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The presence of *Phoronis australis* (Phoronida) in southern Italian waters

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SUMMARY

Since the beginning of the 1990s records of the Phoronida species in the Mediterranean were limited to *Phoronis muelleri* Selys-Longchamps, 1903, *P. hippocrepia* Wright, 1856 and *P. psammophila* Cori, 1889. Thereafter, *P. australis* Haswell, 1883, *P. ovalis* Wright, 1856, and three species belonging to the genus *Phoronopsis* (*P. albomaculata* Gilchrist, 1907, *P. californica* Hilton, 1930 and *P. harmeri* Pixell, 1912) were recorded.

P. australis, distributed in the Indo-Pacific and in the south-eastern Atlantic Oceans, was first recorded in the Mediterranean area along the coasts of Spain and Greece. Data reported in this paper have been collected since 2003 and show the current distribution of *P. australis* in southern Italian waters. Video-photographic records and the examination of the anatomical and ecological features of fifty specimens obtained by means of diving surveys confirmed the presence of the species.

Stable populations of *P. australis* were observed at Milazzo, on the isle of Salina (Sicily) and also on the Calabrian side of the Strait of Messina. The species, which prefers to inhabit the mucous tube of *Cerianthus* spp., was always found in association with *C. membranaceus* (Spallanzani, 1784). As it has happened with other warm-temperate species, *P. australis* could have widened its distribution due to the warming of Mediterranean coastal waters, either through the Suez Canal and the Strait of Gibraltar (double-source hypothesis) or only through the latter (single-source hypothesis). The latter is supported by the earlier occurrence of the population on the Spanish coasts and its relative abundance compared to the Levantine coasts. In both cases, the present record supports the role of the Strait of Messina as a "biogeographic bridgehead" on the scale of the Mediterranean basin.

INTRODUCTION

The phylum Phoronida comprises only two genera, *Phoronis* and *Phoronopsis*, with ten valid species, mostly with wide geographic distributions. Nine species have been recorded from European waters (Emig et al., 2000), eight of which were also present in the Mediterranean: *Phoronis mulleri* Selys-Longchamps, 1903, *P. ovalis* Wright, 1856, *P. psammophila* Cori, 1889, *Phoronopsis albomaculata* Gilchrist, 1907, *P. californica* Hilton, 1930 and *P. harmeri* Pixell, 1912, which dwell on sandy or muddy bottoms, whereas *P. australis* Haswell, 1883 and *P. hippocrepia* Wright, 1856 are hard substrate borers. Up to date the checklist of the Italian marine fauna (http://www.sibm.it/CHECKLIST/princi-

palechecklistfauna.htm) includes only *P. hippocrepia, P. mulleri* and *P. psammophila.*

MATERIALS AND METHODS

The specimens have been under observation since 2003, in the context of several research projects which have been carried out in the Strait of Messina area and nearby southern Tyrrhenian Sea. This was integrated with a visual census and photographic documentation carried out in partnership with local diving associations. Photographic surveys were undertaken using a Nikon COOLPIX7009 camera (7.1 Mpx resolution) and manual collection of *C. membranaceus* tubes was carried out by divers. Samples were fixed with buffered formaldehyde, 4% isotonic solution, and coloured with Bengal Rose. The tubes of *C. membranaceus* were dissected with a fine-pointed lancet to extract specimens of *P. australis*, which were then sliced at the mean upper and mean lower regions. Sections were mounted into concave slides with glycerine-ethanol (2:1) to analyse the muscular bundles; female gonads were also extracted from four specimens and egg diameter was measured by means of a micrometric ocular. Preserved specimens were labelled with the code BAEM07Ph.aus001, at the laboratory of Ecologia del Benthos, University of Messina.

