Biodiversity Journal, 2018, 9 (1): 25–34

Mollusc diversity in Capo d'Armi (Central Mediterranean Sea) subtidal cliff: a first, tardy, report

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ABSTRACT First quantitative data on mollusc assemblages from the Capo d'Armi cliff, at the south entrance of the Strait of Messina, provided a baseline for monitoring changes in benthic biodiversity of a crucial Mediterranean area, whose depletion might already be advanced. A total of 133 benthic taxa have been recorded, and their distribution evaluated according to depth and seasonality. Bathymetric distribution showed scanty differences between the 4-6 meters and 12-16 meters depth levels, sharing all the 22 most abundant species. Season markedly affected species composition, since 42 taxa were exclusively recorded in spring and 35 in autumn, contrary to 56 shared taxa. The occurrence of some uncommon taxa has also been discussed. The benthic mollusc assemblages, although sampled in Ionian Sea, showed a clear western species composition, in accordance with literature placing east of the Strait the boundary line between western and eastern Mediterranean eco-regions. Opposite, occasional records of six mesopelagic species, which included the first record for this area of *Atlanta helicinoidea*, were linked to the local upwelling of Levantine Intermediate Waters.

KEY WORDS Biodiversity; benthos; molluscs; Mediterranean; coastal environment.

Received 03.12.2017; accepted 29.01.2018; printed 30.03.2018

INTRODUCTION

The Strait of Messina, long recognized as a threatened hotspot of biodiversity (Pintner, 1909), is still far from being exhaustively explored, as suggested by the recent revision of "opisthobranch" fauna of transitional waters (Vitale et al., 2016) and by new mollusc species having in the Strait their locus typicus, which notably increased the number of 827 mollusc species assessed for such biogeographic sector (http://www.sibm.it/CHECKLIST/menu%20checklist%20I.htm). Most recent mollusc species included, for example, *Fusinus dimassai* Buzzurro et Russo, 2007; *Tricolia landinii* Bogi et Campani, 2007; *Gibberula cristinae* Tisselli, Agamennone et Giunchi, 2009; *Xylodiscula wareni* Bogi et Bartolini, 2008; *Raphitoma spadiana* Pusateri et Giannuzzi-Savelli, 2012; *Raphitoma smriglioi* Pusateri et Giannuzzi-Savelli, 2013; *Fusinus ventimigliae* Russo et Renda in Russo, 2013; *Granulina lapernai* Smriglio et Mariottini, 2013; *Setia homerica* Romani et Scuderi, 2015; *Skenea giemellorum* Romani, Bogi et Bartolini, 2015; *Vetulonia giacobbei* Renda et Micali, 2016; *Granulina zanclea* Bogi, Boyer, Renda et Giacobbe, 2016; *Jujubinus errinae* Smriglio, Mariottini et Giacobbe, 2016; *Alvania scuderii* Villari, 2017. Such a wealth of diversity, nevertheless, represents the sum of numerous disjoined and often occasional reports throughout at least two centuries from Philippi (1836–1844) and does not take into account the environmental changes that have occurred in the meantime. This is to say that the baselines required for measuring the local effects of the incoming global changes are almost lacking. A review of the whole mollusc diversity is unachievable in the short time due to the extreme complexity of the Strait of Messina ecosystem, but at least some vulnerable environments should be investigated as a priority. The Capo d'Armi cliff, in our opinion, represents one of these priorities, due to the lack of previous investigations, and the key position at the south entrance of the Strait, as well as evident signals of ecosystem decline forecasting a rapid and significant loss of biodiversity.

In this paper, living molluscs contextually sampled from the Capo d'Armi photophilic zone are reported, as a first account of the local mollusc biodiversity. The aim of the study is to provide a baseline for monitoring changes in benthic biodiversity of such crucial area, whose depletion might already be advanced.

MATERIAL AND METHODS

Study area

Capo d'Armi (Fig. 1), the Greek-Roman "Leucopetra", represents the southeastern limit of the Strait of Messina. The backdrops have been recognized as sites of Community importance since 2000 (SIC code IT9350140), with a high degree of vulnerability due to the urbanization. In this area, the continental shelf is lacking, so that the rocky cliff is directly connected to the continental slope, which rapidly overcomes the 1000 meters deep. The local hydrology, since it is directly influenced by the tidal regime and related uphill to the Strait of Messina, is responsible of high levels of plankton primary production (Azzaro et al., 2007).

Figure 1. Study area: Capo d'Armi, Strait of Messina.

