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## *Sertularia marginata* (Cnidaria: Hydrozoa) in the Mediterranean: an alien species in expansion?

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### Abstract

Mature and dense populations of the tropical hydroid species *Sertularia marginata* were detected in the Alboran Sea (Western Mediterranean) and along the Atlantic coast of the Strait of Gibraltar. Until now, it had only been recorded in the eastern basin of the Mediterranean Sea. This species has previously been recorded in estuaries and anthropogenic habitats but, in the area studied here, we only found it in natural zones. These observations could indicate early expansion and naturalization in the Mediterranean Sea. Due to its limited dispersion capacity and the history of its records, the observations provided here support the hypothesis of an arrival and a spread by anthropogenic vectors. A pathway of arrival and dispersion of alien species into the Mediterranean Sea is proposed for future monitoring: from Macaronesia (particularly Canary Islands) to the Atlantic coast of the Strait of Gibraltar and from there to the Mediterranean.

**Keywords:** *Sertularia marginata*, hydrozoa, Mediterranean Sea, Strait of Gibraltar, alien species.

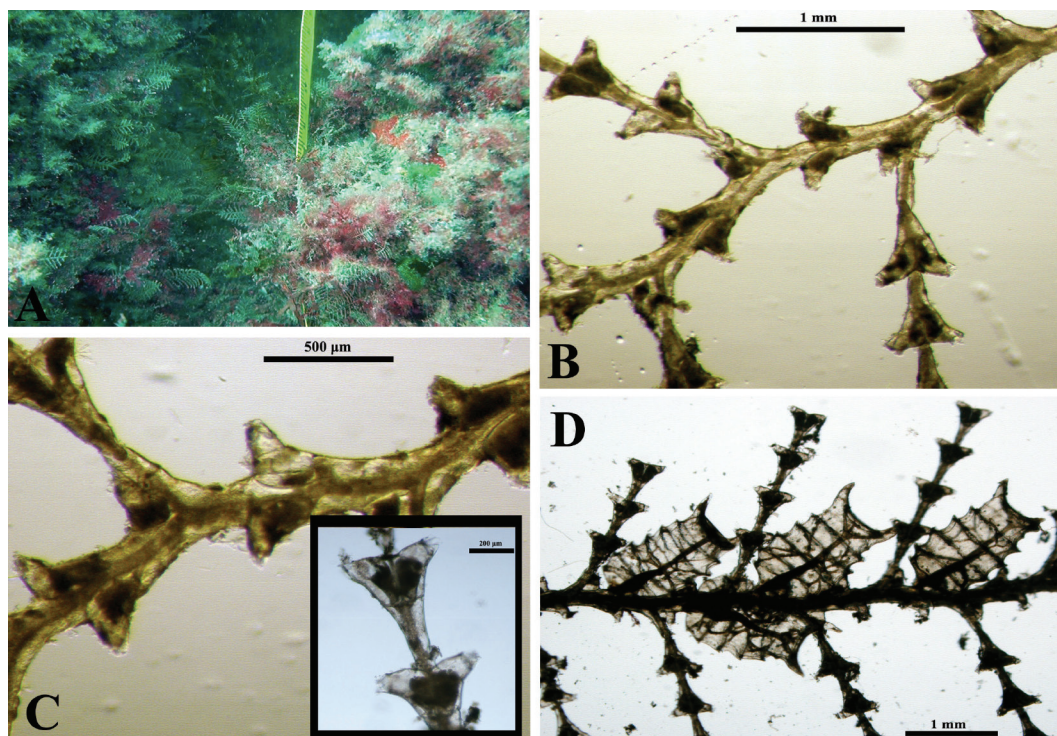
Hydroids are one of the animals within the benthic macrofauna most frequently translocated by human-mediation (Haydar, 2012). They are common components of fouling communities in harbours and ship hulls (Morri & Boero, 1986; Megina *et al.*, 2013), and their life cycles, including encysted phases or ability for reverse development (Boero & Bouillon, 1993; Piraino *et al.*, 2004), make some of them perfect invaders. However, most hydroids are inconspicuous and easily overlooked by non-specialists (Gravili *et al.*, 2008). Many species are likely considered as native because their human-mediated geographical movements are unknown (Haydar, 2012; Megina *et al.*, 2013). Only a few hydroid species are usually included on lists of non-indigenous or invasive species (Streftaris *et al.*, 2005; Zenetos *et al.*, 2010), such as *Cordylophora caspia* (Pallas, 1771), *Eudendrium carneum* Clarke, 1882 or *Clytia hummelincki* (Leloup, 1935), which are well known to be invasive species (Gravili *et al.*, 2008; Zenetos *et al.*, 2010; Haydar, 2012).

