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

Mediterranean Sponge Fauna: a biological, historical and cultural heritage

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SUMMARY

At the end of the last century (year 2000) the Mediterranean sponge species were 605; over 40% are endemic, North Atlantic affinities are 20%, South Atlantic ones are 6%. Lessepsians migrating species are more than 30 (about 5%). Mediterranean Sea was deeply investigated in the past, in spite of that the discovery of new species, or genera, is not a rare event. The species richness of Mediterranean sponges is under pressure and losses are possible because of epidemic diseases and over-fishing of bath sponges. During the last decades the number of species that are actively harvested is dramatically increasing; this tendency in absence of any knowledge on sponge population distribution and density, could lead to local extinctions.

INTRODUCTION

In a world-wide synthesis on sponge biogeography (Soest, 1994) are examined over 11.000 papers, all data on systematic and faunistic of over 7.000 species, belonging to about 1.200 genera. From this study results that 552 species belong to the Western Mediterranean basin while 194 are present in the Eastern one. This record, compared with the sponge species richness of other 34 geographic areas, shows that only Caribbean-Centro-American (640 species), Sino-Japanese (589 species) and Indonesian (965 species) Seas are populated by a more diverse sponge fauna. In a successive study, performed with cladistic methods (Soest, 1998) the very low affinity of the Eastern Mediterranean sponge fauna with any other Sea of the world is evidenced. As for the Black Sea almost no data are available in the scientific literature, as a consequence no comparison can be done.

The number of Mediterranean sponge species has continuously increased up today; first data are reported from the 13th edition of Systema Naturae (Linné, 1789), from that moment successive papers report a continuous and constant

increasing of the number of sponge species ((Fredj, 1974; Vacelet, 1980; Pulitzer-Finali, 1980; Pansini, 1992, 1995, 1996; the check list of the year 2000 counted over six hundreds species (Fig. 1). In the last two years (2000-2002), other five new species were described reaching the record of 610, and surely this trend will persist. The Mediterranean sponge fauna is characterized by high levels of endemism, as a correct management and a rational exploitation appear to be necessary for a correct biodiversity conservation.

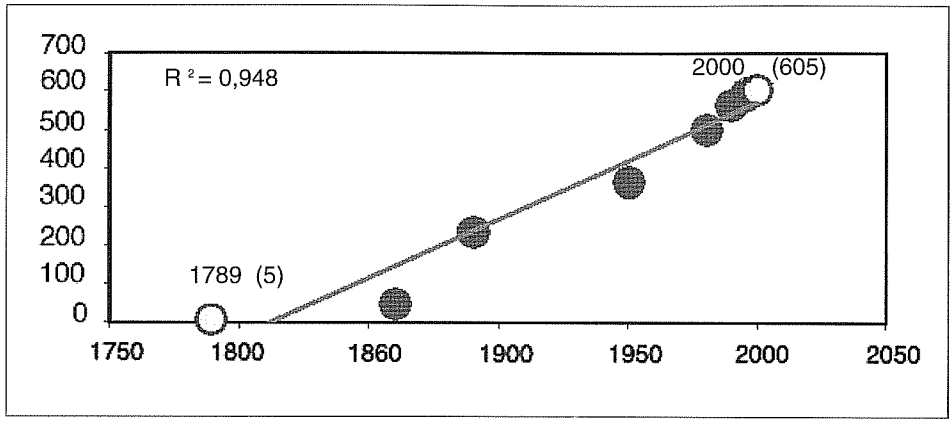

Fig. 1 - The trend of Mediterranean sponge species richness shows a continuous regular increasing starting from the checklist of the13th edition of the Linnean Systema Naturae; this was the first book relating species to geographical sites. Among over 50 sponge species only 5 were indicated as living in the Mediterranean Sea.