RESULTS

Specimens of *Phoronis australis* were observed as symbionts in the tube wall of *Cerianthus membranaceus* at a depth between 25 and 40 m in Sicilian and Calabrian localities. This occurred in a sandy-gravel substrate (Torre Faro 38°16' N, 15°38' E, in 2003; Saline Ioniche 37°54' N, 15°46' E, in 2003; Scilla 38°15' N, 15°42' E, in 2007), in muddy detritic bottom (Lazzaro 37°58' N, 15°39' E, in 2007; Milazzo 38°13' N, 15°15' E, in 2007 and 2008) or even in rocks with mixed sands, as observed at Salina (38°32' N, 14°52' E) in 2006 (Fig. 1A,B). The mean density was 8.3 individuals per host, preferentially positioned in the lower half of the host tube. The occurrence of *C. membranaceous* was very variable all over the investigated area, with scattered small patches of 2-3 specimens and more frequently isolated specimens; the areal density of *Phoronis* was therefore very low.

Specimens with ovigerous metacoele were found during the beginning of July (egg mean diameter 354.42 ± 34.79 μm) (Fig. 2), whereas specimens with brooded egg masses in the lophophoral cavity were found in December (Fig. 1B). In particular, the assessment of egg diameter showed a bimodal distribution of frequencies (Fig. 3), with one half of small-sized gametes (from 130 to 365 μm) and the other half of large-sized eggs (from 480 to 715 μm), although

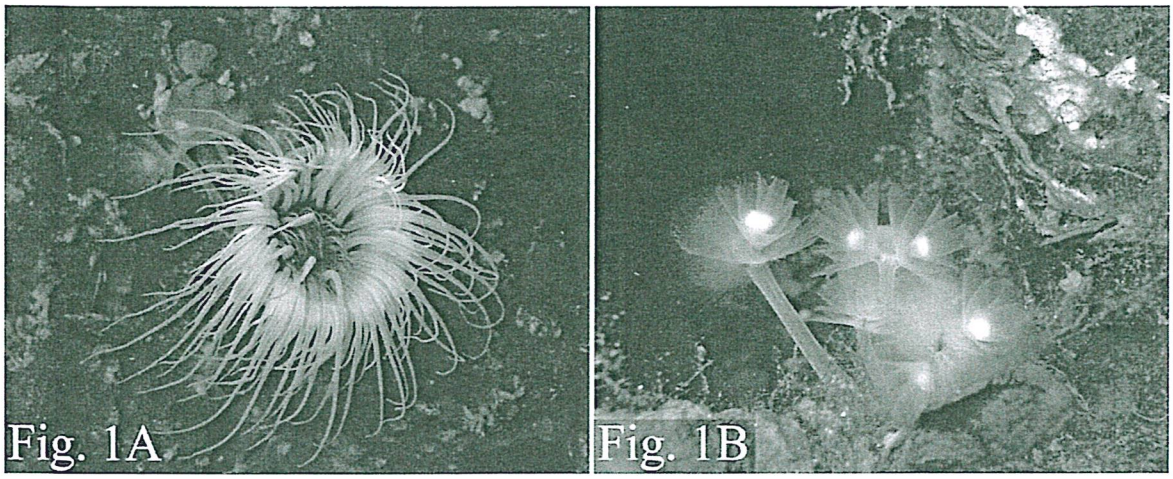

Fig. 1 – A. Specimen of *Cerianthus membranaceus* with symbiotic *Phoronis australis* (Isle of Salina, December 2006). B. Specimens of *P. australis* with brooding egg masses in the lophophoral cavity.