*Sertularia marginata* (Kirchenpauer, 1864) (Fig. 1) is a monosiphonic species of up to 2.5 cm in length. Hydrocaulus with alternate hydrocladia at approximately regular intervals. Hydrocaulus wider than hydrocladia and usually with three hydrothecae. Hydrocladial internodes with two hydrothecae opposite touching frontally. Gonothecae slightly compressed, with circular ribs and two apical spines. Reproduction by short-lived medu-

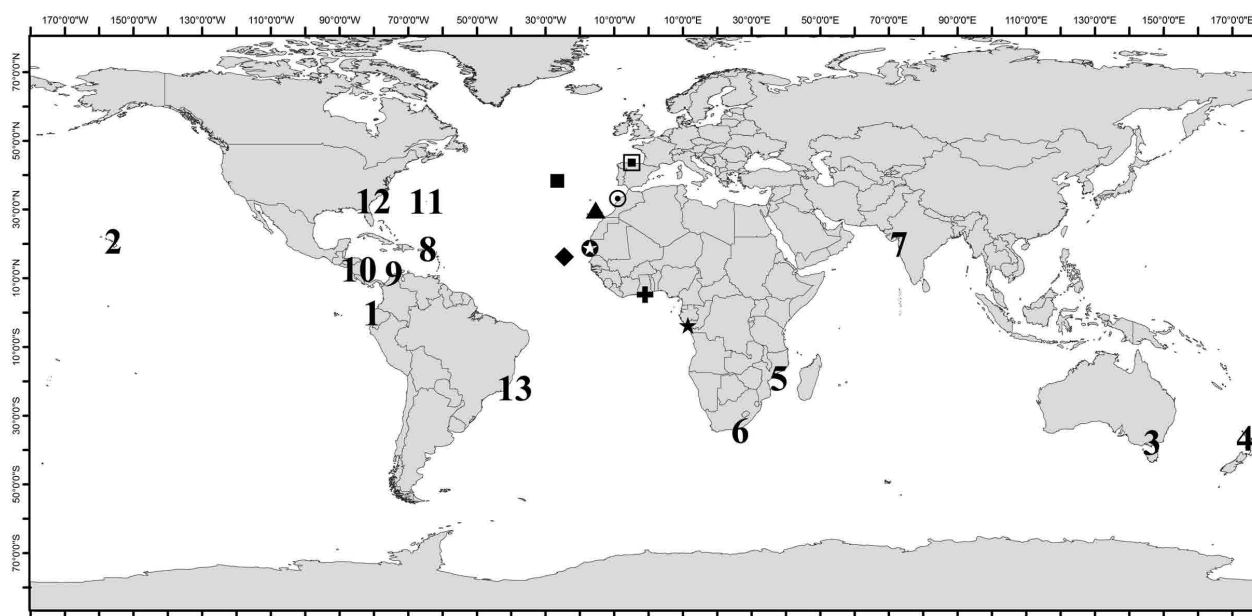
soid. This species is a circumtropical and subtropical hydroid species (Boero & Bouillon, 1993) that has an uncertain type locality: Kirchenpauer (1864) described it in “Mare pacificum, on Sargassum”. There are several records of this species in tropical zones of the eastern (Fraser, 1948), central (Carlton & Eldredge, 2009) and western Pacific Ocean (Bale, 1913; Totton, 1930; Ralph, 1961; Watson, 1994) and the Indian Ocean (Millard & Bouillon, 1974; Millard, 1975; Venugopalan & Wagh, 1986). In the western Atlantic, this species is known from South Carolina (Calder, 1983) to Brazil (Vannucci, 1949), with records in Bermuda (Bennett, 1922; Calder, 1991, 2000) and the Caribbean Sea (Jäderholm, 1903; Vervoort, 1967) (Fig. 2).