SYSTEMATIC AND SPECIES VALIDATION

From the historical point of view, the majority (about 75%) of Mediterranean sponge species were described over one hundred years ago; as a consequence many nominal species are simply "names written on paper" (type specimen are lost; no further findings are known except the first one, and so on). Moreover the majority of historical collections are forgotten, from many decades, in several Natural History Museum, without further studies (systematic research do not pay in terms of fundings and career). In few words: the real number of sponge species of the Mediterranean Sea is unknown and, probably, at present, it is highly over- or under-estimated.

The morphological plasticity of sponges is one of major problems for a correct classification of Porifera (Manconi and Pronzato, 1991; Gaino et al., 1995); many taxa are characterized by morphological traits subjected to high variability induced by environmental parameters; in these cases also very experienced specialists are doubtful. If some classic taxonomic studies indicate that many species are junior synonym of other Mediterranean species (Pronzato et al., 2002a), other revisions

(performed with the help of techniques such as: electron microscopy, biochemistry, molecular biology and genetics) allow to recognize cryptic species (Sole-Cava et al., 1991; Boury-Esnault et al., 1992; Bavestrello et al., 1994; Boury-Esnault et al., 1995; Bavestrello et al., 1996; Muricy et al., 1996).

EXPLOITATION AND PROTECTION OF THE MEDITERRANEAN SPONGE FAUNA

The Mediterranean sponge fauna is protected by local and international protocols (Tab. I). The choice of species to put under safeguard seems to be indicated by their conspicuousity and recognizability (in fact many of them are common and well known also to not specialized marine biologists). On the contrary other species: rare (such as *Darwinella gardineri*, recorded only once in the Mediterranean, Fig. 2a); or restricted in a very small area (such as *Spongionella gracilis*, endemic from the Gulf of Naples, Fig. 2b); or in regression (such as *Calix nicaeensis*, now rare or disappeared from the Ligurian coasts, Fig. 2c), are not included in these directories.

Tab. I - The list of Mediterranean protected Porifera encompasses 15 species. At present, only 4 of them (N° 3, 8, 9, 15) need strict protection rules. Other four species are commercial (bath) sponges (N° 7, 11, 12, 13) and their harvesting is variously ruled by different Mediterranean Countries. The resting species are relatively common (N° 1, 2, 4, 5, 6, 10, 14) but some of them (and many other not reported in the list) produce bioactive compounds, as a consequence an increasing of the fishing effort, in the next future, is a real risk. The list of Mediterranean protected Porifera must be emended; in particular all species producing bioactive metabolites must be included in the first group (commercial sponges). New studies in sponge banks consistency and dynamics must be performed in order to elaborate a more efficient sponge fishery policy.

1) *Aplysina aerophoba*
2) *Aplysina cavernicola*
3) *Asbestopluma hypogea*
4) *Axinella cannabina*
5) *Axinella polypoides*
6) *Geodia cydonium*
7) *Hippospongia communis*
8) *Ircinia pipetta*
9) *Petrobiona massiliana*
10) *Sarcotragus foetidus*
11) *Spongia agaricina*
12) *Spongia officinalis*
13) *Spongia zimocca*
14) *Tethya aurantium*
15) *Tethya citrina*

Sponges belong to the traditional culture of many Mediterranean coastal populations. Species belonging to the genera *Spongia* and *Hippospongia* (Fig. 3) were actively harvested by ancient Egyptians, Phoenicians, Greeks and Romans, since the beginning of civilization, five thousand years ago. A sponge, utilized for many purposes, supplied each roman soldier; in fact a sponge was the medium to give the last comfort to the dying Christ. Sponges, soaked up with milk and honey, were also dummy for babies.