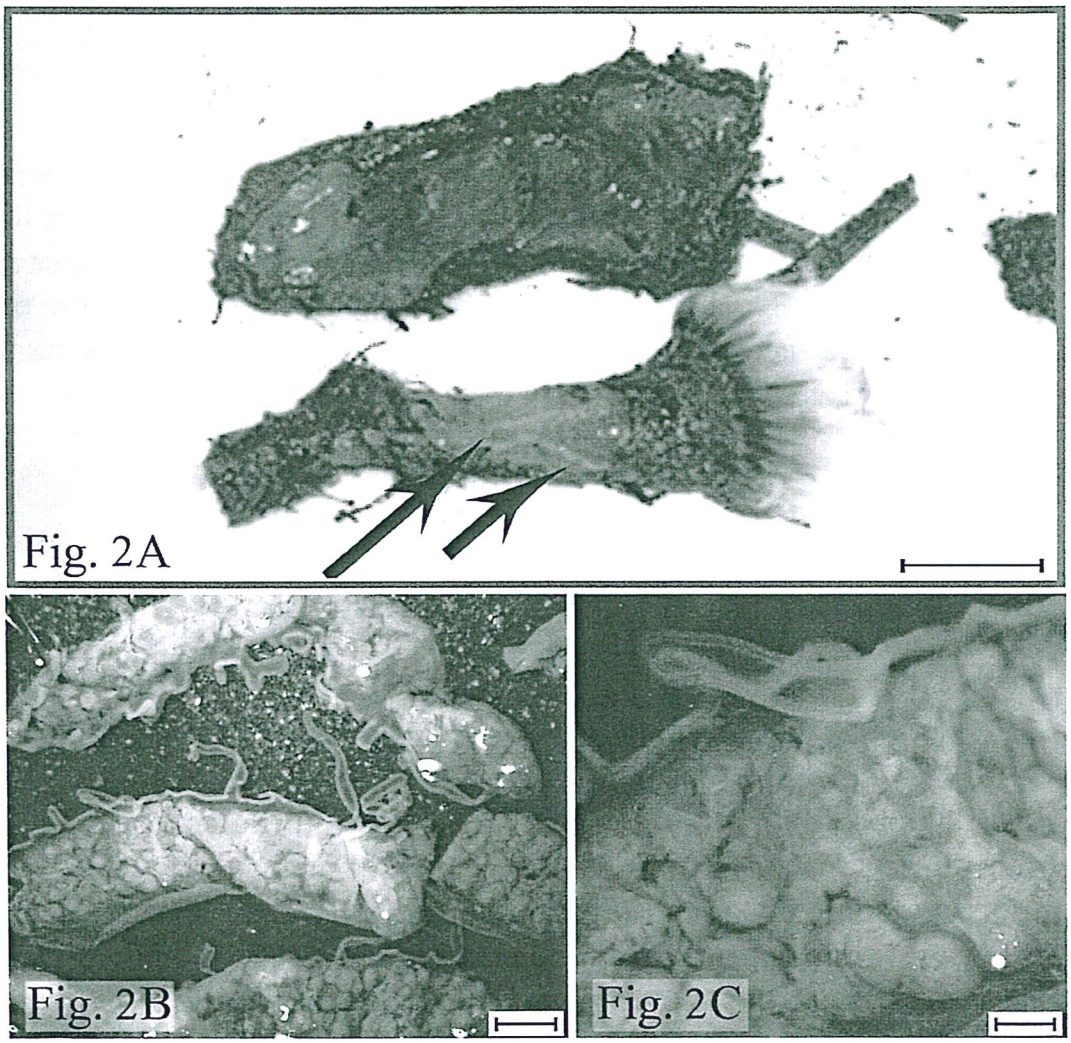

Fig. 2 – A. Dissected specimen of *C. membranaceus* (Milazzo, July 2008) with marks of *Phoronis* tubes (arrows) in the inner wall of the host tube (above); scale bar 100 mm. B. Egg masses extracted from the mid-lower metacoele in four phoronids of the same host (bar 1 mm). C. Particular of the same (bar 0.5 mm).

