

SHORT NOTE

## Estuaries and Gelatinous zooplankton: New records of Ctenophora from the Tropical Coast of Brazil (~3-11°S)

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**Abstract:** The fauna of ctenophores in the coastal zone of tropical Southwestern Atlantic is virtually unknown. *Mnemiopsis leidyi* and *Beroe ovata* are important components of pelagic communities as top predators, which are occasionally abundant and widely distributed on coastal regions of the western Atlantic. However, in this region most of the records are in subtropical areas of SW Atlantic, North Atlantic or in the Caribbean region. In this paper we present information on the occurrence of both species in ten tropical estuaries, located between 3 and 11°S, covering more than 1,000 km of coastal areas. The records were made through visual observation, manual collections (with the aid of a 1 mm mesh size net) and subsurface and bottom zooplankton hauls (200, 300 and 500 µm mesh size). We recorded the occurrence of ctenophores in distinct shallow-water estuaries, including hypersaline and highly polluted environments. These new occurrences expand our knowledge on the distribution of the fauna of ctenophores, as well as on the need to carry out taxonomic works and studies that investigate the influence of environmental variables over the population structure and blooms of these species.

**Résumé :** Estuaires et plancton gélatineux : nouveaux signalements de Ctenophora de la côte tropicale du Brésil (3-11°S). La faune des ctenophores dans la zone côtière de l'Atlantique tropical sud-ouest est pratiquement inconnue. *Mnemiopsis leidyi* et *Beroe ovata* sont des composantes importantes des communautés pélagiques en tant que prédateurs supérieurs, parfois abondantes et largement réparties sur les régions côtières de l'Atlantique ouest. Cependant, dans cette région, la plupart des signalements se situent dans des zones subtropicales de l'Atlantique sud-ouest, de l'Atlantique nord ou des Caraïbes. Dans cet article,

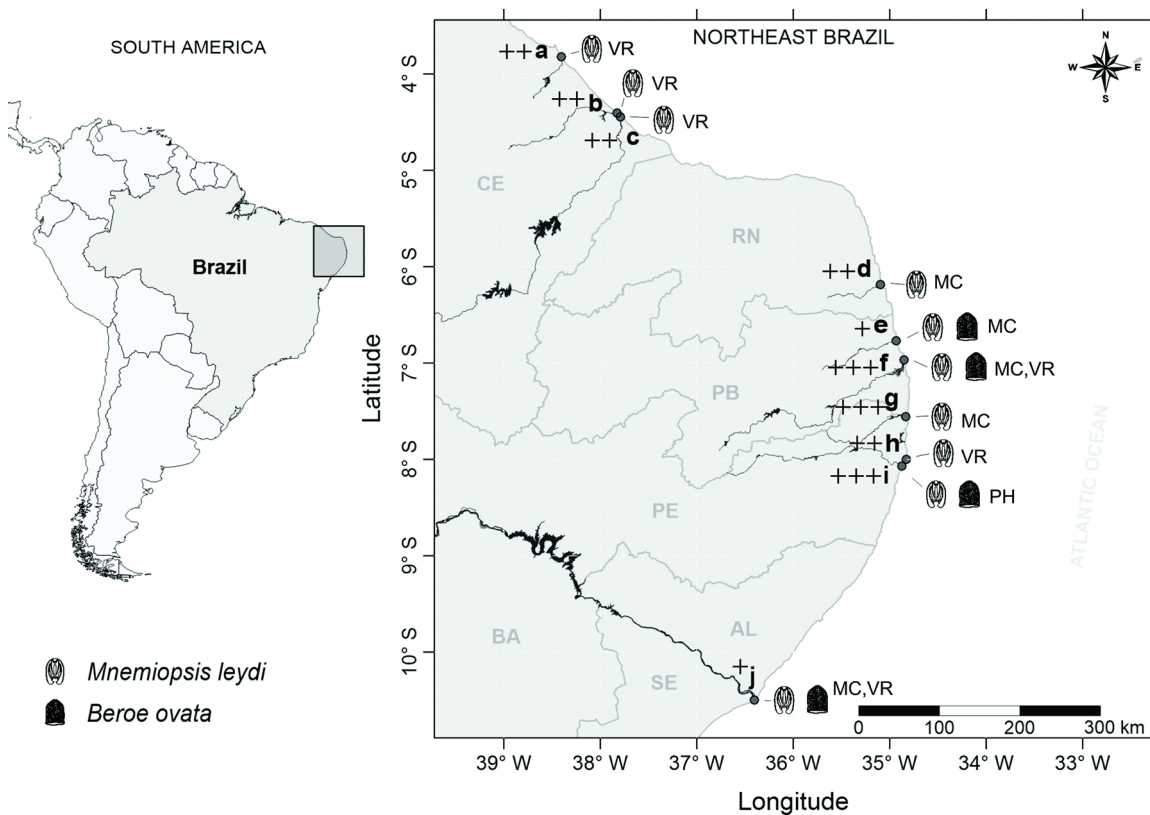
nous présentons des informations sur la présence des deux espèces dans dix estuaires tropicaux situés entre 3 et 11°S et couvrant plus de 1000 km de zones côtières. Les signalements ont été réalisés par observation visuelle, par des collectes manuelles (à l'aide d'un filet de 1 mm) et par des traits de filets à zooplancton sous la surface et au fond (mailles de 200, 300 et 500 µm). Nous avons enregistré la présence de cténophores dans différents estuaires en eaux peu profondes, notamment dans des environnements hypersalins et très pollués. Ces nouvelles occurrences élargissent nos connaissances sur la répartition de la faune des cténophores, ainsi que sur la nécessité de mener des travaux taxonomiques et des études explorant l'influence des variables environnementales sur la structure de la population et la prolifération de ces espèces.