Sampling plan included three sites, about 200 meters away from each other. In each site, two bathymetric levels (4–6 and 12–16 meters deep) were sampled, each performed by three replicates about 20 meters away from each other. Seasonality was evaluated by replicates carried out in Autumn (I time) and Spring (II time). The samples were collected by scraping 30x30 cm surface of rocky substrate, separately gathered in 0.1 mm mesh sampling-nets, and stored in ethanol 75%. In laboratory, macrofauna was sorted under stereomicroscope and the specimens were determined at species level, as far as possible. Specimens were counted separately for each replicate, but taxa abundance per sample was evaluated by the three pooled replicates.

Most relevant species have been photographed by means of USB DCM130 digital camera mounted on a binocular microscope. The photos were then processed with Photoshop software.

Nomenclature followed WoRMS (http://www.marinespecies.org/), updated at 2017-12-24.

RESULTS

Benthic species

A total of 2414 specimens belonging to 133 benthic taxa have been recorded, and their taxonomic position is summarized in Table 1. The species were almost equally distributed between the two seasons, weakly declining from spring to autumn (98 and 91 species, respectively), although specimen abundance increased (1014 and 1360 individuals, respectively). A total of 56 taxa were shared, whilst 42 taxa were exclusively recorded in spring and 35 in autumn. The not shared taxa were generally represented by few specimens, reaching a maximum of 6 individuals for both *Gouldia minima* (Montagu, 1803) and *Tritia incrassata* (Strøm, 1768), recorded in spring. The number of specimen for species was generally low, except for a half

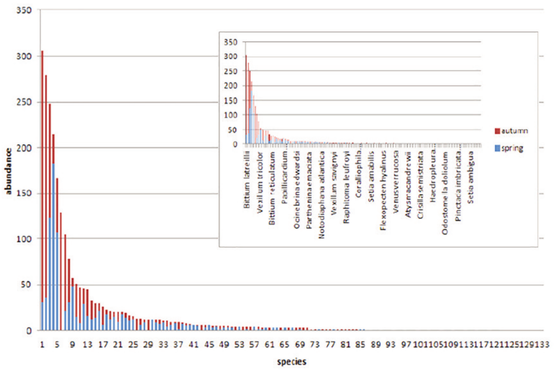

Figure 2. Rank ordination of species (decreasing number of specimens for species) and detail of the 22 most abundant species (> 20 specimens), according to their spring (blue) and autumn (red) abundance.

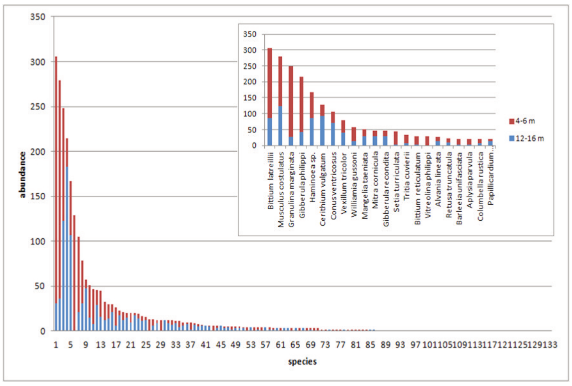

Figure 3. Rank ordination of species (decreasing number of specimens for species) and detail of the 22 most abundant species (> 20 specimens), according to the lower (red) and deeper (blue) bathymetric levels.

dozen of taxa which together accounted for 50% of total (Fig. 2). Within such restricted group of species, the two most abundant ones, *Bittium latreillii* (Payraudeau, 1826) (306 specimens) and *Musculus costulatus* (Risso, 1826) (279 specimens) dominated the autumnal assemblage, followed by *Granulina marginata* (Bivona, 1832) (248 specimens) who was equally distributed between the two seasons. On the other hand, the 4th and 5th ranked species, i.e. *Gibberula philippi* (Monterosato, 1878), 215 specimens, and *Haminoea* sp., (167 specimens), prevailed in autumn. The 129 specimens of *Cerithium vulgatum* Bruguière, 1792 were recorded in spring except for a single one found in autumn.