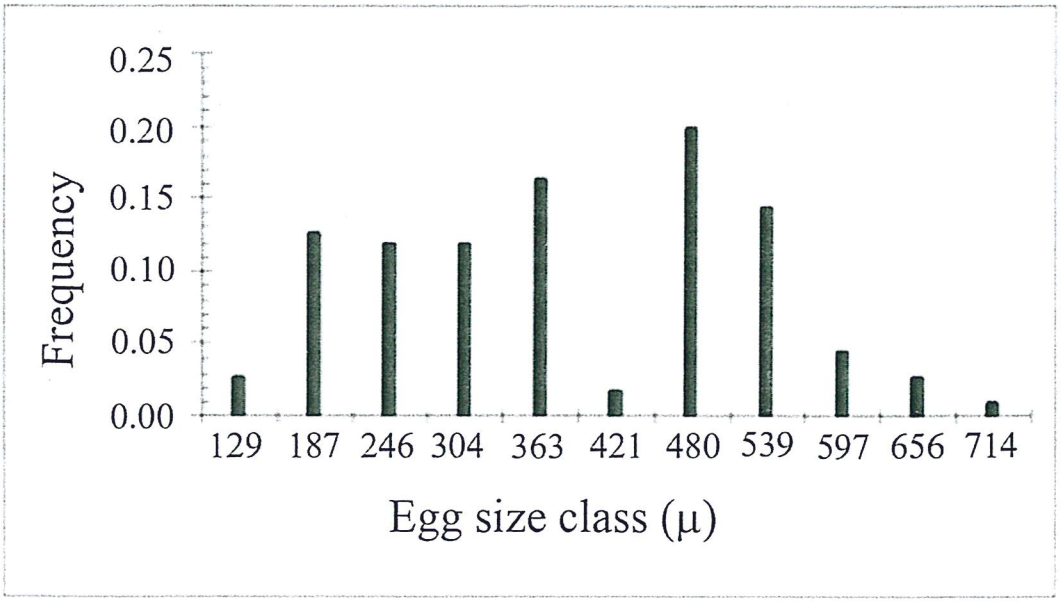

Fig. 3 – Egg size frequency of *P. australis* (four specimens; n = 110), sampled in early July 2008 at Milazzo (southern Tyrrhenian). The wide range of size and the bimodal distribution suggest a multiple spawning event for the species.

the possible increase of size due to fixing solution could not be excluded. Multiple spawning events were thus possible for the populations established in the Strait of Messina. No event of asexual reproduction was observed in our samples, but the coupled position of some specimens suggested that transverse fission also occurred. Dissected specimens showed the general muscular formula: [44-60], arranged as follows:

12-	15-
22	20
9	8-9

DISCUSSION

Phoronis australis is widely distributed in the tropical and warm-temperate waters of the Pacific Ocean (Japan, China, Philippines, Vietnam, Australia, New Caledonia) according to Emig and Roldán (1992), the Indian Ocean (India, Mozambique, Madagascar, Red Sea) according to Emig et al. (1972) and Thomassin and Emig (1983) and the eastern Atlantic (Senegal, Canary Islands, Portugal) according Emig et al. (1972), Ocaña et al. (1991), Álvarez et al. (2005). In the Mediterranean Sea (Fig. 4) the species was first recorded along the southern Spanish coasts (Emig, 1977a; Sanchez-Tocino et al., 1997; Emig et al., 1999, 2000) and in the northern Aegean Sea (Stanjek and Wägele, 1981). This phoronid is considered as an obliged suspension feeder, commensal of An-

