the R-Studio interface (v 2022.7.1.554, RStudio Team, 2022).

At Cabo Polonio *T. turbinata* was present in 17 out of 23 samples analyzed (74%), with the first record in December 2017. When it occurred, it exhibited a wide range of densities: between 18 and 127523 ind m⁻³, which represented between 0.01% and 84% (mean 14%) of total copepod abundance. Highest densities occurred in autumn (mean ± SD: 37794 ± 47908 ind m⁻³) and summer (26083 ± 42578 ind m⁻³), followed by winter (922 ± 1419 ind m⁻³), and spring (84 ± 168 ind m⁻³; present only in December 2017) (Fig. 3A). Exceptionally high densities recorded in Cabo Polonio (April 2018, 1.3x10⁵ ind m⁻³; February 2019, 1.1x10⁵ ind m⁻³; May 2018, 65205 ind m⁻³; April 2019, 56420 ind m⁻³) exceed typical values for the species (e.g., Teixeira-Amaral *et al.*, 2017; Wang *et al.*, 2021), although densities of approximately 70000 ind m⁻³ have been documented in Brazilian coastal waters (Ara, 2002). Also, densities 2-3 order of magnitude higher, in excess of 1x10⁷ ind m⁻³ can be found in copepod swarms



Figure 2. *Temora turbinata*. Pictures were taken under low magnification stereomicroscope and compound microscope. A. Female: dorsal, lateral and fifth pair of cephalothoracic appendages (P5, stained and mounted piece), B. Male: dorsal, lateral and P5 (stained and mounted piece). Scale bars represented at 100 μm (complete specimens) and 20 μm (P5).

(Ueda *et al.* 1983; Ambler *et al.* 1991). The April 2018 peak occurred along a bloom of *Noctiluca* spp. (569869 ind m^{-3}), and *T. turbinata* represented ~10% of the copepod community. In turn, during February 2019, *T. turbinata* dominated the copepod assemblage, accounting for 84% of total copepod abundance.

At La Paloma – Cabo Santa María, *T. turbinata* was present in all seasons except spring, and at both sampling sites, except for the last summer date when it occurred only in the surf zone. Abundances ranged from 93 to 20753 ind m^{-3} , and represented 0.46 – 49.5% (mean 20%) of total cope-

pod abundance. In this case, abundance was highest in summer (mean $\pm$ SD: 7614 $\pm$ 8082 ind m^{-3}) and autumn (6311 $\pm$ 8133 ind m^{-3}), followed by winter (949 $\pm$ 817 ind m^{-3}) (Fig. 3B). Population structure was highly variable, for instance copepodites comprised 1.1 – 97.4% of the population (mean $\pm$ SD: 50.1 $\pm$ 33.8%), while adults accounted for 2.6 – 100% (55.8 $\pm$ 35.8%). Within adults, females accounted for 2.1 – 71.3% (32.5 $\pm$ 22.5%) and males for 0.5 – 50% (26.8 $\pm$ 17.2%).

Adult individual size ranged from 0.64 to 1mm for females (N = 256) and from 0.58 to 1.2 mm

