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INVASION NOTE

Membraniporopsis tubigera, an invasive bryozoan in sandy beaches of southern Brazil and Uruguay

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Abstract The massive irruption of the invasive bryozoan *Membraniporopsis tubigera* (Osburn) in sandy beaches of southern Brazil and Uruguay is reported. The species, originally described from Puerto Rico, Texas and Florida, has also been recorded for Brazilian beaches from 21°S to 26°S as well as for harbours of Australia, New Zealand and the Sea of Japan. The southward spreading rate of this bryozoan along the Brazilian and Uruguayan coasts can be estimated in approximately 183–195 km year^{-1}. The chances that this invasion could proceed southwards in the Southwest Atlantic and the possible impacts that it may be causing are discussed. The case of *M. tubigera* seems to be qualitatively and quantitatively different from those of other alien bryozoans previously recorded for this region, since it appeared massively in exposed sandy beaches, a habitat regarded to date as apparently free from the pervasive ecological impact of invasion by exotic species in the Southwest Atlantic.

Keywords *Membraniporopsis tubigera* · Invasive bryozoan · Sandy beaches · Brazil · Uruguay

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Introduction

Bryozoans are common members of marine fouling assemblages growing on ship's hulls, submerged artificial surfaces, ports and harbours (Ryland 1965; Gordon and Mawatari 1992; Liu et al. 2001). Several non-indigenous bryozoan species have been recorded for Southwest Atlantic harbours (Lichtschein de Bastida and Bastida 1980; Orensanz et al. 2002; Scarabino 2006) and natural habitats (Vieira et al. 2008). Since 1997, however, *Membraniporopsis tubigera* (Osburn 1940), a poorly known anascan cheilostome, appeared suddenly in four Brazilian states from around 21°S to 26°S (Gordon et al. 2006). This species, originally described from Puerto Rico, Texas and Florida

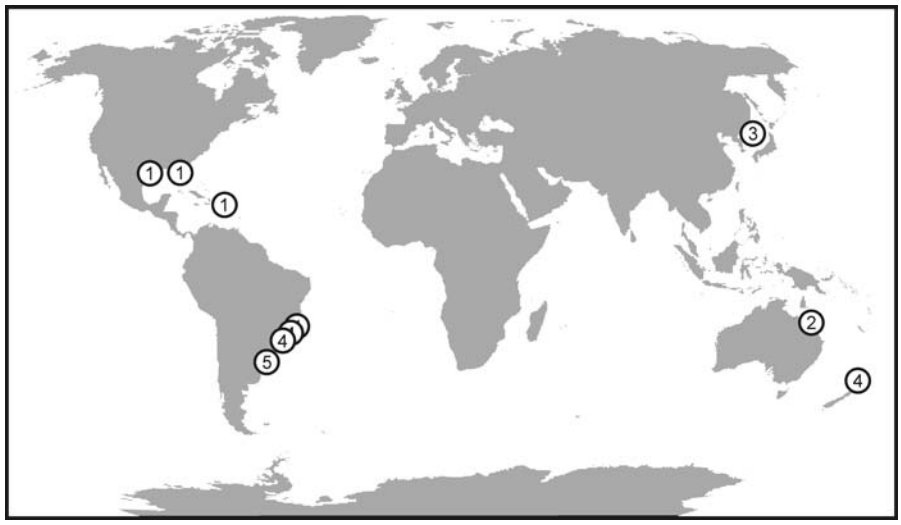

Fig. 1 World distribution of *Membraniporopsis tubigera* based on *1* Osburn (1940), *2* Allen (1953), *3* Kubanin (1977a, b), *4* Gordon et al. (2006) and *5* this study

(Osburn 1940), has also been recorded for Australia (Allen 1953), New Zealand (Gordon et al. 2006) and the Sea of Japan (Kubanin 1977a, b; Fig. 1).

In this paper we report the massive irruption of *M. tubigera* in sandy beaches of southern Brazil and Uruguay, estimate its spreading rate, and discuss its possible impacts and whether this invasion could proceed southwards in the Southwest Atlantic.

Materials and methods

Beach-drift material of an unknown foliaceous bryozoan was collected during visits to the exposed sandy beach of La Coronilla, Uruguay (33°54′S, 53°30′W; Fig. 2) on January 2003 and January 2005. Simultaneously, fish were also collected with a shrimp trawl, as part of a project aimed at ecosystem monitoring at the neighbouring locality of Cerro Verde. Fish samples gathered onboard artisanal fishing vessels were taken to the laboratory for stomach content analysis. Incidental information on the appearance of this bryozoan was also obtained from fishermen working in nearby coastal areas.

