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Review

Loss and gain of marine biodiversity in Mediterranean seawaters

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Abstract: The Mediterranean Sea is one of the most important biodiversity hotspots worldwide. The high biodiversity level of the basin is confirmed by the presence of about 17,000 marine species of which 20.2% are endemics. Amongst them, *Posidonia oceanica* (Linnaeus) Delile can form, in pristine coastal waters, large and extensive meadows, performing a pivotal role in endemic processes. However, the richness of marine biota is, actually, affected by some threats such as habitat loss, marine pollution, climate changes, eutrophication and the establishment of invasive alien species coming from the Indo-Pacific region through the pathway of Suez Canal. This trend could lead to a new kind of marine biodiversity influenced by the introduction of termophilic species altering the pattern of Mediterranean biota. Anyway, it is necessary a global approach, ensuring the better ecological conditions so to protect marine biodiversity in meditrranean seawaters.

Keywords: Mediterranean Sea; *Posidonia oceanica*; marine biodiversity; alien species; endemics

1. Introduction

Coastal areas, representing just the 10% of earth's surface, holds about the 60% of world population [1]. The high demographic pressure could increase in the next decades, as urbanization is driving a growing movement of people towards the coast. Really, many services are provided by coastal systems as are: fishing, harbouring, commercial trade and coastal tourism. Besides, the littoral zone is a sensitive area where sea and land interact and play altogether an important role, integrating coastal water and its watershed in a whole system. However, the increasing urbanization of coastal areas, the proliferation of harbours and the realization of artificial barriers, to protect sandy beaches from erosion, are contributing to fragment marine benthic biocenosis altering their natural connectivity and causing a potential loss in marine biodiversity [2]. The Mediterranean, at the crossroads between land and sea, is a semi-enclosed basin connected, at its western side, with the Atlantic Ocean through the Strait of Gibraltar and, at its southeastern side, with the Indian Ocean through the Suez Canal. The special geographic location of the basin and the late doubling of this last waterway, happened in 2015, have favored the flourishing of many termophilic alien species into the basin. So, the Mediterranean Sea, has became, in time, one of the most important hotspot for the marine biodiversity worldwide. Actually, many threats such as habitat loss, marine pollution, climate changes, eutrophication and bioinvasions are affecting the biological diversity of Mediterranean biota. Amongst the main environmental problems, two critical ones are shoreline erosion and biodiversity loss, closely connected, also, in other semi-enclosed basins as the Baltic and the Black Seas [3–5]. Italian coastal regions, with more than 8000 km of their coasts, altered by human infrastructures, are considered the most densely urbanized and populated among the Mediterranean countries [6]. The tight connection between these issues is especially marked along the Western side of the Mediterranean basin where the increased concentration of mineral particles is a real threat to benthic biota.

2. The biodiversity of *Posidonia oceanica* meadows

Posidonia oceanica meadows, in Italian coastal waters, are suffering from silting processes leading to a reduction in their leaf density and to a remarkable increase in the rate of mortality of the leaves, as highlighted, also, for other Mediterranean meadows [7–13]. Really, this negative trend could be caused by erosion and silting processes leading to a decrease in the photosinthetic ratio of the plants. In the whole Mediterranean Sea, Posidonia beds cover a total surface area between 2.5 and 5.0 million of hectares [14] but in these last decades it is possible to highlight, by scientific literature [15], a progressive regression of the meadows variable between 13% and 50%, in regard to the values recorded in 2000. In the basin, the regressive trend of the surface area covered by Posidonia oceanica meadows, could affect other endemic species still living, as epibiota, on Posidonia blades. In fact, *Posidonia oceanica* performs an important pivotal role in the evolution of some endemic species, such as Bryozoan and Hydrozoan sessile epibiota living on its leaves [16–18] (**Table 1**).

Table 1. List of endemic sessile species recorded on Posidonia leaves.

Species	Authors	Phyla	Classes	Orders
Agloiophenia harpago	(Schenk, 1965)	Cnidaria	Hydrozoa	Leptothecata
Campanularia breviscyphia	(Sars, 1857)	Cnidaria	Hydrozoa	Leptothecata
Coryne epizoica	(Stechow, 1921)	Cnidaria	Hydrozoa	Anthothecata
Electra posidoniae	(Gautier, 1954)	Bryozoa	Gymnolaemata	Cheilostomatida
Microporella joannae	(Clavet, 1902)	Bryozoa	Gymnolaemata	Cheilostomatida
Monotheca posidoniae	(Picard, 1952)	Cnidaria	Hydrozoa	Leptothecata
Tridentata perpusilla	(Stechow, 1919)	Cnidaria	Hydrozoa	Leptothecata
Tricolia speciosa	(Von Mühlfeldt, 1891)	Mollusca	Gasteropoda	Trochida