Harvesting methods become more and more efficient with the help of diving suites. At present a sponge-diver can collect more than 200 specimens during a two hours diving shift. Over-fishing is not the only problem for sponge populations, serious diseases strikes periodically wild populations, causing heavy loss. The synergy of over fishing and disease, from 1985 to 1990, brought bath sponges in the brink of extinction in many Mediterranean areas (Gaino and

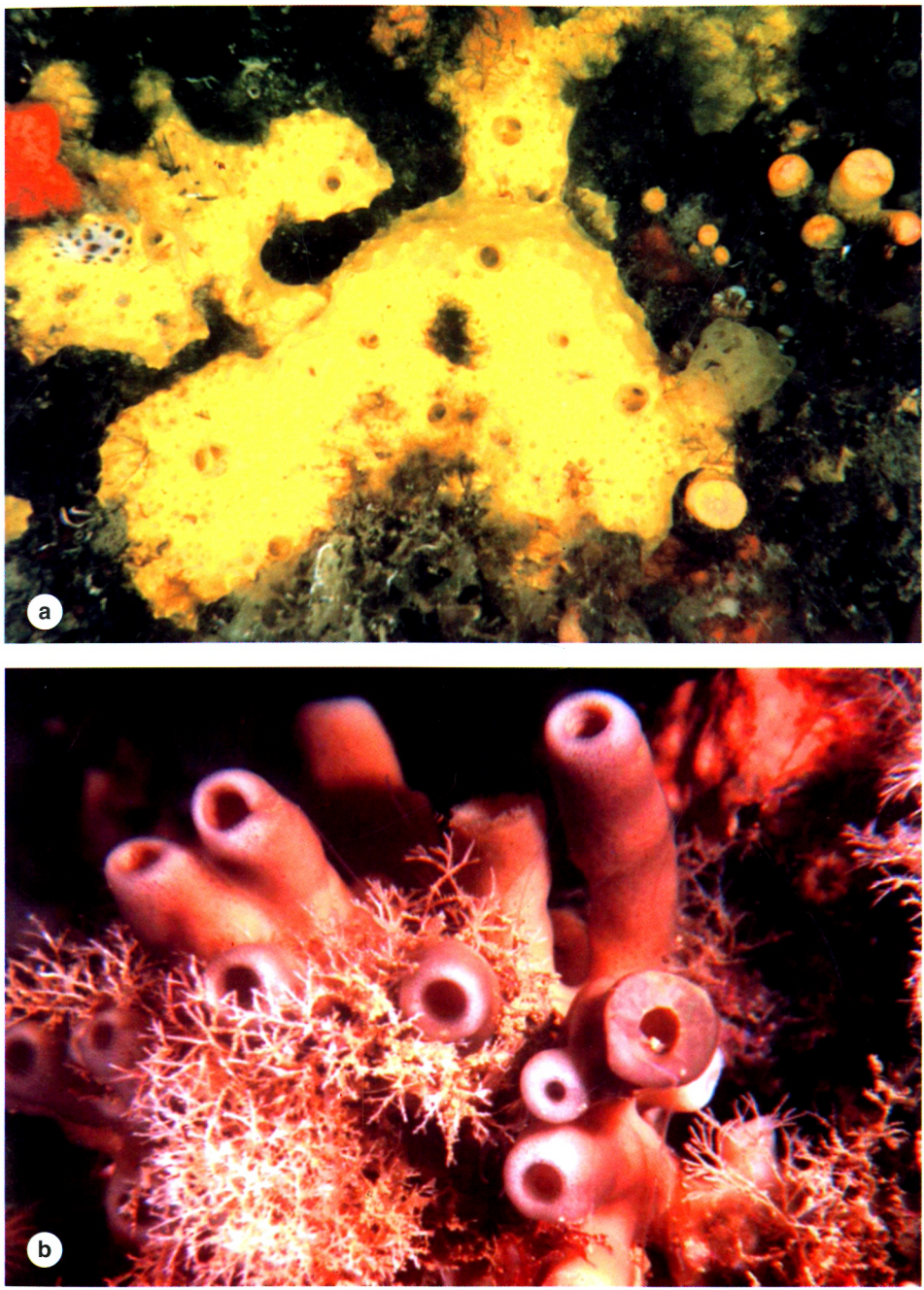

Fig. 2a,b - Three very rare, or restricted to small geographic areas, or in regression sponge species; from top *Darwinella gardineri* (only one finding in the Mediterranean); *Spongionella gracilis* (present only in the Gulf of Naples).