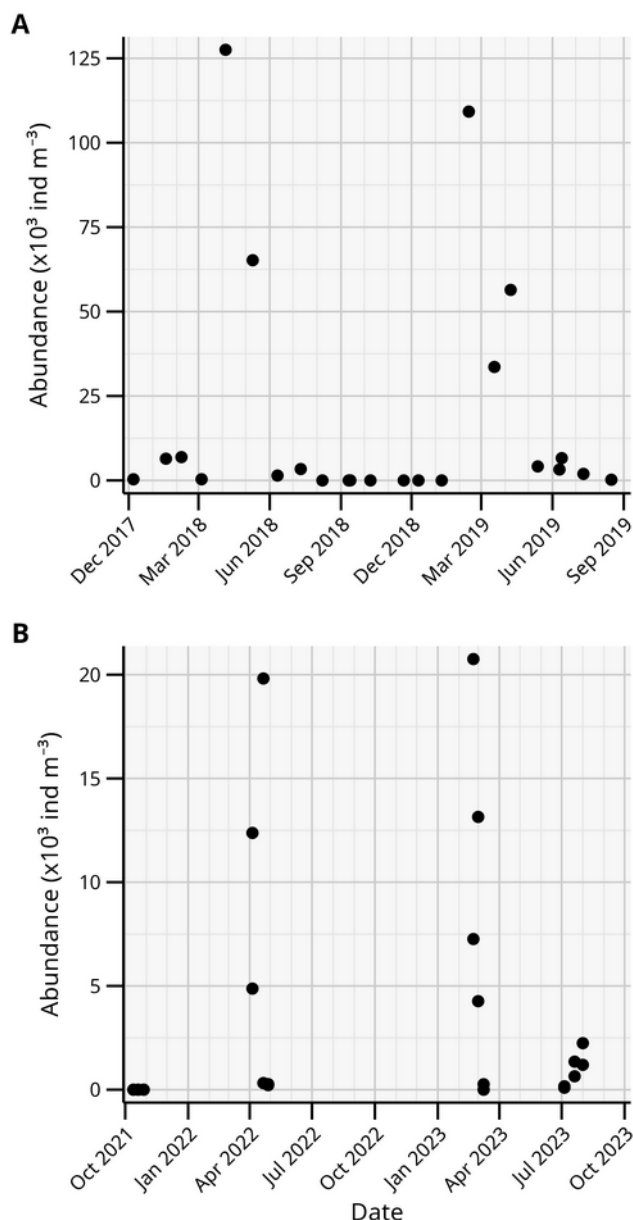


Figure 3. Time variability of the abundance of *Temora turbinata* (x10³ ind m⁻³) in A) Cabo Polonio during the period December 2017 – August 2019; and B) La Paloma-Cabo Santa María between October 2021 and August 2023.

in males (N = 155), with minor size differences between Cabo Polonio and La Paloma (Table I). *T. turbinata* occurred in wide ranges of salinity and temperature (Table I). Across both localities, the abundance of *T. turbinata* was positively correlated with temperature (Spearman's $\rho \sim 0.45$, $n=34$, $p<0.01$) but not with salinity ($\rho \sim -0.04$, $n=34$, $p>0.05$).

The high incidence in zooplankton samples and the high densities reached at both sites, together with population structure data from La Paloma –

Cabo Santa María, consistently indicate a downright adaptation to local conditions and the successful establishment of *T. turbinata* at its southernmost known coastal marine distribution to date. In this context, the current report confirms the presence and establishment of an exotic free-living marine copepod species in Uruguayan waters. It adds to the growing list of exotic invertebrates recorded in Uruguay's marine and estuarine ecosystems, which have so far been predominantly benthic (*Limnopena fortunei*, *Ficopomatus enigmaticus*, *Rapana venosa*; Brazeiro *et al.*, 2021 and references therein), along with the planktonic non-native hydrozoan *Blackfordia virginica* (Vidal *et al.*, 2021) and the zoeal larvae of the crab *Rhithropanopeus harrisi* (Machado *et al.*, 2024).

The single previous report of *T. turbinata* in Uruguayan waters (Cepeda *et al.*, 2020; reporting observations from 2014) and at least one further unpublished record (G. Cepeda, com. pers.¹) place this species in the shelf within the Rio de la Plata plume, near Brazil, with low incidence of occurrence and medium densities. The distance between currently known localities of occurrence in Uruguay and the nearest previous record (Lagoa dos Patos, South Brazil, first recorded in 1992) is substantial but relatively minor for the dispersal potential of marine epipelagic copepods. Findings from Uruguay come ca. 20-30 years after its first report in southern Brazil. Comparatively, the elapsed time between its first record in northern Brazil (~11°S, Araujo & Montú, 1993; samples collected in the late eighties) and that in Lagoa dos Patos (~32°S, Muxagata & Gloeden, 1995; collected in 1992) was much shorter, ca. three to five years for a ~3000 km distance. The late finding of *T. turbinata* in current localities may be attributed to either the very sparse observation efforts allocated so far to characterize the Uruguayan marine plankton (Calliari *et al.*, 2003; Cervetto *et al.*, 2006), to the existence of biogeographic barriers to its southern expansion beyond Southern Brazil, or to a combination of both factors. Research efforts and available information on the marine Uruguayan zooplankton is still very sparse, particularly in areas outside the Rio de la Plata estuary. That undoubtedly plays a role in this late discovery. However, a restricted or slowed down southern expansion cannot be completely ruled out. *Temora turbinata* has a subtropical to warm temperate distribution, with preference for polyhaline waters (Araujo & Montú, 1993; Muxagata & Gloeden, 1995; Ara, 2002; Nascimento *et al.*, 2021). The southern expansion of this species

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Table I. Environmental conditions during the occurrence of *Temora turbinata* in Uruguayan waters and cephalothoracic length (CL, mm) of females and males, at each sampling site. The number of individuals measured is shown between brackets.

