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Marine biogeography of the Mediterranean Sea: patterns and dynamics of biodiversity

The Mediterranean molluscs: the best known malacofauna of the world... so far

MARCO OLIVERIO
Dipartimento di Biologia Animale e dell'Uomo, Università "La Sapienza, Viale dell'Università 32, I-00185 Roma (Italy)
e-mail: marco.oliverio@uniroma1.it

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SUMMARY

The malacofauna of the Mediterranean Sea is commonly regarded as the best known in the world. The reasons are bound to the history of Malacology in Europe, particularly during the XIX and the end of the XX centuries. Over 2000 species of molluscs are listed in the Mediterranean Sea (Sabelli et al., 1990-1992; CLEMAM, and up-to-date). The Italian species account for nearly 80% of the whole Mediterranean malacofauna. A detailed biogeographical analysis of the whole molluscan fauna is not possible due to the lack of reliable distributional data for several groups and some geographic areas. A general overview reveals as the biogeographic structure of the malacofauna is the result of the recent palaeoclimatic and geodynamic history of the basin. The bulk of the fauna is of Atlantic origin (with Atlantic-Mediterranean chorotypes). There is a certain level of endemism, but at the different levels (from the whole basin to the local endemics), the actual status of the alleged endemites should be checked with modern tools. The very recent and present history is characterised by at least two distinct events: the "Lessepsian migration" into the Levant basin, by Red Sea species crossing the Suez Canal, and the accidental introduction in the wild of alien species. Both events contribute (though with partly different mechanisms) to significantly (and sometimes dramatically) alter biodiversity patterns at various scales. With no species included in the CITES documents, and only 14 species included in the "Bern Convention" or the "Habitat Directive" lists, the number of species worthy of protection should be increased.

Support to baseline research on the Mediterranean marine life is strongly urged. Knowledge on the biology of the species is still minimal. Yet, completing the inventorying of the "molluscan diversity" is one of the most exciting challenges for the marine biology of the XXI century.

INTRODUCTION

The marine mollusc fauna of the Mediterranean Sea is commonly considered as the best known in the world. The reasons can be searched for in the roots of European Malacology. Remarkable checklists of the Mediterranean molluscs have been published in the '800 (Table I) since the very beginning of the century. The Golden Age of the European Malacology lays in the acme of the great work of inventorying the biodiversity of the planet. For the Mediterranean Sea this is reflected in the trend of the description of new Mediterranean taxa of Mollusca (Fig. 1).

Tab. I - The major malacological faunas and checklists for the Mediterranean Sea in the "Golden Age".