Data on strandings in southern Brazil were obtained during frequent visits to Cassino (32°14′S, 52°10′W; Fig. 2) and neighbouring sandy beaches of Rio Grande do Sul.

Distances between coastal localities in Brazil and Uruguay were measured using Google Earth®.

Fig. 2 Dates and localities where *Membraniporopsis tubigera* was collected in Brazil and Uruguay. *Abbreviations*: *ES* Espírito Santo; *RJ* Rio de Janeiro; *SP* São Paulo; *PR* Paraná; *SC* Santa Catarina; *RS* Rio Grande do Sul; *UR* Uruguay. Based on Gordon et al. (2006) and this study

Voucher material of *Membraniporopsis tubigera* from La Coronilla has been stored at the Museo Nacional de Historia Natural y Antropología (MUNHINA, Montevideo, Uruguay) and the National Collection of Invertebrates of the Museo Argentino de Ciencias Naturales (MACN-In 37495).

Results

Although sporadic minor occurrences could have gone almost unnoticed during previous years, the first massive stranding of *Membraniporopsis tubigera* on the dissipative exposed sandy beach of Cassino (Rio Grande do Sul, Brazil; Fig. 2), was observed at the end of February 2002, covering about 2 km of the intertidal zone. Since then, massive appearances have been recorded in Cassino every summer, varying in period, location, intensity and extension of the beach affected. For example, almost 1 km of a pristine beach located 60 km to the south, near Sarita lighthouse, was also covered by the bryozoan on February 2003. A large stranding affecting 3 km of the beach and forming layers of more than 30 cm thick was registered on early March 2004 in the most popular area for tourists and bathers in Cassino, located between Arroio do Gelo and Querência. Another massive occurrence took place in the same area in late December 2005, at the beginning of the high tourist season, calling the attention of the media (Fig. 3a) and mobilizing local authorities to clean the beach. This stranding followed a sea swell with 4 m high waves that washed ashore the colonies. Further strandings were observed for short periods during the summers of 2006, 2007 and 2008, the latest also succeeding a big swell that reached the area in early February. During the stranding periods it was noticed that the bottom in shallow waters of the surf zone was also covered by the species, which tends to be accumulated by the hydrodynamic energy of waves and currents within the typical troughs located between the sand bars that run parallel to the beach. It was also observed that a successive large sea swell or a storm surge is the most effective way to clean the intertidal beach, carrying the colonies to the upper supratidal zone, close to the coastal dunes, where they will dry out and eventually disappear under a layer of sand blown by the wind.

In Uruguay, beach-drift material of *Membraniporopsis tubigera* was first observed at La Coronilla on January 2003 (Fig. 2), where it was moderately abundant. A local fisherman (C. Romero, personal communication) reported an increasing frequency of events of massive washing ashore of *M. tubigera* at the area since at least 2003, while in previous years the bryozoan was only noticed sporadically. This species attained peak abundances 2 years later. On January 2005, colonies were cast ashore along 1–1.5 km of the coastline between Canal Andreoni and Punta de La Coronilla, in some places forming layers of about 50 cm or more which negatively affected the recreational use of this sandy beach for a