3. Endemics in Mediterranean Sea

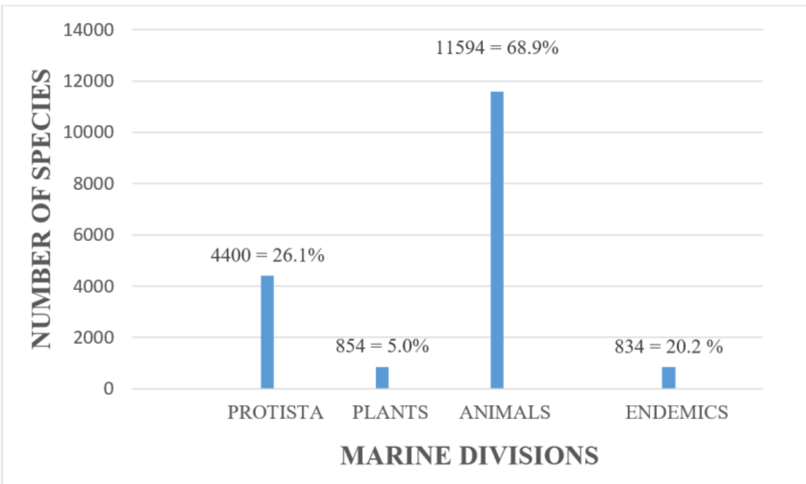

Figure 1. Pattern of Mediterranean marine biota.

The Mediterranean biota is composed by 16,848 species [19] shared out in protista as 26.1%, plants (5.0%) and animal (68.9%) divisions, while the endemic species are estimated about the 20.2% of the whole (**Figure 1**).

The high levels of marine biodiversity in Mediterranean biota derive primarly from the Atlantic Ocean but, anyway, the special variability of climate conditions and the long phylogenetic history of the basin have caused in time the evolution, the diffusion and the establishment of many temperate and endemic species [20–23]. In particular, as regards endemics, their percentages reach a total value of 20.2% distributed in the following divisions: Porifera (48%), Mysidacea (36%), Ascidacea (35%), Cumacea (32%), Echinodermata (24%), Bryozoa (23%), Seaweeds and Seagrasses (22%), Aves (20%), Polychaeta (19%), Pisces (12%), Cephalopoda (10%) and Decapoda (10%) [19] (**Figure 2**).

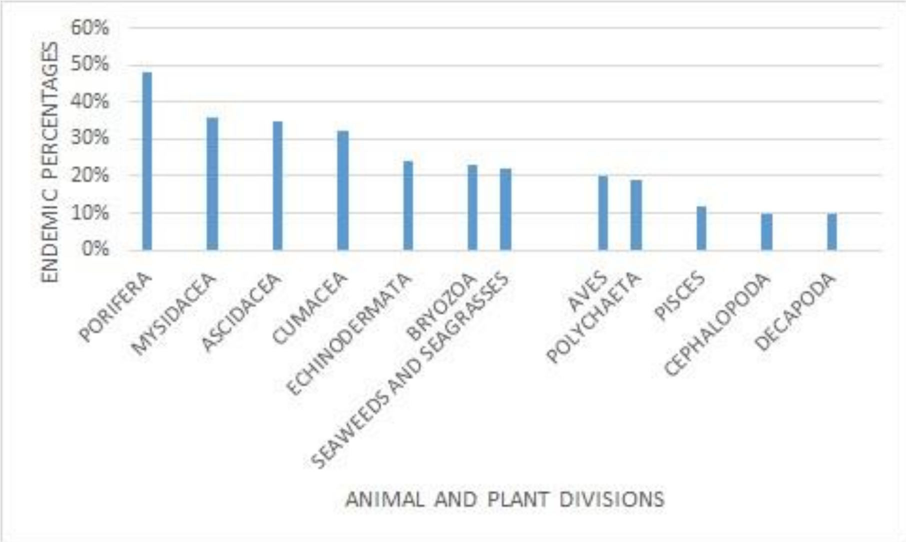

Figure 2. Percentages of endemic species in animal and plant divisions.