Poli J. X.	1791	Testacea Utriusque Siciliae eorumque historia et anatome. Parma, RegioTypographeio, pp. 1-74, i-lxii, pl. 1-18 [1791], pp. 75-264, i-lxxvi, pl. 19-39 [1795].
Payraudeau B.C.	1826	Catalogue descriptif et méthodique des Annelides et des Mollusques de l'île de Corse. Paris, pp. 218 + 8 pl.
Risso A.	1826-1827	Histoire naturelle des principales productions de l'Europe Méridionale et particulièrement de celles des environs de Nice et des Alpes Maritimes. Paris, Levrault, Vol. 1 [1826]. Vol. 2 [Nov. 1827]. Vol. 3 [Sept. 1827]. Vol. 4 molluscs [Nov. 1826]. Vol. 5 [Nov. 1827]
Costa O.G.	1829	Catalogo sistematico e ragionato de' testacei delle Due Sicilie. Napoli 8+CXXXII; pl. 1-3.
Philippi R. A.	1836	Enumeratio molluscorum Siciliae cum viventium tum in tellure tertiaria fossilium, quae in itinere suo observavit. Vol. 1, Schropp, Berlin [Berolini], xiv + 267 p., pl. 1-12 [1836]. Vol. 2. Eduard Anton, Halle [Halis Saxorum] iv + 303 p., pl. 13-28 [1844].
Scacchi A.	1836	Catalogus Conchyliorum regni Neapolitani. Napoli pp. 18.
Aradas A., Maggiore G.	1840-1844	Catalogo ragionato delle conchiglie viventi e fossili di Sicilia. Atti dell'Accademia Gioenia di Scienze Naturali, Catania.
Cantraine F.J.	1841	Malacologie méditerranéenne et littorale. Nouv. Mém. Ac. Roy. Bruxelles 13:1-173.
Requién, E.	1848	Catalogue des coquilles de l'Île de Corse. Avignon: Seguin Ainé. xii + 13-111 pp.
Costa O.G.	1861	Microdoride Mediterranea o descrizione dei poco ben conosciuti od affatto ignoti viventi minuti e microscopici del Mediterraneo. Napoli pp. 80.
Brusina S.	1865	Conchiglie dalmate inedite. Verhandlungen der Kaiserlich-königlichen Zoologisch-botanisch Gesellschaft in Wien 15: 3-42
Brusina S.	1866	Contribuzione pella fauna dei molluschi dalmati. Verhandlungen der Kaiserlich-königlichen Zoologisch-botanisch Gesellschaft in Wien 16: 1-134
Caruana A.	1867	Enumeratio ordinata molluscorum gaulomelitensium of the late Mr. Giuseppe Mamo. Malta, British press pp. 58.
Brusina S.	1870	Ipsa Chiereghinii Conchylia ovvero contribuzione pella malacologia adriatica. Pisa, Biblioteca Malacologica pp. 280.
Aradas A., Benoit L.	1872-1876	Conchigliologia vivente marina della Sicilia. Atti dell'Accademia Gioenia di Scienze Naturali (3) 6: 1-113 + pl. 1-2 [1872]; 113-226 + pl. 3-4 [1874]; 227-324 + pl. 5 [1876]
Brugnone G.A.	1873-1876	Miscellanea malachologica. Palermo. part 1 [1873]; part 2 [June 1876]
di Monterosato, T.A., di Maria	1878	Enumerazione e sinonimia delle conchiglie mediterranee. Giornale di Scienze naturali ed economiche, 13: 61-115.
Bucquoy E., Dautzenberg P., Dollfus G.	1882-1898	Les mollusques marins du Roussillon. Tome I. Gastropodes. 570 p., 66 pl. [1882-1886] Tome II. Pélécypodes. 884 p., 99 pl. [1887-1898]. Paris, J.B. Baillière fils.
di Monterosato T.A., di Maria	1884	Nomenclatura generica e specifica di alcune conchiglie mediterranee. Palermo.
Locard A	1886	Prodrome de malacologie française. Catalogue général des mollusques vivants de France. Mollusque marins, Lyon, Paris pp. X+778.
Kobelt, W.	1887	Prodromus faunae molluscorum testaceorum marina europaea inhabitantium. Nürnberg, pp. IV+550.
Kobelt W.	1887-1908	Iconographie der schalentragende europäischen Meeres-conchylien; part 1 [1887]; part 2 [1888, 1889, 1900, 1901]; part 3 [1902, 1903, 1904, 1905]; part 4 [1906, 1908].
Carus J.V.	1889-1893	Prodromus Faunae mediterraneae sive descriptio animalium maris Mediterranei incolarum. Vol. 2: Brachiostomata. Mollusca. Tunicata. Vertebrata. IX + 854 p. Stuttgart, E. Schweitzerbart.
Locard A.	1892	Les coquilles marines des côtes de France. Paris, J.B. Baillière, fils pp. 384.
Locard A.	1897-1898	Expéditions scientifiques du Travailleur et du Talisman pendant les années 1880, 1881, 1882 et 1883. Mollusques testacés. Paris, Masson, vol. 1 [1897], p. 1-516, pl. 1-22, vol. 2 [1898] p. 517-1044 pl. 23-40
Locard A., Caziot E.	1900	Les coquilles marines des côtes de Corse. Ann. Soc. Linn.
Pallary, P.	1900	Coquilles marines du littoral du Department d'Oran. Journal de Conchyliologie, 48: 211-422, 19 figs., pls. 6-8, 1 map.
Pallary P.	1912	Catalogue des mollusques du littoral méditerranéen de l'Egypte. Mém. Inst. Egypte 7: pp. 139+4 pl.