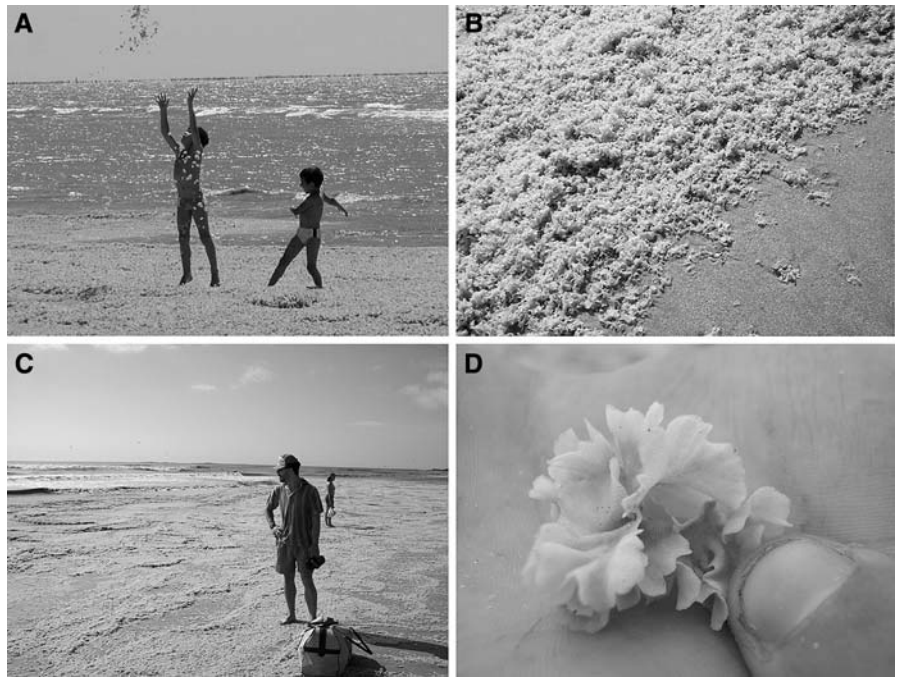

Fig. 3 **a** Frontal cover picture of the newspaper 'Agora', Rio Grande, Brazil, December 28, 2005. **b**, **c** An overview of the massive amounts of *Membraniporopsis tubigera* washed ashore at La Coronilla, Uruguay, January 2005. **d** An erect colony fragment

short period (Fig. 3b, c). Previous records (2003–2004) of massive strandings in the area were smaller in extension but similar in thickness and were concentrated in the embayment close to Punta de La Coronilla.

Among 27 fish species commonly occurring at the area (Segura et al. 2008), white croaker (*Micropogonias furnieri*), king weakfish (*Macrodon ancylodon*), Brazilian coding (*Urophycis brasiliensis*) and rays (e.g. *Sympterygia* spp.) dominated in terms of abundance and biomass during the surveys, but no colonies were detected in the fish stomach contents examined.

Colonies of *M. tubigera* examined in this study agree with descriptions of material from Brazil and New Zealand (Gordon et al. 2006). The erect foliaceous fronds (Fig. 3d) are composed of a bilamellar layer of lightly calcified, nearly rectangular zooids. A characteristic infundibuliform spine closed by an apical membrane occurs at each distolateral corner.

Discussion

The dispersal mechanism utilized by *Membraniporopsis tubigera* is not clear. The colonization of distant harbours in Australia, New Zealand, and the Sea of Japan suggests that either whole colonies, or at least their encrusting portions, are being transported as members of the fouling community of vessels. Conversely, larvae could survive days or weeks in ballast water tanks. Basic aspects of the larval biology and ancestrular morphology of this species, however, are still unknown. The family to which *Membraniporopsis* belongs is uncertain (Gordon et al. 2006). Malacostegine bryozoans (e.g. Membraniporidae) have non-brooded planktotrophic larvae known as cyphonautes, which can be transported through relatively long distances by ocean currents. *Membraniporopsis* was provisionally included in the Flustridae by Gordon et al. (2006), a family with lecitotrophic larvae that are brooded. If this is confirmed, brooding of short-lived larvae should take place within zooidal cavities, since ovicells are lacking in this species.

Data gathered in this study suggest that the habitat of *M. tubigera* is the shallow subtidal of sandy beaches. Its prospecting larvae, however, may need small pieces of shells or hard substrata to settle, metamorphose and bud the encrusting portion of the colony, before giving off the erect branches that make up most of the beach-cast material.

Either by dispersion of colonies or by larval transport, during the last years *M. tubigera* is spreading southwards along the coasts of the Southwest Atlantic, from southeastern Brazilian states towards Rio Grande do Sul and Uruguay. Although it is likely that the actual arrival of an invasive species to a given site may antedate its first massive appearance, we can roughly estimate the southward spreading rate of this bryozoan based on the chronology of its irruptions at different locations. The species was first collected at Itapoá (26°07′S, 48°36′W; Fig. 2) as beach-cast specimens on October 1997 (Gordon et al. 2006) and 53 months later made a massive appearance at Cassino (see "Results"). As both localities are separated by ~810 km, the rate of dispersion of *M. tubigera* can be estimated in ~183 km year^{-1}. Based on the distance and time separating the first occurrences at Itapoá and La Coronilla (~1,038 km and 64 months, respectively) we obtain a similar estimation (~195 km year^{-1}). After its first appearance in Brazil, *M. tubigera* was also found northwards of Itapoá, in the states of Paraná, São Paulo and Espírito Santo (Gordon et al. 2006; see Fig. 2).