**Keywords:** Estuary • *Mnemiopsis leidyi* • *Beroe ovata* • Southwestern Atlantic

## Introduction

Ctenophores inhabit environments under influence of marine waters (estuaries, coastal areas and oceanic regions), and consist of about 200 known species (Mills, 2017). In the Southwest Atlantic, 17 species of ctenophores have been recorded, 13 of them on Brazil, mostly from temperate and subtropical

latitudes with virtually no data from tropical areas (Oliveira et al., 2016; Nogueira Júnior et al., 2018). In this study we provide observations on ctenophore occurrences from ten Brazilian tropical estuaries (3–11°S), updating the distribution of *Mnemiopsis leidyi* A. Agassiz, 1865 (Bolinopsidae) and *Beroe ovata* Bruguière, 1789 (Beroidae) of estuarine environments from the tropical Southwestern Atlantic.



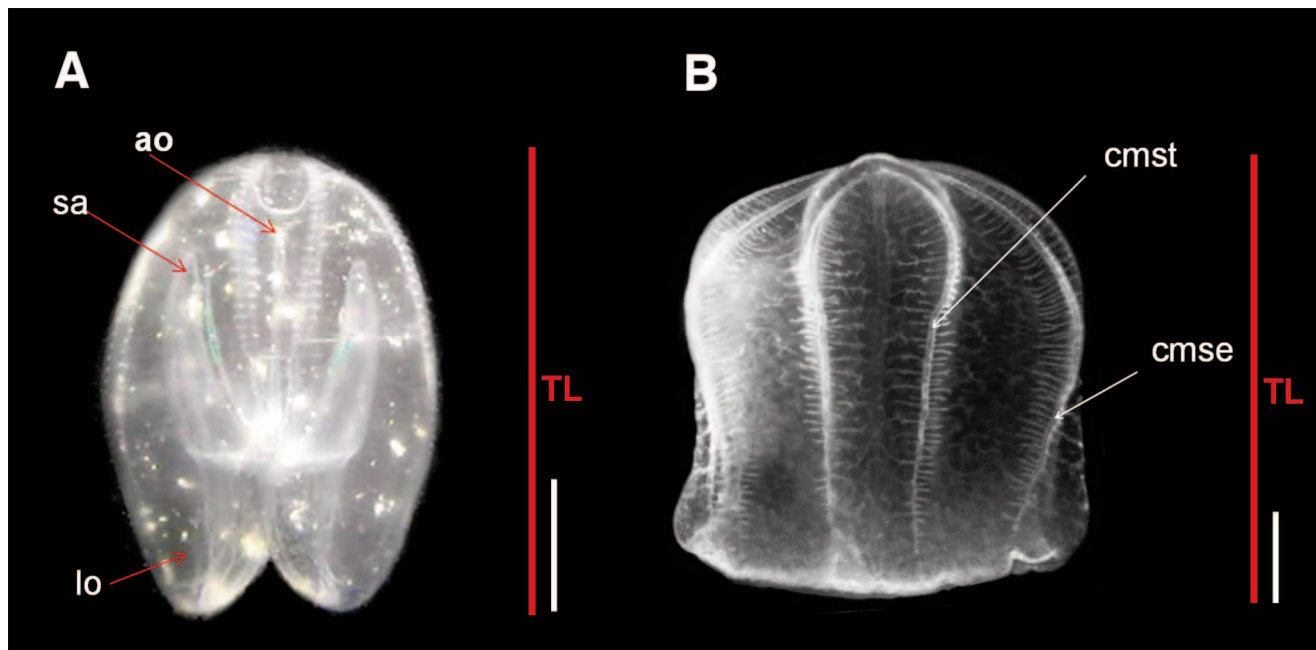
**Figure 1.** Distribution of *Mnemiopsis leidyi* and *Beroe ovata* in ten estuaries of the Brazilian tropical coast: (a) Pacoti River, (b) Jaguaribe River, (c) Piranji River, (d) Guarairas estuary, (e) Barra de Mamanguape, (f) Paraíba River, (g) Goiana River, (h) Santa Cruz Channel, (i) Capibaribe River and (j) São Francisco River. Registration strategy: In situ visual records (VR), manual collection with the small net of 1 mm mesh size (MC) and plankton hauls (PH). Estuaries affected by anthropic activities: Moderate +, Medium ++, High +++.