Fig. 2c - The sponge species *Calyx nicaensis* (disappeared from the Ligurian coasts).

Fig. 3 - The Mediterranean bath sponge species are 5: *Spongia mollissima*, *Spongia agaricina*, *Spongia officinalis, Spongia zimocca, Hippospongia communis* (clockwise). Here are shown naked skeleton as they results after a traditional preparation.

Pronzato, 1989; Gaino et al., 1992; Pronzato et al., 1996; Pronzato et al., 2000). The successive recovery of damaged populations requires long time and can last over 5 years (Rizzello et al. 1997). In spite of that no real active protection was performed till now in order to avoid impoverishment or local extinction of Mediterranean bath sponge banks. Among the fishery rules there is only a generalist suggestion for a harvesting regulamentation (Haywood, 1991).

NEW FRONTIERS OF SPONGE ECO-SUSTAINABLE MANAGEMENT

Recent experiments (Uriz et al., 1992; Faulkner, 1997, 1998, 1999, 2000; Müller, 2002; Sarà, 2002) proved that sponge metabolites are the most active and useful among marine natural products; some of them are listed in catalogues of chemicals from many years. Prices of these compounds are so high that the species from which are extracted must be inserted in the emended list of "commercial sponges". New medicines, based on sponge extracts, are under experiment or has been just introduced on the market. We must realize that the number of sponge species, harvested in large quantities (hundreds of kilos or tons), is rapidly increasing. *Dysidea avara* is actively harvested because a product of its metabolism the avarol (Minale et al., 1974) is a basic compound for antiflogistic ointments. *Fasciospongia cavernosa, Reniera sarai, Cacospongia mollior, Aplysina aerophoba* are now under experimentation and their natural populations could be subjected to over fishing pressure in a few years. A rational exploitation planning is needed in order to avoid these probable phenomena. This evidence makes urgent a revision of the list of protected sponge species (Tab. I); new (rare) species must be added; some other (very common) could be partly cancelled or their harvesting must be controlled.

A simple and eco-sustainable solution is the sponge farming. Sponges are plastic organisms able to perform a clonal proliferation simply by fragmentation. The technologies for sponge culture are easy and not expensive (Pronzato et al., 2002b) (Fig. 4). Sponge culture is possible in combination with all other mari-culture activities (such as fish farming in floating cages) (Manconi et al., 1999). Moreover sponges are very efficient natural water cleaner; they can filter an enormous water volume, performing very high cleaning rates (Reiswig, 1974, 1975). Sponges feed normally on bacteria and organic suspended particles, as a consequence a combination between sponge farming and sources of organic pollution (such as drainages) can reduce environmental damages in coastal areas such as in the case of the M.U.D.S. (Cattaneo-Vietti et al., in press) regularly produced and sold in Italy.

The experience of my research group, in this field, is lasting over ten years; our sponge farms are settled in many Mediterranean sites; the method was experimented under different environmental conditions; the structures are modular and adaptable to all marine bottoms. We experimented successfully over thirty (Tab. II) sponge species, including fresh-water ones (such as *Spongilla*