Bathymetric distribution (Fig. 3) showed scanty differences between the 4–6 and 12–16 meters deep levels, which shared 59 species, including all the 22 most abundant ones. Other 30 species were recorded only at 4–6 meters deep vs the 53 exclusively found at 14–16 meters. Although most of the not shared species (47) provided only a specimen, at least *Rissoa variabilis* (Megerle von Mühlfeld, 1824) and *Tricolia pullus* (Linnaeus, 1758) (12 individuals of both species at 14–16 meters deep) reached almost high concentrations. Within the group of most abundant species, *B. latreillii*, *G. marginata* and *G. philippi* best characterized the shallower depth, *M. costulatus*, *Haminoea* sp. and *Pusia tricolor* (Gmelin, 1791) were almost equally distributed between the two levels, whilst *C. vulgatum* and *Conus ventricosus* Gmelin, 1791 were most abundant at a deeper level.

The most abundant species, as expected, are well known and widely distributed in the Mediterranean Sea. The marginellid *Gibberula recondita* Monterosato, 1884 nevertheless, is a typical western species, unknown in the eastern Mediterranean basins (Gofas, 1990), while *G. marginata* and *G. philippi* (Fig. 4), which are the most tied to the western basins (Gofas, 1990; Boyer et al., 2002), have been sporadically reported in the eastern areas, but without confirmation by pictures of shells and observations on the mollusc chromatic patterns. The same *G. philippi* in the Strait of Messina might be represented by a not yet investigated species complex.

Figure 4. *Gibberula philippi* from Capo d’Armi, Strait of Messina.

SYSTEMATICS

POLYPLACOPHORA

CALLOCHITONIDAE Plate, 1901
Callochiton calcatus Dell'Angelo et Palazzi, 1994

CHITONIDAE Rafinesque, 1815
Chiton (*Rhyssoplax*) *olivaceus* Spengler, 1797

ACANTHOCHITONIDAE Simroth, 1894
Acanthochitona fascicularis (Linnaeus, 1767)

GASTROPODA

SCISSURELLIDAE Gray, 1847
Scissurella costata d'Orbigny, 1824

TROCHIDAE Rafinesque, 1815
Clanculus cruciatus (Linnaeus, 1758)
Jujubinus striatus (Linnaeus, 1758)

CALLIOSTOMATIDAE Thiele, 1924 (1847)
Caliostoma laugieri (Payraudeau, 1826)
Calliostoma sp.

PHASIANELLIDAE Swainson, 1840
Tricolia pullus (Linnaeus, 1758)
Tricolia tenuis (Michaud, 1829)

CERITHIIDAE Fleming, 1822
Bittium latreillii (Payraudeau, 1826)
Bittium reticulatum (da Costa, 1778)
Bittium submamillatum (De Rayneval et Ponz, 1854)
Cerithium renovatum Monterosato, 1884
Cerithium vulgatum vulgatum Bruguiere, 1792

TRIPHORIDAE Gray, 1847
Strobiligera brychia (Bouchet et Guillemo, 1978)
Monophorus sp.

CERITHIOPSIDAE H. Adams et A. Adams, 1853
Cerithiopsis buzzurroi (Cecalupo et Robba, 2010)

EULIMIDAE Philippi, 1853
Melanella polita (Linnaeus, 1758)
Vitreolina incurva (B.D.D., 1883)
Vitreolina philippi (de Rayneval et Ponzi, 1854)

RISSOOIDAE Gray, 1847
Rissoa guerini Recluz, 1843
Rissoa lia (Monterosato, 1884)
Rissoa similis Scacchi, 1836
Rissoa variabilis (Von Muhelfeldt, 1824)
Alvania cancellata (da Costa, 1778)
Alvania cimex (Linnaeus, 1758)
Alvania discors (Allan, 1818)
Alvania hispidula (Monterosato, 1884)
Alvania lanciae (Calcara, 1845)
Alvania lineata Risso, 1826
Alvania cfr *lineata* Risso, 1826
Pusillina lineolata (Michaud, 1832)
Pusillina marginata (Michaud, 1830)
Pusillina philippi (Aradas et Maggiore, 1844)
Setia amabilis (Locard, 1886)
Setia ambigua (Brugnone, 1873)
Setia homerica Romani et Scuderi, 2015
Setia turriculata Monterosato, 1884

RISSOINIDAE Stimpson, 1865
Rissoina bruguieri (Payraudeau, 1826)

BARLEEIDAE Gray, 1857
Barleeia unifasciata (Montagu, 1803)

CAECIDAE Gray, 1850
Caecum subannulatum de Folin, 1870

CALYPTRAEIDAE Lamarck, 1809
Crepidula moulinsii Michaud, 1829
Calyptraea chinensis (Linnaeus, 1758)

NATICIDAE Guilding, 1834
Natica sp.
Notocochlis dillwynii Payraudeau, 1826

ATLANTIDAE Rang, 1829
Atlanta helicinoidea J.E. Gray, 1850
Atlanta peronii Lesueur, 1817