The first half of the XX century saw a severe decline in the Mediterranean taxonomic inventory. This is witnessed both by the lack of remarkable checklists, and by the strong decrease in the description of new taxa of species level. The so-called "Golden Age" of the European Malacology ceased, and a new age restarted only at the end of the '60s and particularly at the beginning of the '70s, continuing in the present days. Of that time are the first attempts to comprehensive revisions of the European marine malacofauna. Nordsieck's works (1968, 1972, 1982), albeit characterised by the "personal" taxonomic concepts of the Author, still stand as a basis for any present revision; along with the manuals by Parenzan (in Italian, 1970, 1974, 1976), they were "the" manuals for the identification of the Mediterranean molluscs during many years. They have been recently joined by several revisions (limited to some taxonomic groups) and by a few field guides (e.g., Poppe and Goto, 1991, 1993) mainly aimed to popularisation, yet with a sufficient scientific carefulness. Very remarkable revisions of the Northeast Atlantic bathyal and abyssal molluscs have been started by Bouchet and Warén (1980, 1985, 1986, 1993), and not yet completed. This last phase allowed the completion of a project for a Mediterranean checklist, with the publication of the *Annotated check-list of Mediterranean marine mollusks* (Sabelli et al., 1990-1992, along with the iconographic support: Giannuzzi-Savelli et al., 1994, 1997, 1999, 2001, 2003) that is still considered a milestone in the field. It served as the core of the ongoing project CLEMAM (*Check-List of European Marine Mollusca: http://www.somali.asso.fr/clemam/index.clemam.html*) and to the preparation of the Mollusca issues of the Italian checklist (Bedulli et al., 1995a,b,c; Bello, 1995; Bodon et al., 1995).

THE MEDITERRANEAN MALACOFAUNA

According to the checklist by Sabelli et al. (1990-1992), the Mediterranean malacofauna includes some 2000 species (Table II). Since its publication, the

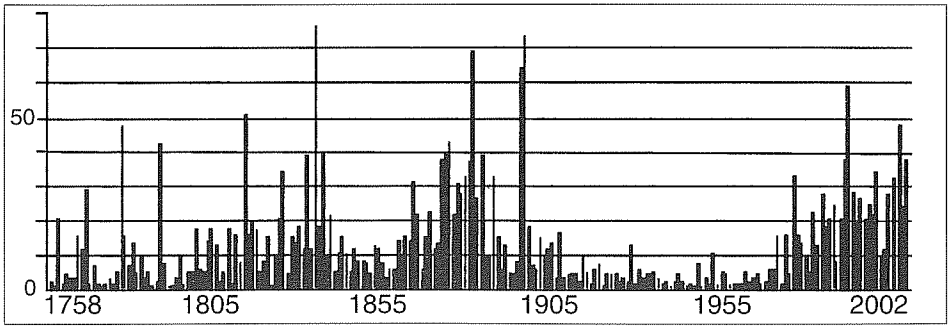

Fig. 1 - New taxa of molluscs described per year after 1759-2002 (data after Bodon et al., and CLEMAM, modified).

up-to-date have been mostly in the form of new species and new records published in the major European malacological journals, and have been progressively incorporated in the iconographic *Atlas* (Giannuzzi-Savelli et al., 1994, 1997, 1999, 2001, 2003). Additionally, I have at hand some unpublished data. The inclusion of all subsequent up-to-date (up to 2002) brings the figure around 2300 species. Even if the number of marine mollusc species in the world cannot be estimated with a reasonable level of accuracy, figures between 50.000 and 100.000 seem the most likely: it means that the Mediterranean malacofauna represents 2-5% of the world marine molluscs. This figure is in agreement with estimates made on the whole marine biodiversity (Bianchi and Morri, 2000).