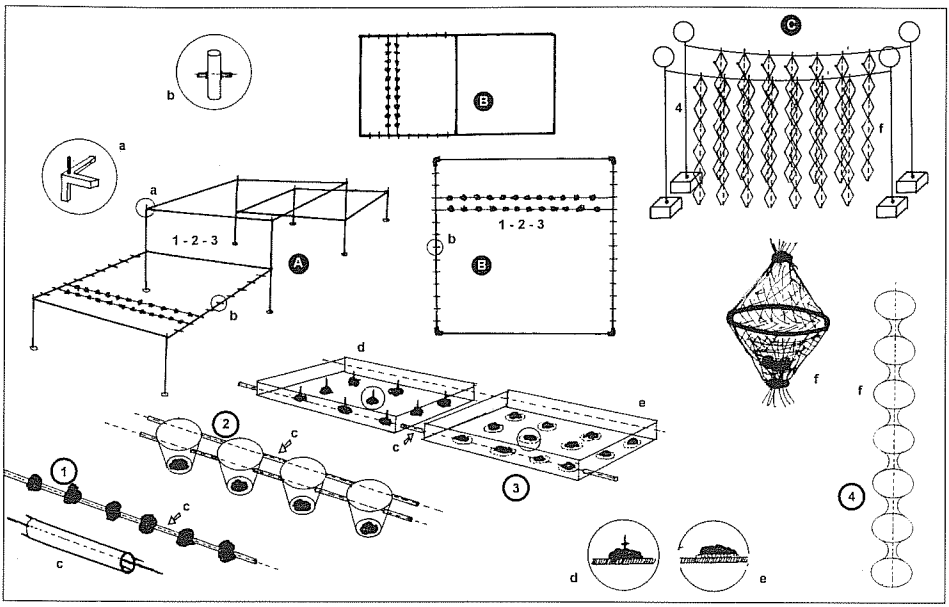

Fig. 4 - The U.S.A.M.A. method for sponge culture. These simple and not expensive structures allow to rear sponges under controlled conditions; the combination of different modules allow to settle sponge farms on every kind of sea bottoms.

lacustris) for potabilization purposes. In some cases growth and clearance rates are very high (Milanese et al., in press) and an eco-sustainable production, of large sponge biomass quantities, is possible.

Tab. II - The list of tested species in sponge farming, including freshwater ones (*), is increasing day by day. After 10 years of experiment is possible to say that for almost ten species a real production for commercial purposes is possible.

Agelas oroides	*Chondrilla nucula*	*Ircinia variabilis*
Aplysina aerophoba	*Chondrosia reniformis*	*Leuconia solida*
Aplysina cavernicola	*Crambe crambe*	*Oscarella lobularis*
Axinella damicornis	*Dictyonella incisa*	*Sarcotragus spinosulus*
Axinella polypoides	*Dysidea avara*	*Sarcotragus foetidus*
Cacospongia mollior	*Dysidea fragilis*	*Spongia agaricina*
Clathrina clathrus	*Ephydatia fluviatilis**	*Spongia officinalis*
Cliona viridis	*Hippospongia communis*	*Spongilla lacustris**

CONCLUSIVE REMARKS

Mediterranean sponges are a biological, cultural and historical heritage that must be preserved for next human generations. From the biological point of view there are evidences that, notwithstanding this sea is one of most studied in the world, new taxa are continuously recorded (two new genera in a submerged marine cave, near Marseille, Vacelet, 1998). Sponge fishery belongs to the ancient

culture of many coastal Mediterranean human populations and must be maintained using new rational methods of exploitation and protection of wild sponge populations integrated with modern systems of sponge culture. The scientific historical heritage of Mediterranean Porifera biodiversity is preserved in few Natural History Museum but recent collections are not compared with ancient ones; the result is that the real number of Mediterranean sponge species is practically unknown. Without data on the real distribution of species and on the fluctuation of natural populations (under natural or antropic pressure) a real management of sponge biodiversity is hard to perform.

Finally I would like to point out the problem of sponge variability in space, time and physiology. We know very well that many species (not only among sponges) show geographical varieties; for example, body shape is significantly different in populations of *Spongia officinalis*, from Portofino and Crete, in spite of their identical skeletal network (Pronzato et al., in press). Geographical differences in life cycles (e.g. reproduction rates) and in physiological processes are also possible and are under investigation. Our aim is to rear sponges, able to produce active compounds, for commercial purposes. We presume that all life processes, of specimens under captive maintenance, are the same of wild specimens, but we are not sure of that: we need further final evidences.

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