MURICIDAE Rafinesque, 1815
Hexaplex trunculus trunculus (Linnaeus, 1758)
Ocinebrina aciculata (Lamarck, 1822)
Ocinebrina edwarsii (Payraudeau, 1826)
Muricopsis cristata (Brocchi, 1814)
Coralliophila meyendorffii (Calcara, 1845)

MARGINELLIDAE Fleming, 1828
Granulina marginata (Bivona, 1832)

CYSTISCIDAE Stimpson, 1865
Gibberula miliaria (Linnaeus, 1758)
Gibberula philippi (Monterosato, 1878)
Gibberula cfr *philippi* (Monterosato, 1878)
Gibberula recondita Monterosato, 1844

MITRIDAE Swainson, 1829
Mitra cornicula (Linnaeus, 1758)

COSTELLARIIDAE MacDonald, 1860
Pusia savignyi (Payraudeau, 1826)
Pusia tricolor (Gmelin, 1790)

BUCCINIDAE Rafinesque, 1815
Euthria cornea Linnaeus, 1758
Chauvetia affinis (Monterosato, 1889)
Enginella leucozona (Philippi, 1844)
Aplus dorbignyi (Payraudeau, 1826)

NASSARIIDAE Iredale, 1916 (1835)
Tritia cuvierii (Payraudeau, 1826)
Tritia incrassata (Stroem, 1768)

COLUMBELLIDAE Swainson, 1840
Columbella rustica (Linnaeus, 1758)
Mitrella scripta (Linnaeus, 1758)

FASCIOLARIIDAE Gray, 1853
Fusinus dimassai Buzzurro et Russo, 2007
Fusinus pulchellus (Philippi, 1844)

CLATHURELLIDAE H. Adams et A. Adams, 1858
Clathromangelia granum (Philippi, 1844)

CONIDAE Fleming, 1822
Conus ventricosus Gmelin, 1791

RAPHITOMIDAE Bellardi, 1875
Raphitoma bicolor (Risso, 1826)
Raphitoma contigua (Monterosato, 1884)
Raphitoma laviae (Philippi, 1844)
Raphitoma leufroyi (Michaud, 1828)
Raphitoma linearis (Montagu, 1803)

MANGELIIDAE P. Fischer, 1883
Mangelia multilineolata (Deshayes, 1835)
Mangelia taeniata (Deshayes, 1835)

PYRAMIDELLIDAE J.E. Gray, 1840
Parthenina decussata (Montagu, 1803)
Parthenina emaciata (Brusina, 1866)
Parthenina interstincta (J. Adams, 1797)
Parthenina sp.
Megastomia conoidea (Brocchi, 1814)
Odostomia sp.
Odostomella bicincta (Tiberi, 1868)
Odostomella doliolum (Philippi, 1844)
Liostomia cfr *hansgei* Warén, 1991
Turbonilla gradata Bucquoy, Dautzenberg et Dollfus, 1883
Turbonilla pusilla (Philippi, 1844)
Turbonilla cfr *sinuosa* (Jeffreys, 1884)
Eulimella acicula (Philippi, 1836)

BULLIDAE Gray, 1827
Bulla striata Bruguiere, 1792

RETUSIDAE Thiele, 1925
Retusa mammillata (Philippi, 1836)
Retusa minutissima (Monterosato, 1878)
Retusa truncatula (Bruguiere, 1792)

NOTODIAPHANIDAE Thiele, 1931
Notodiaphana atlantica Ortea, Moro et Espinosa, 2013

HAMINOEIDAE Pilsbry, 1895
Haminoea sp.
Atys macandrewii Smith E.A., 1872

PHILINIDAE Gray, 1850 (1815)
Philine catena (Montagu, 1803)

CRESEIDAE Rampal, 1973
Styliola subula (Quoy et Gaimard, 1827)

LIMACINIDAE Gray, 1840
Heliconoides inflatus (d'Orbigny, 1834)
Limacina trochiformis (d'Orbigny, 1834)

PERACLIDAE Tesch, 1913
Peracle reticulata (d'Orbigny, 1834)

VOLVATELLIDAE Pilsbry, 1895
Ascobulla fragilis (Jeffreys, 1856)

PLEUROBRANCHIDAE Gray, 1827
Berthella plumula (Montagu, 1803)

APLYSIIDAE Lamarck, 1809
Aplysia parvula Mörch, 1863
Petalifera petalifera (Rang, 1828)