*In situ* visual records (VR), manual collections (MC) with the aid of a small sieve of 1 mm of mesh size and subsurface (1 m depth), bottom (5 and 8 m depth), oblique and vertical hauls (PH) using cylindrical-conic plankton nets with 200, 300 and 500  $\mu\text{m}$  mesh sizes were used to record the occurrence of ctenophores in ten Brazilian tropical estuaries (Fig. 1). These estuaries are relatively shallow (< 10 m water depth) and under the influence of warm and oligotrophic coastal waters. The *in situ* identification followed Oliveira et al. (2007). For adults identification of *M. leidyi*, the presence of the lobes appearing at the height of the apical organ and creating a long auricular groove between the lobe and the central region of the body was used (Fig. 2A), while for *Beroe ovata* identification, the body flattened in the tentacular axis and the anastomoses of gastrovascular diverticula (Fig. 2B) were used.

The present work covers more than 1,000 km of Brazilian coastal areas and includes numerous estuaries. The Lobata *M. leidyi* was recorded in ten estuaries in different expeditions performed between 2003 and 2016 (Fig. 1). In the estuaries where visual records (Piranji river in May 2016, Pacoti and Jaguaribe River in December 2003, and Santa Cruz Channel in March 2007 and February 2008) and manual collections (Guarairas in November 2013,

Barra de Mamanguape in April 2016 and Goiana River in February 2015) were performed, fewer individuals were registered (< 10). Only in the estuaries of the Paraíba River (between December 2013 and July 2016) and in the mouth of the São Francisco River (May 2014), higher abundances were recorded, with more than 50 individuals. Information on abundance and size were recorded only in the estuary of the Capibaribe River (May 2012, June and July 2016 and February 2017). In this estuary, 692 individuals (larvae and adults) were sampled in the rainy season, ranging from 0.1 to 9 cm in total length (TL), whose abundance value was highest at night (13.5 ind  $10\text{ m}^{-3}$ ). In the dry season, only 28 individuals (adults) were collected, with TL between 1.3 and 6.6 cm and abundance lower than those obtained during the rainy season (maximum of 1.3 ind  $10\text{ m}^{-3}$ ).

The species *Beroe ovata* occurred in four of the ten estuaries covered in this study (Fig. 1) with fewer individuals than *M. leidyi*. This may be probably related to the low sampling effort and usual lower abundance because it is a predator of *M. leidyi*, presenting a lower number of individuals when compared to its prey. A total of 1, 4, 2 and 1 individuals were recorded in Barra de Mamanguape, Paraíba River and Capibaribe estuaries, and at the mouth of the São Francisco River, respectively. In the



**Figure 2.** View of the stomodeal plane of the two Ctenophora species reported in this study. **A.** *Mnemiopsis leidyi*: ao, apical organ; sa, auricular furrow; lo, oral lobe (Photo: Díaz, X.F.G.). **B.** *Beroe ovata*: cmse, substomodeal meridional canal; cmst, subtentacular meridional canal. The red line indicates the total length (TL) and the white line is the scale (10 mm). (Photo: Rodrigues, T.)

