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Intertidal biodiversity hotspot strikes again: first record of *Caliphylla mediterranea* A. Costa, 1867 (Mollusca, Sacoglossa) in the Adriatic Sea, Italy

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Abstract. The Mediterranean Sea is considered a hotspot of molluscan diversity even if many marine environments are still poorly explored and could mask rare and/or neglected diversity. During a night survey in a rocky tide pool in the Adriatic Sea, near Ancona, Italy, *Caliphylla mediterranea* A. Costa, 1867, a rare sacoglossan mollusc, was observed and documented. This finding constitutes the first record of this species for the Adriatic Sea and one of the few for the whole Mediterranean basin extending the known distributional range of this poorly known species.

Key words. Biodiversity, citizen science, Heterobranchia, Mediterranean Sea, tide pools.

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INTRODUCTION

Despite being 0.82% of the world's oceanic surface, the Mediterranean Sea is recognized as a global hotspot of marine biodiversity, hosting over 4% of all known marine taxa (Bianchi and Morri 2000; Coll et al. 2010; Mouillot et al. 2011; Trainito and Baldacconi 2021). Among all the known animal groups, molluscs are one of the most representative in the Mediterranean Sea, with about 2,000 species—18% of the entire Mediterranean marine fauna, including both native and non-native taxa—reported so far (Sabelli and Taviani 2013; Prkic et al. 2014; Carmona 2020; Chimienti et al. 2020; Furfaro and Mariottini 2020; Martín-Hervás et al. 2020; Furfaro et al. 2021b; Trainito and Baldacconi 2021; Renda et al. 2022). Within this phylum, the marine Heterobranchia represent a highly specialized subclass of Gastropoda. They are characterized by unique morphological and ecological adaptations like the reduction or complete loss of the shell in the adult stage, a key character that coevolved with highly specialised alternative defensive strategies. The presence of toxic and/or repellent chemical compounds (Gavagnin et al. 2019; Avila 2020), symbiotic associations with other taxa (Pelletreau et al. 2012; Chan et al. 2018; Furfaro et al. 2021a), regeneration ability and autotomy (Mitoh and Yusa 2021; Furfaro and Mariottini 2021; Gutierrez-Andrade and Middlebrooks 2023), and kleptopredation behaviour (Willis et al. 2017; Goodheart et al. 2018; Maggioni et al. 2023) are just few examples of the extraordinary abilities of these specialised gastropods that are, indeed, of interest in fields of basic and applied research (Cimino and Ghiselin 1999; Dean and Prinsep 2017; Gavagnin et al. 2019; Katz and Quinlan 2019; Zhuo et al. 2022).

Within the Heterobranchia, the superorder Sacoglossa comprises approximately 300 accepted species (Jensen 2007), at least 38 of which are known to inhabit the Mediterranean Sea (Jensen 2007; Trainito and Doneddu 2014; Martin-Hervás et al. 2020; Trainito et al. 2022). Almost all the sacoglossan species are herbivorous and capable to extract the cytoplasmatic contents of siphonalean green algae (Ulvophyceae) (Jensen 1994; Williams and Walker 1999; De Vries et al. 2014), but they can also show interesting and unexpected interactions with different taxa such as symbiotic crustaceans (Furfaro et al. 2021a) and atypical borrowing behaviour (Trainito et al. 2022). However, a distinctive feature of many species belonging to this group is

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the kleptoplasty—the sequestration of functional chloroplasts from algal cells, which are subsequently retained within the cells of the digestive diverticula (Williams and Walker 1999). Several studies demonstrated these chloroplasts can remain photosynthetically active for many weeks, contributing to the host's energy metabolism (Clark et al. 1990; Williams and Walker 1999; Rumpho et al. 2007; Wägele 2015). The duration of photosynthetic activity can vary according to the degree of specialization. In fact, some species, like *Elysia chlorotica* A.A. Gould, 1870, are capable to maintain functional chloroplasts for several months, while others, like *Caliphylla mediterranea* A. Costa, 1867, show a rapid and almost immediate decline of the photosynthetic activity (Clark et al. 1990; Pierce et al. 1996; De Vries et al. 2014).

Sacoglossa species can live in different shallow marine areas, including transitional coastal sites such as the Mediterranean rocky tide pools (Riccardi et al. 2022; Trainito et al. 2022; Toso et al. 2024). This latter environment revealed a good source of heterobranch diversity, even if only few of these environments have been explored so far in the Mediterranean Sea (Toso et al. 2024). The rocky tide pools located near Passetto Beach, Ancona, Italy, in the northern Adriatic Sea (sector 9) (Bianchi 2004), revealed a hotspot of neglected and/or unknown Heterobranchia species (Riccardi et al. 2022; Toso et al. 2024). In fact, tidal dynamics in conjunction with the limestone coastal substrate give rise to ephemeral intertidal pools (De Pippo and Donadio 1999; Cerrano et al. 2014) which temporarily retain a diverse assemblage of organisms during low tides, isolating them until the next tidal inundation.