SIPHONARIIDAE Gray, 1827
Williamia gussoni (Costa O. G., 1829)

BIVALVIA

ARCIDAE Lamarck, 1809
Arca noae Linnaeus, 1758

NOETIIDAE Stewart, 1930
Striarca lactea (Linnaeus, 1758)

MYTILIDAE Rafinesque, 1815
Modiolula phaseolina (Philippi, 1844)
Musculus costulatus (Risso, 1826)

PINNIDAE Leach, 1819
Pinna nobilis Linnaeus, 1758

PTERIIDAE Gray, 1847 (1820)
Pinctada imbricata radiata (Leach, 1814)

PECTINIDAE Rafinesque, 1815
Flexopecten hyalinus (Poli, 1795)

LIMIDAE Rafinesque, 1815
Lima sp.
Limaria hians (Gmelin, 1791)
Limaria cfr *loscombi* (Sowerby G.B.I, 1823)

LUCINIDAE Fleming, 1828
Ctena decussata (Costa O.G., 1829)

CHAMIDAE Lamarck, 1809
Chama gryphoides (Linnaeus, 1758)

CARDITIDAE Férussac, 1822
Cardita calyculata (Linnaeus, 1758)

CARDIIDAE Lamarck, 1809
Parvicardium scriptum (Bucquoy, Dautzenberg et Dollfus, 1892)
Parvicardium sp.
Papillicardium papillosum (Poli, 1796)

TELLINIDAE Blainville, 1814
Tellina sp.

SEMELIDAE Stoliczka, 1870 (1825)
Abra alba (Wood W., 1802)

VENERIDAE Rafinesque, 1815
Venus verrucosa Linnaeus, 1758
Gouldia minima (Montagu, 1803)
Lajonkairia lajonkairii (Payraudeau, 1826)

HIATELLIDAE Gray, 1824
Hiatella arctica (Linnaeus, 1767)

Table 1. Molluscs from Capo d'Armi, Strait of Messina: taxonomic position.

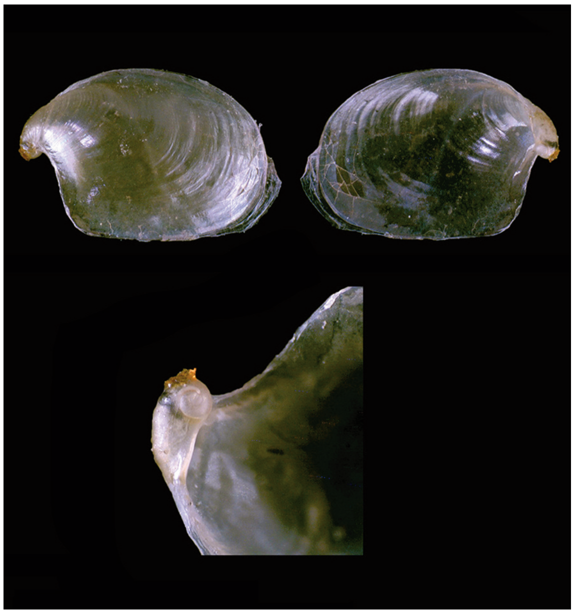

Figure 5. *Aplysia parvula* from Capo d'Armi, Strait of Messina.

Less abundant species, whose occurrence might be considered negligible in quantitative terms, included some taxa on which it is worth to dwell. The rayed pearl oyster *Pinctada imbricata radiata* (Leach, 1814), for example, is an "hystorical" Lessepsian migrant that reached the Gulf of Gabes, in central Mediterranean, at the end of the 19th century (Bouchon-Brandely & Berthoule, 1891) and only fifty years later the islands in the south of Sicily (Bombace, 1967; Sabelli, 1969); it took the species a further half-century to reach the Strait of Messina where it was sporadically recorded during 2000–2001 and regularly found since 2007 (Crocetta et al., 2009; Giacobbe et al., 2010). The present record (first one in the framework of a quantitative sampling plan), may be considered a last evidence of *P. imbricata radiata* settlement in the Strait of Messina area.