4. A new kind of biodiversity

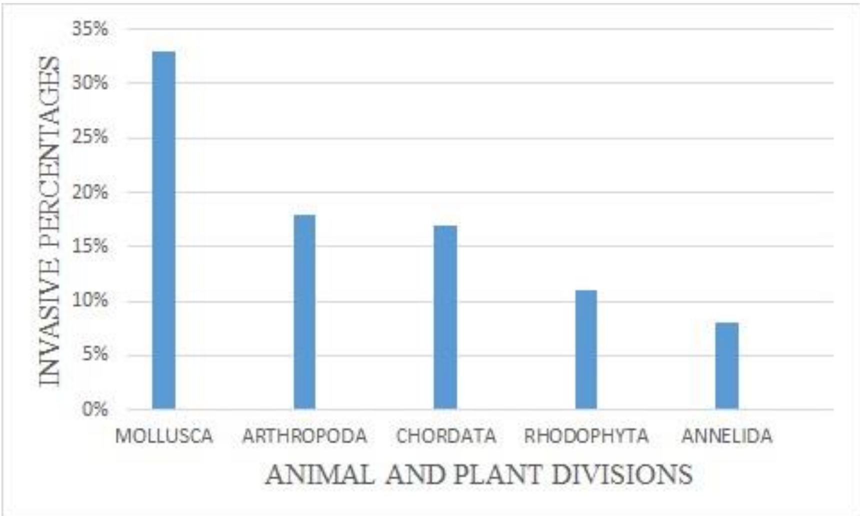

Figure 3. Percentages of Invasive Alien Species in animal and plant divisions.

In these last decades, there is, also, a new kind of Mediterranean marine biodiversity caused by the introduction into the basin of many Invasive Alien Species (IAS) coming from the Indo-Pacific region through the Suez Canal [24–30]. Most of these thermophilic species are littoral and sublittoral benthic organisms belonging to the following phyla: (Mollusca 33%), Arthropoda (18%), Chordata (17%), Rhodophyta (11%) and Annelida (8%) [19] (**Figure 3**).

5. Threats to marine biodiversity

The estimated richness of marine biota shows, actually, a clear decreasing gradient of species and a general drop in biodiversity levels from the northwestern to the southestern regions of the basin [31,32]. Actually, there are many threats affecting marine biodiversity in Mediterranean Sea. According to Lotze et al. [33], habitat loss is the main risk factor (76%) followed by exploitation (54%), pollution (49%), climate changes (38%), eutrophication (35%), bioinvasions (25%), maritime trafic (12%) and aquaculture (10%) (**Figure 4**).

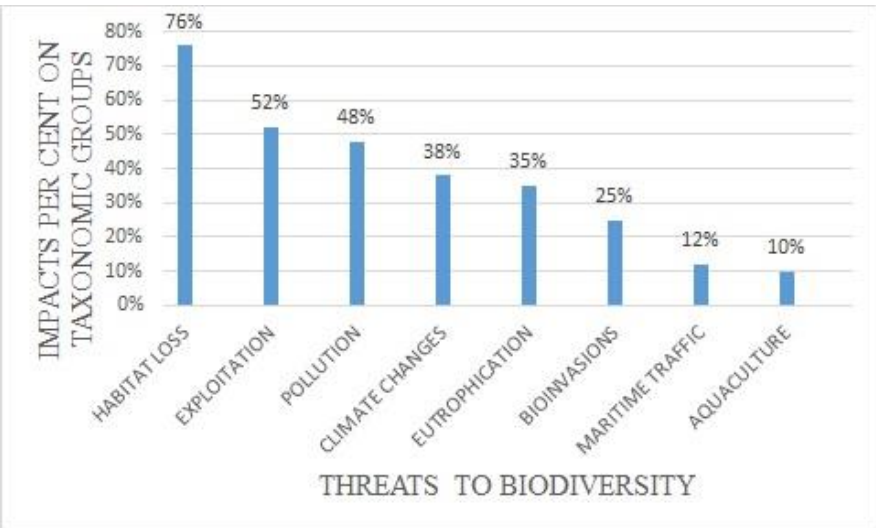

Figure 4. Percentages of risk categories threatening marine biodiversity in Mediterranean Sea ([19], modified).

These values are drawn from published data and scientific opinions by experts for 13 taxonomic groups very sensitive to the present threats affecting marine biodiversity [34]. This trend is expected to grow in the future, affecting a great number of taxonomic groups and endemic species, so leading to important changes in the functioning and in the structure of coastal ecosystems.

6. Conclusions

The study shows a marine region characterized by high biodiversity levels and by a great diversification of species but there is an urgent need of further studies in some marine areas largely unexplored such as the African coast and the deepths of the Mediterranean basin. This report shows the high complexity of Mediterranean Sea where natural and human forces interact, affecting marine biodiversity. Really, our knowledge is quite limited and lacking of a real comprehension about how different impacts could interact each other. So, it is necessary a global approach to choose the better conservation and management efforts aimed to preserve Mediterranean biodiversity. In conclusion, the protection of the Mediterranean ecoregion can only be achieved by guaranteeing favourable ecological conditions for species, habitats, mankind and ecological processes.

Conflict of interest: The author declares no conflict of interest.

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