As shown in Table II, the malacofauna of the Mediterranean Sea is a good representation of that of the North-eastern Atlantic province (NEA), figuring about 60% of the NEA species (68% if considering 2300 M species). This is mostly due to the origin of the Recent Mediterranean benthic biota. The biogeographical structure of the marine malacofauna of the Mediterranean Sea is in fact, mainly the result of its peculiar recent palaeoclimatic and geodynamic history (see e.g., Raffi and Marasti, 1982; Raffi et al., 1985; Di Geronimo, 1990; Raffi and Monegatti, 1993; Bianchi and Morri, 2000; Taviani, 2002 and this volume). At taxonomic ranking above the species level representation is even higher. In the Mediterranean Sea nearly 80% of the NEA families of marine molluscs are represented, and the 279 families are nearly 60% of the total marine families known in the world.

All major groups include taxa in the need of some systematic work. Unfortunately, only a small part of the research in taxonomy/systematics of the Mediterranean molluscs employed modern techniques (from caryology to molecular genetics). This fact leaves open new frontiers to further insights in the fields of genetic variation (from population to species), gene flow and

Tab. II - Number of species and families in the Mediterranean and NE Atlantic areas.

	Mediterranean		NE-Atlantic		Global
	species	families	species	families	families
Caudofoveata	6	3	33	4	4
Solenogastres	30	10	63	12	22
Polyplacophora	32	6	57	6	9
Monoplacophora	1	1	6	1	5
Gastropoda	1482	164	2594	211	260
Cephalopoda	61	21	94	33	45
Bivalvia	410	72	491	76	117
Scaphopoda	16	2	40	6	9
total families		279	3378		471
total species	2038			349	

microevolutionary patterns, phylogenetic issues, with relevant effects on taxonomy. Currently, given the high diversification of the molluscs, the range of variation (and thus of uncertainty) in the estimates of species richness can be in some families (small sized, but highly speciose, such as Rissoidae, turrids s.l., Pyramidellidae, Leptonidae etc.) of 30-40%. Nevertheless, the level of knowledge of the species composition of the whole Mediterranean malacofauna and of its systematics can be considered as good, especially if compared with the same knowledge of the faunas of other seas. Such a good knowledge in the species composition, and the good systematic classification of the fauna, do not correspond to a comparably as good knowledge on the distributional patterns within the Mediterranean Sea. This is due mostly to the lack of comparable data for some areas (most of N African coasts, Eastern Mediterranean Sea) and of distributional data for some taxonomic groups (some "minor" classes such as scaphopods and aplacophorans, but also the very bivalves; specialistic groups, particularly among the very small sized gastropods, etc.). This hampers a comprehensive biogeographical analysis of the Mediterranean malacofauna. The faunistic exploration of the Mediterranean Sea has received a remarkable improvement during the last two decades. The results from sampling e.g., in the Eastern Mediterranean basin, the Sicily Strait, the Iberian peninsula, along with the increasing mass of geographic dataset made available by reliable amateur collectors, significantly changed our assumptions about the distribution of many species. Biogeographic analyses of the Mediterranean zoobenthos such as those by Fredj (1974), Fredj and Laubier (1985), or Di Geronimo (1990) need some revision. Nevertheless, a descriptive summary of the main chorotypes (Tab. III) occurring in the Mediterranean malacofauna (excluding the Cephalopoda: Bello this volume) can be attempted. It will give an idea of the wide variety of biogeographical dynamics operating in this phylum in the ambit of the eastern Atlantic (Ekman, 1953; Fredj, 1974; Briggs, 1995; Vermeij, 1980). For three groups (Polyplacophora and among gastropods, Rissooidea and Opisthobranchs) the data available allow a biogeographic analysis of the fauna.

Wide range (Cosmopolitan + Circumtropical)

Several wide range (mostly cosmopolitan) species (55 spp, 2.5% of the total malacofauna), are hosted among the pelagic groups (Janthinidae [3 species] and Firoloidea [=Heteropoda, 18 spp] in the prosobranchs, Thecosomata [30 spp] and some Gymnosomata [4? spp] among the opisthobranchs). The particular pelagic life habit gives reason of this unusual pattern, although warnings have been recently raised about possible genetic differentiation over a large geographic scale.