The geographic distribution of *M. tubigera* known to date (Figs. 1, 2) suggests that this species could thrive in tropical and warm-temperate coastal waters worldwide. As Gordon et al. (2006) have stressed, it is also possible that *M. tubigera* may even not be native to Puerto Rico or the southern United States, where it was originally described (Osburn 1940), given that it was not known prior to the 1940s and its congeneric species are east Asian (Liu et al. 1999). The biogeographic (Boschi 2000) and oceanographic (Guerrero and Piola 1997; Piola et al. 2000) affinities among southern Brazil, Uruguay and the northern, warm-temperate coast of Argentina suggest that the invasion of *M. tubigera* could proceed south, at least up to San Matías and San José gulfs (ca. 41°–42°30′S), colonizing resorts of great tourist and recreational value along low diversity sandy beaches of Buenos Aires Province (Dadón 1999). The freshwater plume of the Río de la Plata estuary (Piola et al. 2000, 2008), however, may act as a temporary barrier to the dispersion of this bryozoan. A global scenario of progressive increase in mean seawater temperature (Hansen et al. 2006) could enhance the future

dispersion of *M. tubigera* in temperate coastal waters, alleviating the thermal constraints that may be restricting its current distribution.

Observational and experimental studies may be necessary to test the impacts that the massive irruption of *M. tubigera* may be causing in the Southwest Atlantic coastal areas. Several hypotheses may be tentatively proposed: (a) Since bryozoans are filter-feeding colonial organisms with relatively high clearance rates (Bullivant 1968; Winston 1977), massive concentrations of this species may be depleting phytoplankton in shallow subtidal areas (Buss and Jackson 1981), probably competing for food with other filter-feeders inhabiting sandy beaches, such as infaunal bivalves. This is of concern, since the yellow clam *Mesodesma mactroides* and predator intertidal gastropods such as *Olivancillaria teaguei*, *O. contortuplicata* and *Olivella formicacorsii* are regionally regarded as vulnerable or endangered species according to IUCN categories (Mansur et al. 2003; Scarabino 2004; Scarabino et al. 2006). (b) The massive strandings following sea swells may be serving as temporary refuge and food source, favouring organisms occurring at relatively high levels of southern Brazilian and Uruguayan sandy beaches, particularly cirolanid isopods and talitrid amphipods (Escofet et al. 1979; Gianuca 1987; Defeo et al. 1992). Conversely, it may also be possible that the thick layers of beach-cast bryozoans could locally cause some mortality of intertidal infaunal organisms by suffocation. (c) Although *M. tubigera* did not occur in fish stomach contents at La Coronilla, it seems likely that the huge biomass available for secondary consumers might be altering the existing benthic and demersal food webs in the shallow subtidal (Garcia and Gianuca 1997). In New Zealand, the species has been found filling the stomachs of the snapper *Pagrus auratus* (Gordon et al. 2006).

Several species of invasive bryozoans have already been recorded for the Southwest Atlantic. *Watersipora subtorquata*, a widespread fouling species (Gordon and Mawatari 1992), was found by various authors in the Brazilian states of Espírito Santo, Rio de Janeiro and São Paulo since 1842 (reviewed in Vieira et al. 2008). The ctenostome *Victorella pavida* occurs in estuarine, shallow subtidal habitats of Montevideo harbour (Uruguay) (Mañé-Garzón and Leymonié 1971, quoted in Scarabino 2006). *Cryptosula pallasiana*, a ubiquitous fouler of worldwide distribution (Gordon and Mawatari 1992) has been recorded for Rio de Janeiro (see Vieira et al. 2008), Uruguay (Calvo 1984, as *Cryptosula* sp., see Scarabino 2006), and three harbours of Buenos Aires Province, Argentina (Lichtschein de Bastida and Bastida 1980). The arborescent cheilostomes *Bugula flabellata*, *B. neritina*, *B. simplex* and *B. stolonifera* are common members of the fouling community in harbours of Buenos Aires Province (Lichtschein de Bastida and Bastida 1980). In addition, *B. neritina* has also been recorded for Port Williams, in the Malvinas/Falkland Islands (Hastings 1943). The case of *M. tubigera*, however, seems to be qualitatively and quantitatively different, since this bryozoan appeared massively in exposed sandy beaches, a habitat regarded as apparently free from the pervasive ecological impact of invasion by exotic species in the Southwest Atlantic (Orensanz et al. 2002), affecting the recreational use of coastal resorts.

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