The Caraibic Sea hare, *Aplysia parvula* (Fig. 5), that we report for the first time in the Strait of Messina, despite its western Atlantic origin, in Mediterranean Sea has been first recorded in the eastern basin, from Turkish waters (Swennen, 1961). Numerous but often unconfirmed records affected both Atlantic and Mediterranean coasts of Spain and Balearic Islands (Terlizzi et al., 2005; Koukouras, 2010; Scuderi & Terlizzi, 2012). Such peculiar Amphi-Atlantic and Mediterranean distribution, however, may suggests a cryptogenic status of the Mediterranean populations, which might belong to a different species than the west Atlantic topotypical ones (Zenetos et al., 2010). A very similar case concerned *Notodiaphana atlantica* Ortea, Moro et Espinosa, 2013 (Fig. 6), a shelled Heterobranchia that has been described from specimens collected between Bahamas and Cuba, and shortly after reported from several Mediterranean localities such as Djerba (Tunisia), Cabo Negro (Morocco), Messina and Augusta (Sicily), and Strait of Sicily (Micali, 2014). Here again, the doubt that Atlantic and Mediterranean populations might belong to genetically distinct species, is legitimized by the disjoined Amphi-Atlantic distribution. Another shelled Heterobranchia, *Atys macandrewi* E.A. Smith, 1872 (Fig. 7), described from Lanzarote (Canary Islands), has been cited in recent years for several Mediterranean localities as Malta, Messina, Tel Aviv (Cachia & Mifsud, 2007), Cyprus (Delongueville & Scaillet, 2010), Malaga and Motril from Spagna, Pantelleria and Lampedusa from Italy, and Elafonissi from Greece (Micali et al., 2016). Such records identify an area which includes both Mauritanian and Mediterranean provinces, although it is limited to medium-low latitudes.

Both the latter two species, already reported for the Strait of Messina (Cachia & Misfud, 2007; Micali, 2014), had robust confirmation in the present quantitative sampling.

The Sacoglossa *Ascobulla fragilis* (Jeffreys, 1856) (Fig. 8), whose prevalent western distribution includes the Italian Tyrrhenian coasts according to the SIBM check-list of Italian marine species (http://www.sibm.it/CHECKLIST/menu%20checklist%20I.htm), before now has not been reported from the Strait of Messina. However, some uncertainties concern the effective areal of this species, known from Alboran and other Mediterranean coasts of Spain (Cervera et al., 2004) but dubiously reported in WoRMS (http://www.marinespecies.org/), from other western areas, whilst it was ascertained from eastern Mediterranean, notably Greece (Koulouri et al., 2006). Such disjoined distribution, if not refuted by future reports in central Mediterranean, might involve some genetic divergence between the western and eastern populations. In this regard, the present first record in the Strait of *A. fragilis*, is not conclusive, since it might represent a link between two apparently disjoined populations, or it could be contextualized in the well known "Atlantic affinity" (Bianchi et al., 2012) of the ecosystem in the Strait of Messina.

Planktonic species

Besides benthic species, the examined samples provided 46 living specimens of six planktonic taxa, accidentally trapped by algal covering; such species have been here reported as a contribution to the knowledge of the complessive mollusc diversity in Capo d'Armi area. They included the Littorinimorpha *Atlanta peronii* Lesueur, 1817 and *A. helicinoidea* J.E. Gray, 1850, and the Thecosomata *Heliconoides inflatus* (d'Orbigny, 1834), *Limacina trochiformis* (d'Orbigny, 1834), *Peracle reticulata* (d'Orbigny, 1834) and *Styliola subula* (Quoy et Gaimard, 1827). Both the *Atlanta* Lesueur, 1817 species have a circumtropical distribution that includes the Mediterranean Sea, but while *A. peronii* is common in the whole Mediterranean, *A. helicinoidea* exclusivelly occurs in the eastern basins (Wall-Palmer et al., 2016). This latter taxon, that has been dubiously cited in the most recent check-list for the Italian Seas (http://www.sibm.it/CHECKLIST/menu%20 checklist%20I.htm), has not been previous reported in literature for the Strait of Messina area (Guglielmo et al., 1995).

The Thecosomata *H. inflatus*, belonging to a species complex which includes Atlanto-Mediterranean, Indo-Pacific, South Eastern Atlantic and North Indian entities, in Mediterranean is known from the western basins. *Limacina trochiformis* is abundant in the South Western and Eastern areas (Rampal, 2017), similarly to *S. subula* and to the epibathyal *P. reticulata*, which shows a disjoined distribution in Alboran sea and Eastern basin (Rampal, 1975, 2011).

Figure 6. *Notodiaphana atlantica* from Capo d'Armi, Strait of Messina.