The first records of *S. marginata* in the eastern Atlantic were in tropical regions: Congo (Leloup, 1939) and Ghana (Buchanan, 1957). Later, it was recorded in Cape Verde (Medel & Vervoort, 1998), the Mauritanian region (Patrioti, 1970; Medel & Vervoort, 1998) and the Azores (Rees & White, 1966; Medel & Vervoort, 1998). *Sertularia marginata* was not found until the 1980's in the Canary Islands (Izquierdo *et al.*, 1990), the northern coast of the Iberian Peninsula (García Corrales *et al.*, 1980) (Fig. 2) and the Spanish coast of the Gulf of Cádiz, close to the Strait of Gibraltar, the Atlantic entrance to the Mediterranean Sea (Medel Soteras *et al.*, 1991) (Fig. 3).

*Sertularia marginata* is considered an alien species



**Fig. 1:** *Sertularia marginata* (Kirchenpauer, 1864) sampled on shipwreck in the Spanish coast of the Gulf of Cádiz. A) Colonies on shipwrecks, B-C) Hydrothecae, C) Gonothecae.



**Fig. 2:** Distribution of *Sertularia marginata* (Kirchenpauer, 1864) without the records in the Mediterranean Sea and the Gulf of Cádiz (in Fig. 3). Eastern Pacific (1) = Santa Elena Bay, Ecuador (Fraser, 1948); Central Pacific (2) = Waikiki, Hawaii (Carlton & Eldredge, 2009); Western Pacific (3-4) = 3: Victoria, Australia, Port Phillip (Bale, 1913) and Eastern Victoria (Watson, 1994); 4: New Zealand, North Island, Spirits Bay (Totton, 1930) and Long Beach (Ralph, 1961). Indian Ocean (5-7) = 5: Mozambique (Millard & Bouillon, 1974); 6: South Africa, False Bay to Inhaca (Millard, 1975); 7: Mumbai, India (Venugopalan & Wagh, 1986). Western Atlantic (8-13) = 8: Saint Barthélemy (Jäderholm, 1903) and Saint Thomas, U.S. Virgin Islands (Vervoort, 1967); 9: Puerto Colombia, Colombia (Vervoort, 1967); 10: Limon Bay, Costa Rica (Vervoort, 1967); 11: Bermuda (Bennitt, 1922; Calder, 1991, 2000); 12: South Carolina, St Helena and Charleston Harbour (Calder, 1983); 13: Ilha do Francês, Brazil (Vannucci, 1949). Eastern Atlantic (symbols) = ★: Congo (Leloup, 1939); +: Ghana (Buchanan, 1957); ◆: Cape Verde (Medel & Vervoort, 1998); ⊙: Mauritania (Medel & Vervoort, 1998); ▲: Canary Islands (Izquierdo, *et al.*, 1990); ■: Azores (Rees & White, 1966; Medel & Vervoort, 1998); ⊙: Morocco (Patriti, 1970); □: North Iberian Peninsula (García Corrales *et al.*, 1980).



in the Mediterranean Sea (Morri *et al.*, 2009) and, until now, it had only been recorded in the eastern basin. Picard (1958a), reported previous collections of this species in Syria, Lebanon and Israel. Vervoort (1993), found some specimens in material deposited in the Zoological Museum of the University of Tel-Aviv, corresponding to samplings carried out between 1954 and 1977 in Israel. Morri *et al.* (2009), found fertile material in Selaata (Lebanon) (Fig. 3). Schuchert (pers. comm.) collected *S. marginata* in the Island of Paros (Greece) in 1990. The specimens were deposited in the Natural History Museum of Geneva (HNG-INVE-29463).

Although the Suez Canal is the most common pathway for introductions to the Eastern Mediterranean (Galil & Zenetos, 2002; Gofas & Zenetos, 2003), Picard (1958b) considered that *S. marginata* is not a lessepsian species because, unlike species that have entered into the Mediterranean through the Suez Canal, *S. marginata* is not found in both the Canal area and Egyptian waters. Morri *et al.* (2009) were in agreement with Picard (1958b) and, based on the colonies found by Medel Soteras *et al.* (1991), they considered a possible introduction through the Strait of Gibraltar, crossing the central Mediterranean, and extending into the eastern Mediterranean by shipping.