Capibaribe estuary only one individual was collected in May 2012 and another in July 2016.

The feeding habits, wide environmental tolerance and easy adaptations to polluted waters favors the increase of Ctenophora distribution (Oliveira, 2007). Based on the wide latitudinal range of both *M. leidy* and *B. ovata* in coastal waters of the North West Atlantic Ocean, and due to their physiological flexibility to withstand a wide range of different environmental conditions, such as a wide range of variability in temperature, salinity (among 5 and 70 practical salinity units) and dissolved oxygen (Mianzan et al., 2009; Costello et al., 2012), it has recently been suggested that these ctenophores probably occur in all southwestern Atlantic brackish-water ecosystems (Nogueira Júnior et al., 2018).

Environmental conditions of transitional ecosystems (salinity, temperature and productivity) facilitate the development of *M. leidy* in wide range of variations in morphological features, growth rate and size, metabolism level, size of maturity, fecundity (Shiganova et al., 2014). In the present study the record of *M. leidy* in the hypersaline estuary of the Pacoti River, which typically exhibits salinities above 40 (Barroso et al., 2016), corroborates the information of tolerance to contrasting environmental conditions. Additionally, all the sampled estuaries are under environmental impact due to anthropic activities. Although some of them are included in Environmental Protection Areas (a, d, e), most of them are urban (a, b, f, g, i), with erosion problems due to mangrove deforestation (a, i, h), present problems by intensive activities of shrimp farming (a, b, c, d, h) and overfishing (h), hydrodynamic alterations by dams (j) and suffer, as a main problem, with the release of domestic and industrial untreated sewage without (a, b, f, g, h, i) (Fig. 1). The estuaries were categorized in this study according to the amount of impacting anthropogenic activities reported in previous studies (Souza & Neumann-Leitão, 2000; CONDEPE/FIDEM, 2005; Leitão et al., 2007; Silva et al., 2011; Albuquerque, 2013; Silva & Oliveira, 2013; Andrade et al., 2014; Sousa et al., 2015; Silva & Miller, 2016) which allowed us to observe that most estuaries are between moderate to highly impacted (Fig. 1).

Copepods and fish larvae and eggs – including species of great economic importance – are the main prey of *M. leidy* (Houde et al., 1994; Purcell & Arai, 2001; Purcell et al., 2010). When food is abundant, these gelatinous carnivores can grow rapidly, increasing significantly in biomass at certain times of the year (Purcell & Arai, 2001). *B. ovata* feeds exclusively on other ctenophores, notably *M. leidy* (Matsumoto & Harbison, 1993) which explain their

general co-occurrence. In regions where *M. leidy* was introduced accidentally (e.g. in the Black Sea) it was observed that *B. ovata* naturally controlled the overpopulation of the invading ctenophore (Finenko et al., 2011).

Records of large spatial and temporal increases of ctenophores in estuarine systems are cited worldwide (Condon et al., 2010; Jaspers et al., 2011; Shiganova et al., 2014). Since ctenophores can directly influence the cycling of nutrients because of their high biomass during blooms (Condon et al., 2010), it is necessary to investigate the spatial and temporal dynamics of these populations and the importance of human impacts. Blooms of *M. leidy* were observed in the Chesapeake Bay, a well-studied estuary that receives large inputs of inorganic nutrients (Condon et al., 2010). No information is available on ctenophores blooms events occurring in the tropical Brazilian estuaries. First, we need to know if there are natural fluctuations in the populations, if there is any seasonality and how they respond to trophic conditions of the environment. Thus, information on the abundance, size and biomass of *M. leidy* and *B. ovata* in tropical Brazilian estuaries are particularly useful estimators for the marine resources management, since ctenophores consume zooplankton massively, including fish eggs and larvae and invertebrates and can directly impact recruitment, to the point where it is impossible to recover the ecosystem.

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