CONCLUSIONS

The present report provides a first contribution to the mollusc diversity in a poorly investigated area, although the latter is full of interest in the contest of Mediterranean biogeography. It also improves our knowledge on the Strait of Messina ecosystem, of which has been recognized the absolute peculiarity. Such data, unfortunately, described an environment whose decline was meanwhile highlighted by the incipient rarefaction of the algal canopy, preluding to the barren-dom-inated present seascape. Benthic mollusc assemblages, although sampled in Ionian Sea, showed a clear western species composition, confirming previous literature that placed east of the Strait the biogeographic boundary line between western and eastern Mediterranean eco-regions (Bianchi, 2007 and literature herein cited). Pelagic molluscs, by contrast, showed a more marked eastern imprint, in agreement with Guglielmo et al. (1995) highlighting the role of local upwelling in the occurrence of pelagic assemblages tied to the Levantine Intermediate Waters, LIW.

Figure 7. *Atys macandrewi* from Capo d'Armi, Strait of Messina.

ACKNOWLEDGEMENTS

We wish to thank Franck Boyer (Garrigues Sainte Eulalie, France), Danilo Scuderi (Catania, Italy), Francesco Pusateri (Palermo, Italy), Italo Nofroni (Roma, Italy) their suggestions and contribution in species determination.

Figure 8. *Ascobulla fragilis* from Capo d'Armi, Strait of Messina.

REFERENCES

Azzaro F., Decembrini F., Raffa F. & Crisafi E., 2007. Seasonal variability of phytoplankton fluorescence in relation to the Straits of Messina (Sicily) tidal upwelling. Ocean Science Discussions, 4: 415–440, www.ocean-sci-discuss.net/4/415/2007/.

Bianchi C.N., 2007. Biodiversity issues for the forthcoming tropical Mediterranean Sea. Hydrobiologia 580: 7. https://doi.org/10.1007/s10750- 006-0469-5

Bianchi C.N., Morri C., Chiantore M., Montefalcone M., Parravicini V. & Rovere A., 2012. Mediterranean Sea biodiversity between the legacy trom The Past and a future of change. In: Life in the Mediterranean Sea: A Look at Habitat Changes. Editor: Noga Stambler, 55 pp.

Bombace G., 1967. Sul rinvenimento di alcuni esemplari di *Pinctada radiata* (Leach) nelle acque del Canale di Sicilia (Mollusca, Bivalvia). Natura, 58: 298–304.

Bouchon-Brandely M. & Berthoule A., 1891. Les pêches maritimes en Algérie et en Tunisie. Rapport au Ministère de la Marine, Paris, 118 pp.

Boyer F., Pelorce J. & Hoarau A., 2002. Le genre *Granulina* sur le littoral de Ia Cote d'Azur: récolt e observations. Bollettino Malacologico, 39: 165–170.

Cachia C. & Mifsud C., 2007. On the occurrence of *Atys macandrewii* E.A. Smith, 1872 (Gastropoda: Haminoeidae) in the Mediterranean. Iberus, 25: 43–48

Cervera J.L., Calado G., Gavaia C., Malaquias M.A.E., Templado J., Ballesteros M., García-Gómez J.C. & Megina C., 2004. An annotated and updated checklist of the opisthobranchs (Mollusca: Gastropoda) from Spain and Portugal (including islands and archipelagos). Boletín Instituto Español De Oceanografía, 20: 1–122.

Crocetta F., Renda W. & Vazzana A., 2009. Alien Mollusca along the Calabrian shores of the Messina Strait area and a review of their distribution in the Italian seas. Bollettino Malacologico, 45: 15–30.

Delongueville C. & Scaillet R., 2010. Première signalization d'*Atys macandrewii* Smith E.A., 1872 sur les côtes de Chypre Nord. Novapex/Société, 11: 51–52.

Giacobbe S., De Domenico F., Iarrera S.P.M., Mangano M.C., Porporato E. & Spanò N., 2010. Alien molluscs and crustacean decapods in the Straits of Messina (Central Mediterranean sea). Rapport de la Commission Internationale pour l'Exploration Scientifique de la Mer Méditerranée 39: 528.

Gofas S., 1990. Le genre *Gibberula* (Marginellidae) en Méditerranée. Lavori della Società Italiana di Malacologia, 23: 113–139.

Guglielmo L., Crescenti N., Costanzo G. & Zagami G., 1995. Zooplankton and micronekton communities in the Straits of Messina. In: Guglielmo L., Manganaro A. & De Domenico E. (Eds.), The Straits of Messina ecosystem: 247–270.