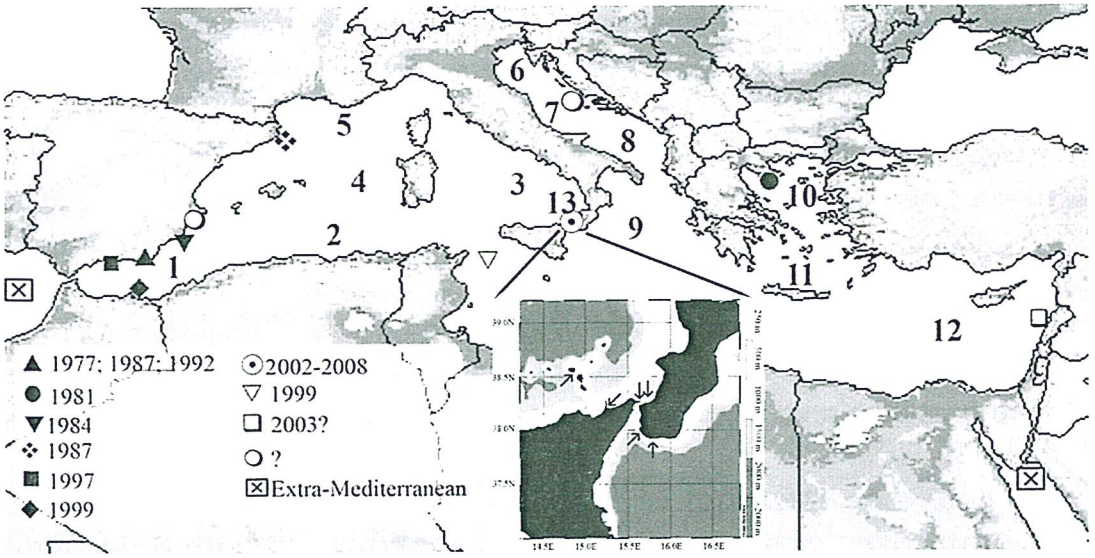

Fig. 4 – Records of *P. australis* Haswell, 1883 in the Mediterranean Sea compared to the current presence in the Sicilian and Calabrian coasts. Full symbols refer to bibliographic citations (see the text). Empty symbols refer to unofficial records, not dated with certainty ("?") and personal communications. Numbers indicate the biogeographic sectors (Bianchi, 2007 modified). Sub-panel: present records of *P. australis* (arrows) in the southern Italian coasts.

thozoan Ceriantharia particularly of the genus *Cerianthus*, though in the Western Mediterranean it has been also reported in muddy coarse detritic sands, within the rhizomes of *Posidonia oceanica* and even in a hard bottom with scarce concretions (see references in Emig et al., 2000). As a symbiont, *P. australis* bores the tube wall of the host between the fourth and fifth mucous layers (Emig et al., 1972), with densities of 20/50 individuals per host, reaching up to 100 individuals in tropical regions (Emig, 1979; Alvarez et al., 2005). These values are far above the average densities observed in southern Italian seas. Bathymetric distribution is narrower than in the original area (Alvarez et al., 2005), coinciding with the lower limit only. The low host density and the reduced infestation intensity make the species rather rare at the moment.

Visual census demonstrated the widespread distribution of the species in the Strait of Messina, with a preference for muddy coastal sandy/detritic bottoms. *In situ* and laboratory observations showed a delayed reproductive period from the beginning of summer up to the onset of the cold season. The egg mean diameter in the early July samples was far above those recorded by other authors who reported an average size of 100 μm, with a moderate yolk content (Emig, 1977b, 1979). Such big sized eggs were clues of a reduced pelagic stage with lecitotrophic and slow-dispersive larvae (to date unknown), a life-history trait coherent with a symbiotic habit. This aspect might be counterbalanced by its extended reproductive period and by the widespread distribution of the host *C. membranaceus*, justifying the moderate rapidity of dispersal throughout the Mediterranean Sea during the last 30 years. Moreover, the low grade of epibio-

sis of *C. membranaceus* in the Mediterranean and the absence of real competitors for space make its tube a new habitat free to be colonized. Similarly with other non indigenous species (see Occhipinti-Ambrogi, 2007; Wallentinus and Nyberg, 2007), the spread of *P. australis* may be favoured by the lack of any competition and tied to its peculiar life-habit and not species-specific symbiontic association. Our observations did not highlight any evidence of damage in the host, in agreement with Emig et al. (1972) who examined Madagascan populations. At the present time, the spread of *P. australis* does not appear to have determined any particular alteration in the autochthonous biota, whereas its stable presence seems to have increased the local biodiversity (Parker et al., 1999; Galil, 2007).

According to the chronology of records, the immigration of *P. australis* to Mediterranean coastal waters could have occurred through both the Strait of Gibraltar and the Suez Canal at the same time or, alternatively, only through the former. In the first scenario, the Strait of Messina would join the two supposed areas of immigration while in the second it would act as a bridgehead for the diffusion of marine species towards eastern regions (Fig. 4, sub-panel).

CONCLUSIONS

The present article represents the first published record of *P. australis* from Italian coastal waters. Up-to-date records demonstrate that *P. australis* has spread across the Mediterranean from the westernmost region to the Aegean Sea. The frequent occurrence of brooding individuals indicates that this warm-water symbiotic lophophorate has already established stable populations. There is no evidence of direct negative effects on the receiving environment. However, its highly patchy areal and its moderately low occurrence indicate an irregular spreading from the incoming tropical Mediterranean Sea (Bianchi, 2007). More data on the reproductive biology and life history traits is needed to explain the real population dynamics of this species and to identify its spatial distribution both on a small and a large scale.

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