Among the benthic species the family Ranellidae (with teleplanic planktonic larvae) hosts four circumtropical species: *Ranella olearia* (Linné, 1758), *Cymatium*

parthenopeum (Von Salis, 1793), *Charonia lampas* (Linné, 1758), *C. tritonis variegata* (Lamarck, 1816), and three species with very wide range outside the Mediterranean Sea: *Cymatium corrugatum* (Lamarck,1816), *Cabestana cutacea* (Linné, 1767), *C. doliaria* (Linné, 1767). With them the number of wide range species sums to some 62, nearly 3% of the total.

Atlantic-Mediterranean

Given the linked palaeogeographic history between Atlantic and Mediterranean Sea, it is obvious that a large part of species belong in this group. Actually, it includes species with different chorotypes, each underlying significantly different biological properties. Many popular species with a rather large distribution, ranging from northern Europe southward to West African coasts (and obviously the Mediterranean Sea) are included herein. This is the case, e.g., of the abalone *Haliotis tuberculata* (L., 1758), the rock-shell *Stramonita haemastoma* (Linné, 1767), the cockle *Laevicardium norvegicum* Spengler, 1790, the small Faeroe gari clam *Gari fervensis* (Gmelin, 1791).

Several species show their northern limit in the western Iberian Peninsula (approximately between 36°-43° Lat. N): this is the case of the columbellids *Columbella rustica* (Linné, 1758) and *Mitrella pallaryi* (Dautzenberg, 1927) or the bursid *Bursa scrobilator* Linné, 1758. The boundary area is not characterised by strong changes in the benthic habitat, thus, it is argued that the northern limits are set in these cases by reproductive constraints, such as a lower temperature limit for gametogenesis or embryogenesis. The presence of these thermophilous species in the Mediterranean Sea is often related to the invasion of the basin by Mauritanian-Senegalese stocks, during the warm phases of the Late Tertiary-Quaternary (see Taviani et al., 1991).

A number of species (of Boreo-Celtic affinities) reach the northern European coasts, as is the case of the polyplacophoran *Lepidopleurus (Leptochiton) cancellatus* (Sowerby G.B.II, 1840), the gastropods *Propilidium scabrosum* Jeffreys, 1883 and *Nassarius (Sphaeronassa) mutabilis* (Linné, 1758), the bivalves *Dacrydium hyalinum* Monterosato, 1875 and *Lucinoma boreale* (Linné,1758), the scaphopod *Pulsellum lofotense* (Sars M.,1865). In many cases they have a southern limit, usually around Mauritania (approximately between 30°-35° Lat. N): this is the case again of *Columbella rustica* (Linné, 1758), of the neogastropods *Ocenebra erinacea* (Linné, 1758), *Mitra cornea* Lamarck, 1811. The area interested by these boundaries is rather large and the factors involved can be of various origins (e.g., the competition with Guinean species, the high input of freshwater and terrigenous sediments by the large West-African rivers). A series of species with this chorotype have close relatives (sister species) in the Senegalese province and/or the Macaronesian archipelagos. Examples of such pairs are: *Columbella*

rustica vs. *C. adansoni* Menke, 1853 (Oliverio, 1995), *Mitra cornea* vs. *M. nigra* Gmelin 1791 (Rolán, 1997), *Nassarius ferrusaci* Payraudeau, 1826 vs. *N. caboverdensis* Rolàn, 1984 (Oliverio, 1996). This pattern of affinity can usually be related to the relatively well documented history of the Tertiary Mediterranean benthic faunas. A part of these lineages is now extinct in the Mediterranean Sea (see e.g., Bouchet, 1983), and the descendants inhabit in the Gulf of Guinea and/or adjacent regions (from northern Namibia to southern Senegal). In several instances, the Tertiary ancestors have undergone speciation events resulting in sister taxa mostly with disjunct distributions.

Mediterranean

Exclusively Mediterranean species would represent good endemics. A good example of true Mediterranean endemites is the clam *Chamelea gallina* (L., 1758): diagnostic genetics and morphology with its Atlantic sister species *C. striatula* (da Costa, 1778) has been provided by Backeljau et al. (1994). Many of the several tens of molluscs species strictly associated to the *Posidonia oceanica* Linné (Delile) meadows, have ranges corresponding to that of the phanerogam: e.g., the polyplacophoran *Lepidochitona furtiva* (Monterosato, 1876), the archaeogastropod *Gibbula umbilicaris* (Linné, 1758), the caenogastropod *Rissoa auriscalpium* (Linné,1758), the Mediterranean awning clam *Solemya togata* (Poli, 1795).