Locality	Temperature	Salinity	Female CL	Male CL
Cabo Polonio – STPCP	11.67 – 22.94	17.92 – 32.94	0.65 – 0.83 (17)	0.58 – 0.70 (6)
La Paloma – La Aguada surf	12.34 – 24.48	11.85 – 33.3	0.64 – 0.93 (115)	0.62 – 0.86 (74)
La Paloma – La Aguada littoral	11.70 – 24.42	25.55 – 33.19	0.66 – 1 (124)	0.61 – 1.2 (75)

may be partially constrained by oceanographic conditions along the Uruguayan shelf. In southern Brazil and particularly further south, the increasing winter–spring influence of the Patagonian Current (coastal branch of the cold Malvinas Current over northern Argentinian and Uruguayan shelf), together with the predominantly northward-flowing brackish Río de la Plata plume (Piola *et al.*, 2018), may act as partial barriers. That is consistent with its occurrence in Uruguayan waters predominantly during the warm period, and with the positive correlation between its abundance and water temperature.

Investigations of zooplankton from Uruguayan waters, including the Río de la Plata, shelf and slope ecosystems between the late 90's and early 2000's did not report *T. turbinata*, but only *T. stylifera* (Méndez *et al.*, 1997; Berasategui, 2003; Berasategui *et al.*, 2005, 2006; Cervetto *et al.*, 2006; Acha *et al.*, 2020). According to reviewed regional literature (Méndez *et al.*, 1997; Berasategui, 2003; Berasategui *et al.* 2005, 2006; Cervetto *et al.*, 2006; Acha *et al.*, 2020) it is highly likely that until the mid 2000's *T. turbinata* was not present in the Río de la Plata and its area of influence, at least in conspicuous numbers. Investigations in smaller scale estuaries during the second half of the 2000's (Laguna de Rocha, in the La Paloma-Cabo Santa María area, and Solís Grande, a sub-estuary in the external Río de la Plata, respectively) reported *Temora* sp. as a substantial component of the zooplankton assemblage (Calliari *et al.*, 2009; Machado *et al.*, 2017). Therefore, a future re-evaluation of such samples may contribute to narrowing down the timing of *T. turbinata*'s appearance and geographic distribution south of Lagoa dos Patos.

Along neritic waters of Brazil, Uruguay, and Argentina *Temora stylifera* is the single native species of the genus, with a southward distribution reaching ~37°S off Buenos Aires province (Argentina; Berasategui, 2003; Ferreira *et al.*, 2009).

Several reports indicate that the presence of *T. turbinata* has led to the decline of the native congeneric populations in Brazilian coasts (Ara, 2002; Lopes *et al.*, 2009; Santos & Meuer, 2016) and to their displacement from the continental shelf to oceanic regions (Ara, 2002; Lopes *et al.*, 2009). *Temora turbinata* has broad tolerance to temperature and salinity, achieving higher densities in low-salinity coastal and estuarine waters, whereas *T. stylifera* is associated with higher-salinity waters (Ara 2002, Resgalla Jr. *et al.* 2008). Its high biomass-specific growth may also represent a competitive advantage relative to native congeners (Ara, 2002). Consistent with this pattern, *T. stylifera* was only recorded in La Paloma in February 2023 at a very low density (11 ind m⁻³) relative to *T. turbinata*. Together, these traits highlight the potential of *T. turbinata* for its establishment and spreading in the estuarine environment of the Río de la Plata (Carlton & Schwindt, 2024). Special attention should be given to monitoring programs focused on the Río de la Plata area, and in shelf and coastal waters further south to detect potential new occurrences of this species in the near future.

Ethical statement

The present investigation did not involve regulated animals and did not require approval by an Ethical Committee.

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