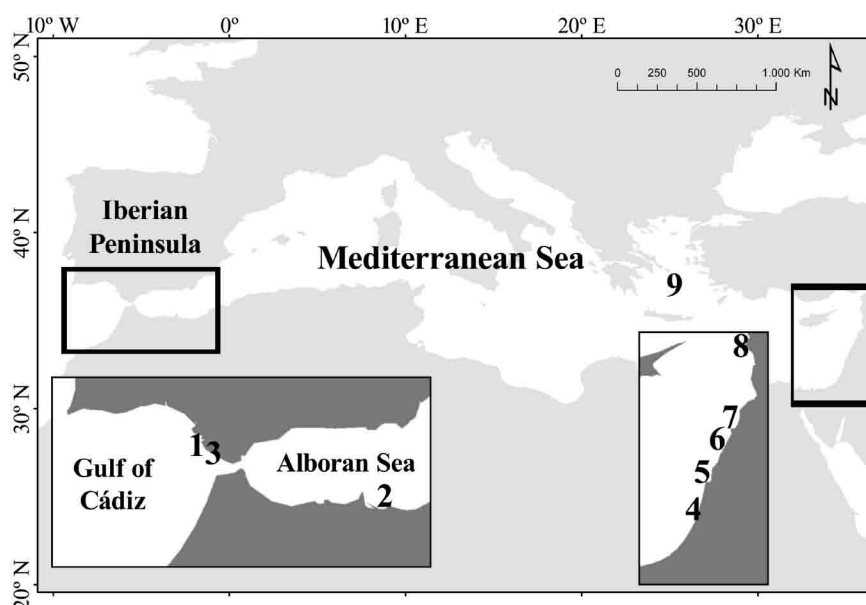
We detected two populations of *S. marginata* during an extensive sampling program for marine benthic hydroids in coastal ecosystems, covering the Gulf of Cádiz, the Strait of Gibraltar and the Alboran Sea during 2007 (González-Duarte *et al.*, 2013) with additional samplings carried out in September 2012 (Fig. 3). We collected a sample of 35 colonies of *S. marginata*, several of them

fertile, in the Chafarinas Islands (Southern Alboran Sea, Western Mediterranean). Collections at this site consisted of 4 vertical transects, down to -25 m, and 1 m wide. Chafarinas Islands were extensively studied in 1991 by Peña Cantero & García Carrascosa (2002) and the species was not found, which suggests a recent arrival.

In September 2012, we found a dense population of *S. marginata* 30km northwest of a site sampled by Medel Soteras *et al.* (1991), at -10m on a shipwreck from the Battle of Trafalgar (36°24.57'N; 6°14.15'W). *Sertularia marginata* was a very abundant component of the benthic community and most colonies were fertile (Fig. 1). We counted up to 69 colonies in 15 × 15 cm photoquadrats extracted from video transects.

The two populations detected provide relevant information to elucidate the vector and pathway of introduction of *S. marginata*, as well as to discuss the present status of this species in the Mediterranean. A natural dispersion into the Eastern Mediterranean through the Suez Canal does not seem probable (Picard, 1958a; Morri *et al.*, 2009). But entry through the Strait of Gibraltar and dispersion to the Eastern Mediterranean using its own means also seems unlikely, given that the species had never been detected at any intermediate point before 2007 (Boero & Fresi, 1986; De Vito, 2006; Puce *et al.*, 2009; Gravili *et al.*, 2013).

Other than the observed disjunctive distribution in the Western and Eastern Mediterranean, it presents a disjunctive amphi-Atlantic distribution that could be correlated with a dispersion by anthropogenic vectors (Haydar, 2012). Indeed, it has been recorded as an introduced species in Hawaii through fouling and ballast water



**Fig. 3:** Records of *Sertularia marginata* (Kirchenpauer, 1864) in the Gulf of Cádiz and Mediterranean Sea. 1-2: present paper, 1) Sancti Petri, Shipwreck, 2) Chafarinas Islands. 3) Caños de Meca and Roche (Medel Soteras *et al.*, 1991). 4-5: Israel coasts, 4) Palmakhim (Vervoort, 1993), 5) Tantura (Picard, 1958a; Vervoort, 1993) and Akhziv (Vervoort, 1993). 6-7: Lebanon coasts, 6) Beirut (Picard, 1958a), 7) Selaata (Morri *et al.*, 2009). 8) Latakia, Syria (Picard, 1958a).