Although the number of true Mediterranean endemics is quite probably high, it is here stressed that a good number of the alleged endemites should be carefully re-examined. One of the problems is given by the actual occurrence of the species in the Recent fauna. This is the case of the single monoplacophoran species reported for the Mediterranean Sea – *Veleropilina reticulata* (G. Seguenza, 1876) – known only on the base of empty shells, suspected to be of Würmian age. Another problem is the actual status of the Mediterranean populations. The exclusively Mediterranean *Pecten jacobaeus* (Linné, 1758) has long been considered a different species from the common Atlantic Saint-Jaques clam *P. maximus* (Linné, 1758), and from the close, westafrican *P. keppelianus* Sowerby III, 1905. Recently, molecular data have been used to suggest (rather surprisingly) that *jacobaeus* and *maximus* be conspecific (Canapa et al., 1999, 2000).

The hydrological-climatic dynamics that have interested the Mediterranean basin during the ice cycles from the Late Tertiary to the Holocene had dramatic and differential effects in the Eastern vs. the Western sub-basins. It is not surprising thus, that the most evident biogeographic structure of the benthic faunas is longitudinal, between the two sub-basins. A number of species have more or less strictly Eastern Mediterranean ranges. Examples are known in many

families of gastropods and bivalves. Noteworthy, the prosobranch gastropods of the Eastern Mediterranean show an increasing dominance of non-planktotrophic developers, vs. the Western Mediterranean (Oliverio, 1997). Also in this case, the presence of pairs of sister species in the two sub-basins is largely documented, underlying interesting evolutionary dynamics correlated to climatic fluctuations (Oliverio, 1996b).

Also on a smaller scale, local endemics are known, yet not common. They can be important descriptors of the more recent history of local areas and then of the basin, and should be carefully evaluated. The archaeogastropods *Gibbula spratti* (Forbes,1844), from the Aegean Sea and *Gibbula nivosa* Adams A., 1851, from Malta are good example of true local endemics, as is the muricid *Aspella anceps* (Lamarck,1822) from the Levant basin. At this level, a common problem in malacology is particularly evident. The actual range of variation and the effects of epigenetic plasticity on shell morphology are not well known. This has lead to the present practice in conchiferan taxonomy, where populations with constant and somehow striking deviating shell features are ranked and described as species or subspecies. In many cases, these "taxa" live in somehow extreme environments, such as the hyper- or hypohaline lagoon, and are endemics to small localities. For instance, the Northern Adriatic Sea hosts many allegedly endemic taxa (e.g., the trochids *Gibbula albida* (Gmelin, 1791) and *Calliostoma virescens* Coen, 1933), notwithstanding its very recent post-glacial recolonisation. Several populations of the muricid genus *Ocinebrina*, well characterised morphologically, may also deserve a re-examination by molecular tools, in order to understand if and which of the several described taxa are valid: e.g., *Ocinebrina ingloria* (Crosse, 1865) again from the northern Adriatic (mostly Venice lagoon), *Ocinebrina hispidula* (Pallary, 1904) and *Ocinebrina aciculata exilis* Houart, 2001 from the Gulf of Gabès.

Alien species

Two remarkably different phenomena gave rise to a large number of populations of allochtonous benthic species in the Mediterranean Sea: the Lessepsian "migrations" and the introduction by man of alien species. The distinction is required by the different biological properties of Lessepsian "migrants" and introduced aliens (see Oliverio, 1995; Oliverio and Taviani this volume). Thus, for instance *Strombus persicus* Swainson, 1821, and *Rapana venosa* (Valenciennes, 1846) have been accidentally introduced by man, whilst e.g., *Rapana rapiformis* (Von Born, 1778) is a true Lessepsian "migrant". Over 100 species of molluscs are considered as Lessepsian "migrants" (including polyplacophorans, bivalves and gastropods). They represent 5% of the total Mediterranean malacofauna, but up to 10% of the molluscs of the Levant basin.