Koukouras A., 2010. Check-list of marine species from Greece. Aristotle University of Thessaloniki. Assembled in the framework of the EU FP7 PESI project. [Internet]; Available from: http://www.marinespecies.org/aphia.php?p=sourcedetails&id=149096

Koulouri P., Dounas C., Arvanitidis C., Koutsoubas D. & Eleftheriou A., 2006. Molluscan diversity along a Mediterranean soft bottom sublittoral ecotones. Scientia Marina, 70: 573–583.

Micali P., 2014. On the presence of *Notodiaphana atlantica* Ortea, Moro et Espinosa, 2013 in the Mediterranen Sea, with notes on *Retusa multiquadrata* Oberling, 1970 and *Cylichna mongii* (Audouin, 1826) (Cephalaspidea Cylichnidae). Biodiversity Journal, 5: 499–504.

Micali P., Bogi C. & Galil B.S., 2016. On the occurrence of *Atys angustatus* E. A. Smith, 1872 and *Atys macandrewii* E.A. Smith, 1872 (Cephalaspidea: Haminoeidae) in the Mediterranen Sea. Iberus, 34: 1–5.

Philippi R.A., 1836-1844. Enumeratio molluscorum siciliae cum viventium in tellure tertiaria fossilium, quae in itinere suo observavit. Berolini, XIV+267 pp., 12 tav. (1836); Halis Saxonum, IV+303 pp., 16 tav. (1844).

Pintner T., 1909. Messina, ein zerstörtes Paradies der Zoologen. Schriften des Vereins zur Verbreitung naturwissenschaftlicher Kenntnisse Wien, 49: 103–131.

Rampal J., 1975. Les Thécosomes (Mollusques pélagiques). Systématique et Evolution. Ecologie et Biogéographie méditerranéennes. Thèse Doctorat d'Etat, Université de Provence Aix-Marseille II, C. N. R. S. AO 11932: 1–485.

Rampal J., 2011. Clés de détermination des Thecosomata (Pteropoda) (Mollusca Opisthobranchia Holoplanctoniques) de Méditerranée et de l'Atlantique Eurafricain. Revue des Travaux de l'Institut des Pêches maritimes, 37: 369–389.

Rampal J., 2017. Euthecosomata (Mollusca, Gastropoda, Thecosomata). Taxonomic review. bioRxiv preprint first posted online Jan. 6, 2017; doi: http://dx.doi.org/10.1101/098475.

Sabelli B., 1969. Ritrovamenti malacologici a Pantelleria e nei banchi di pesca tunisini. Conchiglie, 5: 3–11.

Scuderi D. & Terlizzi A., 2012. Manuale di malacologia dell'alto Ionio. Ed. Grifo, Lecce, 188 pp.

Swennen C., 1961. On a collection of Opisthobranchia from Turkey. Zoologische Mededelingen, 38: 41–75.

Terlizzi A., Scuderi D., Fraschetti S. & Anderson M.J., 2005. Quantifying effects of pollution on biodiversity: a case study of highly diverse molluscan assemblages in the Mediterranean. Marine Biology, 148: 293–305.

Villari A., 2017. A new remarkable species of the *Alvania scabra* (Philippi, 1844) group from the Ionian Sea: *A. scuderii* n. sp. (Gastropoda Rissoidae). Biodiversity Journal, 8: 937–942 available online at http://www.biodiversityjournal.com/pdf/8%284%29_937-942.pdf

Vitale D., Giacobbe S., Spinelli A., De Matteo S. & Cervera J.L., 2016. "Opisthobranch" (mollusks) inventory of the Faro lake: a Sicilian biodiversity hot spot. Italian Journal of Zoology, 83: 524–530. http://dx. doi.org/10.1080/11250003.2016.1236843

Wall-Palmer D., Smart C.W., Kirby R., Hart M.B., Peijnenburg K.T.C.A. & Janssen A-W., 2016. A review of the ecology, palaeontology and distribution of atlantid heteropods (Caenogastropoda: Pterotracheoidea: Atlantidae). Journal of Molluscan Studies, 82: 221–234.

Zenetos A., Gofas S., Verlaque M., Cinar M., Garcia Raso J., Bianchi C., Morri C., Azzurro E., Bilecenoglu M., Froglia C., Siokou I., Violanti D., Sfriso A., San Martin G., Giangrande A., Katagan T., Ballesteros E., Ramos-Espla A., Mastrototaro F., Ocana O., Zingone A., Gambi M. & Streftaris N., 2010. Alien species in the Mediterranean Sea by 2010. A contribution to the application of European Union's Marine Strategy Framework Directive (MSFD). Part I. Spatial distribution. Mediterranean Marine Science, 11: 381– 493.