In this context, new observations from the same area, the semi-closed rocky tide pools in Ancona, revealed another case of a rare sacoglossan species, increasing the list of the Heterobranchia known from this poorly explored Mediterranean environment and from the whole Adriatic Sea.

METHODS

The survey was conducted in a semi-closed limestone rocky tide pool near Passetto Beach, Ancona, Italy (43°37′08.8″N, 013°31′55.0″E) during an incoming tide, with the sea level rising from −0.28 m at 18:00 (UTC+1), to 0.00 m at 22:30 (UTC+1) on 1 March 2025 (ISPRA 2025). The environmental characteristics of the tide pool and the associated benthic communities were consistent with those already reported in the previous studies focused on this site (Riccardi et al. 2022; Toso et al. 2024). Pictures were taken using an Olympus TG-4 camera equipped with underwater housing and external flash UFL-3.

RESULTS

One specimen belonging to *Caliphylla mediterranea* was photographed during a night dive in the semi-closed limestone rocky tide pool near Passetto Beach in Ancona, Italy (Figure 1).

Phylum Mollusca
Class Gastropoda
Subclass Heterobranchia
Superorder Sacoglossa
Family Caliphyllidae Tiberi, 1881
Genus *Caliphylla* A. Costa, 1867

***Caliphylla mediterranea* A. Costa, 1867**
Figures 1, 2

Observations. ITALY — Ancona • Passetto Beach; 43°37′08.8″N, 013°31′55.0″E; ca. 15 cm depth; 01 Mar. 2025, 22:07; Paoletti obs.; 1 specimen, ca. 20–30 mm, adult, photophilic algae on hard substrate in semi-closed tide pool.

Identification. Taxonomic identification was conducted through the analysis of *in situ* pictures of the specimen observed underwater but not collected. Morphological features such as body shape and colour pattern which were clearly visible from the underwater images of the observed specimen were compared with what reported so far in the identification guides (Trainito and Doneddu 2014) and in the available literature, including original description and the following redescriptions (Costa 1867, 1869; Trinchese 1870; Bergh 1876; Gascoigne 1979).

Morphology description. The body of the observed specimen was elongate, translucent, with vivid green/brown coloration due to the presence of digestive diverticula and chloroplasts in the whole body (Figure 2A–C). It showed small red and white dots all over the body, with a thin layer of white dots concentrated at the base and along the edges of the cerata, sometimes scattered along their whole surface.