The phenomenon is thus very remarkable also in terms of alteration of the previous pattern of biodiversity.

While the Lessepsian "migrations" have the properties of a natural biological phenomenon, possibly directed toward a dynamic stability, the introductions by man often raise serious concerns (see also Zibrowius, 1991). The tendency to be invasive of the naturalized populations represents a problem to the autochtonous biodiversity, as the case of the edible Mediterranean Venus clam shows. *Tapes decussatus* (Linné, 1758) is nowadays nearly replaced by *T. philippinarum* (Adams and Reeve, 1850), both in the market and in several wild environments (especially in North Adriatic). The two small mussels *Musculista senhousia* (Benson in Cantor, 1842) and *Xenostrobus securis* (Lamarck, 1819), rise serious wondering for the lagoon communities where they are spreading. In these cases (and possibly in most of the others), the actual risks for the autochtonous fauna and flora, in terms of competition with allochtonous species, and introduction of pathogens or parasites are unknown.

Tab. III - Percentage of chorotypes for three groups of molluscs.

	Taxonomic group (number of species) and source of data		
chorotypes	Polyplacophora (29) Dell'Angelo, Smriglio (1999)	Rissooidea (186) Oliverio, unpublished	Opisthobranchs (409) Cattaneo (1989)
Atlantic- Mediterranean	41.3%	38.4%	53.6%
Western Mediterranean	3.4%	18.5%	
Eastern Mediterranean		9.6%	
entire Mediterranean	48.3%	13.0%	
Mediterranean (tot.)	51.7%	41.5%	26.9%
Wide range	3.4%	3.9%	4.9%
Lessepsian	3.4%	5.0%	4.2%
?		11.1%	10.0%

For a few groups, the available data allow to draw some biogeographic pattern (Table III). The Mediterranean Polyplacophora have been recently revised and the whole fauna figured and published (Dell'Angelo and Smriglio, 2000). A total of 29 species have been scored with certainty in the Mediterranean Sea (plus two species with very doubtful records). Of the 29 taxa, 12 (41.3%) have Atlantic-Mediterranean chorotype, 11 (37.9%) have a clearly Mediterranean chorotype while 3 (10.4%) slightly extend into the Ibero-Moroccan Gulf, 1 has a western-Mediterranean chorotype (summing up 49% of Mediterranean chorotypes), 1 (3%, *Chiton hululensis*) is a Lessepsian invader and finally 1 (*Lepidochitona cinerea*) is reported as with a

very wide (=cosmopolitan?) distribution, but many of its extra-Mediterranean records should be very carefully checked.

The Mediterranean Rissooidea have been mostly revised in the last two decades by several specialists (Oliverio et al., 1987, 1989, 1990). A total of 186 species are presently listed for the Mediterranean Sea. According to the distributional data available (11.1% not scorable), 38.4% of the species have AM chorotypes. Chorotypes of the Mediterranean type are shown by 41.5%: of these 13% are Mediterranean, 9.6% are Eastern Mediterranean, 18.5% Western Mediterranean. Only 3.9% are reported as cosmopolitan or circumtropical, and 5% are Lessepsian invaders.

Cattaneo and Thompson (1989) made a biogeographic analysis of the opisthobranch fauna of the Mediterranean Sea. With about 10% not scored, 53.6% of the species were of Atlantic-Mediterranean chorotype; 26.9% Mediterranean, 4.9% cosmopolitan or circumtropical, and 4.2% were Lessepsian invaders.

The figures in the three studies are not always congruent. The percentage of Lessepsian and wide range species are very similar. The lower percentage of Mediterranean chorotypes in the opisthobranchs was already expected to change with an increase in the knowledge of lesser studied groups, while the values for the Polyplacophora can be biased by the small sample size.