(Carlton & Eldredge, 2009). *S. marginata* has been collected in several harbours and estuary areas: Port Phillip in Southern Australia (Bale, 1913), Bombay (Venugopalan & Wagh, 1986), Charleston Harbour in South Carolina (Calder, 1983), Puerto Colombia (Vervoort, 1967) and the mouth of the BouRegreg river (Patrìti, 1970). Present available evidence is in agreement with the hypothesis of Morri *et al.* (2009) of an anthropogenic introduction in the Eastern Mediterranean.

Nevertheless, *S. marginata* has also been recorded as a rafting species on floating substrata (Thiel & Gutow, 2005). Aliani & Molcard (2003) have shown that rafting material could play an important role in the dispersion of benthic invertebrates in the Tyrrhenian and Ligurian Seas. Their numerical model showed that 45% of floating objects could reach the Ligurian coast from Corsica in 50 days, a distance of about 75 km. The journey between the Strait of Gibraltar and the Aegean or Levantine Sea, however, is some 3000 km; several basins with diverse hydrological conditions and complex shoreline geomorphology are crossed, which constitute efficient traps for floating items (Thiel & Gutow, 2004). In contrast to most Sertulariidae species with fixed sporosacs, *S. marginata* reproduces by a medusoid, not swimming for more than two hours (Migotto, 1998), but this would facilitate its dissemination along this journey. Its dispersion to the Levantine Sea by ships seems to be a more parsimonious explanation, due to the intense maritime traffic in the Mediterranean Sea, but more information about hydroid populations from the southern coast of the Mediterranean would be useful to elucidate between the different hypotheses.

The detection of this species in the Atlantic entrance to the Mediterranean (Medel Soteras *et al.*, 1991) followed the same pattern as other tropical or subtropical species: it occurred there a few years later than a first citation in the Canary Islands (López-González *et al.*, 2010). This has been related to the intense maritime traffic between these islands and Cádiz Bay (López-González *et al.*, 2010). In case of an anthropogenic arrival by maritime traffic, one would expect to find pioneer populations in harbours (Carlton, 2009; Mead *et al.*, 2011). However, our exploration of the Gulf of Cádiz and the Alboran Sea included two commercial harbours (Cádiz and Almería, see Megina *et al.*, 2013), and this species was not found at these sites.

According to Zenetos *et al.* (2005), invasive species are “introduced species that have overcome biotic and abiotic barriers, and are able to disseminate away from their area of initial introduction through the production of fertile offspring with noticeable impact”. Other invasive hydroids in the Mediterranean, such as *Eudendrium carneum*, are very abundant in harbours and marinas and can constitute dominant organisms in these benthic assemblages, but they are absent in natural zones (Marques *et al.*, 2000; Morri *et al.*, 2009; Megina *et al.*, 2013).

*Sertularia marginata*, in the Mediterranean, was mainly found in natural habitats (Morri *et al.*, 2009; this research). Chafarinas Islands is a Marine Protected Area where the marine environment is well preserved and far from any urban nucleus. The population in Cádiz was in an old shipwreck, a naturalized anthropogenic habitat, completely covered by encrusting calcareous organisms and integrated in the surrounding natural rocky reef.

In the Eastern Mediterranean, despite several previous records (Picard, 1958a; Vervoort, 1993), Morri *et al.* (2009) only found *S. marginata* in one of the sampled sites. Although this material was fertile, these authors suggested that the species could have failed to become fully naturalized in the Eastern Mediterranean. In the Western Mediterranean, the two populations reported were fertile, notwithstanding that previous records in this area, more than 25 years before, consisted of infertile colonies in a restricted zone (Medel Soteras *et al.*, 1991). The available evidence would be in agreement with a slow natural expansion of this species in the Gulf of Cádiz and the Alboran Sea.

Only further molecular analysis between western and eastern Mediterranean populations, Atlantic and Indo-Pacific specimens, will be able to provide additional information about the true origin and avenue of introduction in the Mediterranean Sea, and whether the western and eastern specimens have the same origin. The status of this species in the Mediterranean is still unclear, but evidence provided here makes it advisable to monitor the evolution of its populations.

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