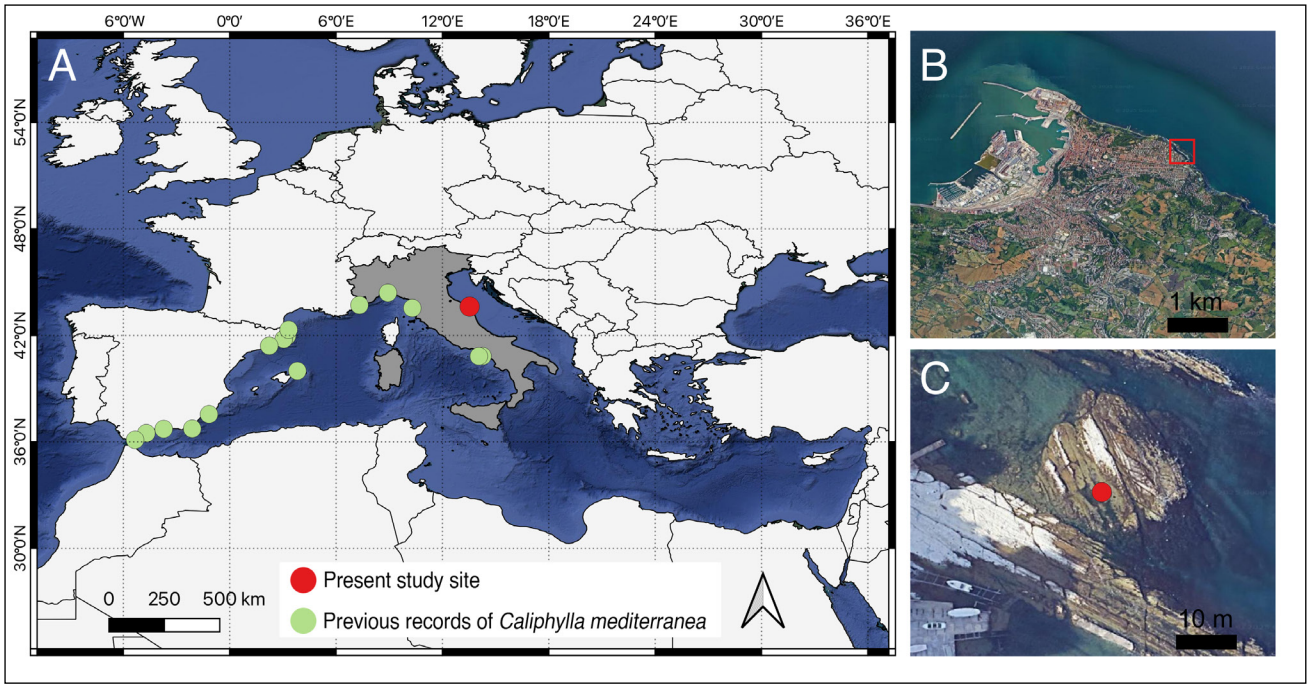

Figure 1. Distribution map of *Caliphylla mediterranea* in the Mediterranean Sea. **A.** Based on bibliographic data and present study. The green dots indicate the previously known records; the red one indicates the new record. Satellite image by ©2025 Google, NASA. **B, C.** The exact site of the new record object of the present study, indicated by the red frame (**B**) and the red dot (**C**). Satellite pictures by ©2025 Google, Airbus/CNES (B) and ©2025 Google, Airbus (C). Map produced using QGIS v. 3.40.2 Bratislava (QGIS Developing Team 2025).

Figure 2. Underwater images showing the external morphology of *Caliphylla mediterranea* from the study site. **A–C.** Right, left, and frontal views, respectively, of the observed specimen. **D.** Detail of the cephalic portion with the Y-shaped rhinophores and the short oral veil. **E.** Dorsal view of the observed specimen. **F.** Detail of the cephalic portion and the small eyes.

A small white dotted spot was present between the rhinophores. The head was characterized by bearing bifid, rolled, and Y-shaped rhinophores, with their tips divided into unequal parts (Figure 2D). There were small eyes behind the bases of the rhinophores (Figure 2E, F). Near the mouth, an oral veil with short oral tentacles was present. The individual showed numerous leaf-shaped cerata, which were flatted and ovoid, of different sizes, smaller laterally and increasingly larger in the middle-dorsal area, but never larger than the maximum body width. The cerata were set in four longitudinal rows and presented a high concentration of digestive diverticula. The tall, oval pericardium was in the dorsal area, behind the head and hidden by the cerata. The posterior of the foot was short.

Ecology. The specimen was observed in a semi-closed tide pool at night. It showed a strong host-cryptic-ity to photophilic green algae, in this case *Ulva* sp. The crypticity can be even more pronounced on *Bryopsis plumosa* (Hudson) C. Agardh, 1823, the algae on which it usually feeds, as reported by Di Marzo et al. (1993).

Distribution. In the Mediterranean Sea *C. mediterranea* is present only in the western basin (Figure 1A): Italy (Costa 1867; Trinchese 1870; Gascoigne 1979; Di Marzo et al. 1993), France (Pruvot-Fol 1954), Spain (Luque 1983; Templado et al. 1987; García Raso et al. 1992; Ocañahe Martin et al. 2000; Parera et al. 2020; Ballesteros et al. 2022; Salvador et al. 2022), Murcia, and Gibraltar (García Gómez 2002). However, its distribution is currently considered as amphi-Atlantic, having been reported from the Cape Verde (Ortea and Moro 2018), Azores (Jensen 2014), and Canary Islands (Ortea 1981, Ortea et al. 2000), Ascension Island (Padula et al. 2017), the Atlantic coast of Morocco and Senegal (Pruvot-Fol 1953), Florida (Clark and Jensen 1981; Clark et al. 1990; García et al. 2007; Jensen 2014), the Virgin Islands (Jensen 2014), the Gulf of Mexico (De La Cruz-Francisco 2025), the Caribbean coast (García et al. 2007; Goodheart et al. 2016; Caviedes et al. 2019) and Brazil (García et al. 2007; Padula et al. 2012; Galvão Filho et al. 2015; Xavier et al. 2017; Delgado et al. 2022).