CONSERVATION ISSUES

Presently, there are no Mediterranean species of molluscs included in the CITES documents and no marine protected areas were made to protect vulnerable or endemic mollusc species. Only for *Patella ferruginea* and *Gibbula nivosa* the threatening is considered very risky. Many species are indeed part of communities with some degree of regression; this is the case of the molluscs associated with the deep water white corals (natural regression), or to the *Posidonia oceanica* meadows (induced by man, by climatic variations and by competition with allochtonous invaders as *Caulerpa taxifolia* in the northern Tyrrhenian Sea). Nevertheless, only 14 species are included in the "Bern Convention" or the "Habitat Directive" lists. The list of species worthy of protection could be easily increased (Scotti and Chemello, 2000 and Table IV), at least with the few locally endemics (or those with very restricted ranges), and the so called "rare species", whose life cycles make them particularly vulnerable. These numbers are, in any case, an underestimation of the real degree of extinction risk, due to a diffuse lack of knowledge in taxonomy, ecology and biology of many threatened species.

Tab. IV - List of endangered species in the Mediterranean Sea (after Scotti, Chemello, 2000, modified), along with their present condition (CE, critically endangered; EN, endangered; VU, vulnerable: IUCN categories, Seddon, 1998) and if available, the relevant document (II: appendix II to Bern Convention on the conservation of European wildlife and natural habitats; IV: annex IV of the EC Directive on the Conservation of Natural Habitats and of Wild Fauna and Flora; SC: Scotti, Chemello, 2000).

species	IUCN category	document reference
Patella ferruginea Gmelin, 1721	CE	II, IV
Patella nigra Da Costa, 1771	EN	SC
Gibbula nivosa Adams A., 1851	CE	SC
Dendropoma petraeum (Monterosato, 1884)	VU	II
Zonaria pyrum (Gmelin, 1791)	EN	II
Schilderia achatidea (J.E. Gray in G.B. Sowerby II, 1837)	EN	II
Luria lurida (Lamarck, 1810)	EN	II
Erosaria spurca (Linnaeus, 1758)	EN	II
Charonia lampas lampas (Linnaeus, 1758)	EN	II
Charonia tritonis variegata (Lamarck, 1816)	EN	II
Bursa scrobilator Linnaeus, 1758	EN	SC
Cymatium parthenopeum (Salis Marschlin, 1793)	EN	SC
Ranella olearia (Linnaeus, 1758)	VU	SC
Tonna galea (Linnaeus, 1758)	VU	II
Mitra zonata Marryat, 1818	EN	SC
Lithophaga lithophaga (Linnaeus, 1758)	VU	II, IV
Pholas dactylus Linnaeus, 1758	VU	II
Pinna nobilis Linnaeus, 1758	VU	IV
Pinna rudis Linnaeus, 1758	VU	II
Atrina pectinata (Linnaeus, 1767)	EN	SC
Solemya togata (Poli, 1795)	EN	SC

CONCLUSIONS AND THE ITALIAN SITUATION

The Mediterranean Malacofauna is still considered as the best known in the world. This is the result of a European tradition in the field of taxonomy and faunistics where the Italian research played a crucial role. Presently, there is a strong need to increase the taxonomic knowledge, by making large use of modern techniques (including the molecular data acquisition and the electron microscopy). Information on the biology of the species (e.g., life cycles, autoecology, spatial distribution details: all data available for less than 2-3% of the Mediterranean malacofauna) is still minimal as is the integration in modern databases of the geographic data of the public and private collections. Contrary to what happens elsewhere, in Italy and in many European countries, the researches on taxonomy and faunistics are neglected even by the few specialists left, due to the lack of funding (Boero, 2001). Entire classes (Caudofoveata and Solenogastres, but also Scaphopoda and in great part Bivalvia) are handled only by a few foreign specialists. Several less well explored environments may provide very interesting novelties (deep bottoms, marine caves, meiobenthos etc.).

The over 1500 species found in the Italian waters represent 75% of the total Mediterranean marine malacofauna (over 90% of the families represented). These simple figures tell that Italian research in this field could play a crucial role. Completing the inventorying of the biodiversity (thus, also of the malacological components), is one of the most exciting challenge for the marine biology of the XXI century. Important aspects of such diversity (from the alpha level of the taxonomy to the more sophisticated aspects of biology) are still to be discovered and described, a mandatory and urgent prerequisite to the definition of the conservation issues.

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