Remarks. This species has a long and troubled taxonomic history that still requires some clarification, especially about the identity of extra-Mediterranean populations. In fact, according to Ortea 1981, *Caliphylla* specimens originally identified by Pruvot-Fol in 1953 from the Atlantic coast of Morocco and Senegal, should be reclassified as *C. viridis* (Deshayes, 1857) due to different morphology (shape of the cerata and dorsal pigmentation) with Mediterranean populations. Caviedes et al. (2019) reported an undescribed species from the Gulf of Mexico on the basis of a single specimen that, however, exhibited several morphological traits consistent with *C. mediterranea*. Later, Alves et al. (2022) described a new species of *Caliphylla*, *C. yemanjae* Alves, Lima, Johnsson & Neves, 2022, from the Tropical Southwestern Atlantic (Brazil), highlighting a greater species diversity within the genus than previously thought. However, additional specimens collected in Brazil in the same year and provisionally assigned to *C. mediterranea* showed intermediate morphological characteristics (head shape, body coloration and shape of the cerata) between *C. mediterranea* and *C. yermaniae*, raising some doubts on the validity of the latter species. This complex scenario calls into question the assumed amphi-Atlantic distribution of *C. mediterranea* as a single, polymorphic species. Further anatomical and molecular analyses are necessary to reveal its true biogeographic range and clarify its extra-Mediterranean taxonomic status (Carmona et al. 2011; Jensen 2014). *Caliphylla mediterranea* is the only *Caliphylla* species present in the Mediterranean Sea, although two records, from Gozo (Malta) and Rhodos (Greece), of *C. viridis* recently reported in a website deserve confirmation (Ballesteros et al. 2025). *Caliphylla mediterranea* external morphology is characterized by the presence of four rows of flat, leaf-shaped cerata and dark green-brownish pigmented dorsal area (Gascoigne 1979), while cerata of *C. viridis* appear leaf-shaped and irregular, showing clear white pigmented spots in correspondence of the head and pericardium (Ortea 1981). Finally, *C. yermaniae* shows very long leaf-shaped cerata, a bright, light-green dorsal pigmentation, and a round head distinct from the body (Alves et al. 2022), in contrast to the head continuous with the body of *C. mediterranea* (Gascoigne 1979). For all these reasons, the specimen found in this study can be confidently identified as *C. mediterranea*.

DISCUSSION

The present find of a *Caliphylla mediterranea* specimen from the rocky tide pools in Ancona, constitutes not only a new record of this species after about half a century but also represents the first documented occurrence of this species in the Adriatic Sea. In fact, although *C. mediterranea* was originally described from Naples, Italy, subsequent observations have been scarce in the Mediterranean Sea and almost restricted to the western basin, with only a few outdated records available so far (Costa 1867; Trinchese 1870; Bergh 1876; Gascoigne 1979) (Figure 1). This new record, approximately 1,700 km from the nearest previous observation in Naples, suggests that *C. mediterranea* is capable of inhabiting marine environments with varied ecological conditions, like those characterizing two different seas (Tyrrhenian and Adriatic) and suggests a potentially broader distribution of this species than previously known. Furthermore, the discovery of this species in an area which has recently been the subject of a study of the heterobranch fauna (Riccardi et al. 2022; Toso et al. 2024) is quite unexpected and underlines the importance of continued monitoring of this area. In fact,

despite their ecological sensitivity and susceptibility to anthropogenic pressure (Turchetti and Tarsetti 2007), such habitats also provide valuable opportunities for benthic biodiversity assessments. Indeed, since they are easy to access, they facilitate data collection through non-invasive observational methods, including citizen-science initiatives, as already done in other environments on the platform iNaturalist (Aristeidou et al. 2021), and contributions from underwater macro-photographers.

This new record of *C. mediterranea* draws renewed attention to the study of neglected and/or rare Mediterranean species, which are usually characterized by cryptic appearance and can cause an underestimation of the overall biodiversity in the Mediterranean. For all these reasons, an increased effort is required to fulfil some gaps that still exist in the knowledge of the taxonomy of this genus and in the ecology and distribution of such poorly known species, hopefully by involving both scientists, amateurs and/or underwater photographers.

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ADDITIONAL INFORMATION

Conflict of interest

The authors declare that no competing interests exist.

Ethical statement

No ethical statement is reported.

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Author contributions

Conceptualization: LP, GF. Data curation: LP, YT, ET, MS. Funding acquisition: GF. Investigation: LP. Methodology: LP, YT, ET, MS, GF. Resources: LP, GF. Supervision: GF. Visualization: YT, MS. Validation: ET, GF. Writing – original draft: LP, YT. Writing – review and editing: LP, YT, ET, MS, GF.

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Data availability

All data that support the findings of this study are available in the main text.

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