MARINE ALGAE AND PLANTS

M. A. O. Figueiredo
Programa Zona Costeira, Instituto de Pesquisas Jardim Botânico do Rio de Janeiro, Brazil

J. C. Creed
Departamento de Ecologia, Universidade do Estado do Rio de Janeiro, Brazil

Keywords: Biological Diversity, Community structure, Macroalgae, Marine Environment, Seagrass

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Summary

Marine algae and seagrasses are morphologically diverse plant groups in tropical regions that together are the main primary producers and base of food chain in the oceans. Some algae and seagrasses are 'ecosystem engineers' as they change the environment and the diversity of marine life. Both algae and seagrasses produce young recruits by sexual reproduction or body fragmentation, that once settled may have a short to long lives. They are found from estuarine to true marine environments, inhabiting hard and soft bottoms from between tidal ranges to deep waters on the continental shelf. The tropical Indo-Pacific region is considered their center for species diversity. Geographical barriers have isolated many species of algae and seagrasses. Their distribution is also limited by latitudinal temperature range and their abundance by local environmental productivity and degree of exposure to disturbances. On the upper shore they are exposed to high temperatures and desiccation stress and on the lower shore they are limited principally by fish and sea-urchin herbivores and competition with other animals and plants. Wave sheltered places are dominated by large sized algae on hard substrata and seagrasses in sediments. Large canopy forming algae and seagrasses shade and limit algae growth beneath, but epiphytes also reduce light availability to their algae or seagrass hosts. Competition in stratified plant communities in the tropics depends on the ability of algal and seagrass species to occupy the space, capture light and nutrient resources, and resist or recover thallus and leaf loss by grazer activity.

1. Introduction

Algae were the first photosynthetic cellular 'plants' from which all subsequent groups of plants might have arisen in the past. They are very diverse group of organisms that range from single-celled to multicellular forms, show a low level of thallus differentiation (Figure 1) and lack elementary conducting tissues of more advanced plants. Macroalgae attain visible sizes and are organized in filamentous or parenchymatous thalli. Larger algae that have a very complex differentiated thallus are named ‘seaweeds’ and when they are attached by a holdfast with upright stems and fronds as tall as trees are known as ‘kelps’ (e.g., *Macrocystis* reaches 65 m height). Kelps in dense populations form marine ‘forests’ restricted to deep waters by nutrient enriched upwellings or cool oceanic currents throughout the tropical region, with their canopies shading algae beneath (e.g., *Laminaria*). There are about 10,500 species of seaweeds classified in three divisions according to pigment and storage contents in their thallus: red algae (Rhodophyta), brown algae (Ochrophyta, Phaeophyceae) and green algae (Chlorophyta). Their reproduction varies from vegetative by thallus fragmentation to asexual and sexual processes involving mostly motile zoospores or gametes and in some cases alternation of haploid and diploid generations.

Figure 1. Foliaceous brown algae *Padina* forms a leaf-like thallus.
Photo by J. C. Creed.

Seagrasses, like the algae are a polyphyletic group with multiple evolutionary origins, though they are all monocotyledonous flowering plants which grow fully submerged and rooted on marine and estuarine bottoms (Figure 2). They are not a diverse group with 50-60 species globally comprising 13 genera and 6 families (Hydrocharitaceae, Ruppiaceae, Posidoniaceae, Zosteraceae, Cymodoceaceae, Zannichelliaceae). Therefore they are not true grasses. There is quite some debate by research scientists as to how to define a seagrass, but general consensus is: that they must live in the estuarine or marine environment; be adapted to high and possibly fluctuating salinities; have the ability to grow when fully submerged; have specialized leaves without stomata and reduced cuticle; have rhizome or underground stem and roots which resist anoxia and anchor the plants; have a submarine pollination mechanism; seed underwater. Most of these characteristics are not exclusive to seagrasses.

Figure 2. Seagrasses *Halophila* and *Halodule* on soft bottom.
Photo by J. C. Creed.

Through photosynthesis algae and seagrasses are important primary producers of organic compounds regarded to be the base of the food chain in the oceans. They also may build habitats, physically changing the environment and the diversity of marine life. Seagrasses stabilize sediments allowing macroalgae to grow there as well. Calcified macroalgae build reefs and rhodolith (Figure 3) deposits that are also critical habitats for animals and other plants. Such species are termed 'ecosystem engineers'. Epiphytic animals and plants may live on their surface or endophytic within their thallus and tissues or aggregate close to their thallus growing as epilithic or episamic organisms. Macroalgae play an important role in marine environments but can be regarded as nuisance when they spread over coral reefs and drift detached along coastal shores.

Figure 3. Rhodolith built by calcified red algae.
Photo by A. B.Villas-Boas.

2. Macroalgae and Seagrass Diversity

Ecosystems in the tropics, such as coral reefs, beach-rocks, rocky shores, sandy beaches, estuaries, mangroves and seagrass beds provide a wide variety of substratum and refuges for algal spores to settle and grow. Despite the greater variety of habitats, the biological diversity of macroalgae in tropical regions is not always considered as high as in warm-temperate regions. The low diversity of algae in the tropics is also likely to result from space competition with hard corals that may restrain marine algae in extensive areas where biogenic reefs developed. Consumption by herbivorous fishes and sea-urchins and low nutrient levels in seawater are major causes of a decrease in algal diversity in the tropics. However, marine flora surveys in the tropics are not as common as elsewhere in the world, which might account for a relatively small number of algal species reported.

Tropical marine algae distribution can be distinguished by four regions: (1) Eastern Atlantic, (2) Western Atlantic, (3) Indo-West Pacific and (4) Eastern Pacific. In the Western Atlantic region, for example, algal diversity is expected to be over 600 species in the Caribbean and at least 400 species on the northeastern tropical coast of Brazil. On the western coast of Africa at least 300 species have been reported. The Indo-West Pacific is the most extensive tropical marine region and is considered a ‘hotspot’ of diversity. In the Philippines, for instance, over 900 species of marine algae have been described (250 of green, 154 of brown and 506 of red algae). The Eastern Pacific region is the poorest in species richness, with probably no more than 300 infra-generic taxa.

Seagrasses are distributed throughout most of the world's shallow seas in coastal zones but individual species are usually limited in their geographic range to tropical or temperate regions. Based on the floristic composition a number (9 to 10) of seagrass regions have been recognized which can be synthesized into only three which are entirely tropical: the Wider Caribbean, Tropical Indo-Pacific, South-East Atlantic/West Africa. Evidently, broad patterns in seagrass distribution are dictated by sea temperature, though these floras do not always have clear boundaries and are characterized as much by the absence of true temperate species as by the presence of tropical ones. Five centers of higher seagrass diversity are known, two of which are temperate (southern Australia and Japan) the rest of which (Southeast Asia, eastern India and eastern Africa) pertain to the tropical Indo-Pacific seagrass region. Highest seagrass diversity are found in India and the Philippines (14 species) and Papua New Guinea (12 species). These patterns mirror diversity patterns found in corals, mangroves and macroalgae, though the number of species is far lower than the algal flora.

The Wider Caribbean has moderate seagrass diversity, with species of *Halodule*, *Halophila*, *Ruppia*, *Syringodium* and *Thalassia*. Despite being isolated by the Amazon River estuary the Brazilian flora is considered part of this seagrass region due to the presence of *Halodule*, *Halophila* and *Ruppia*. The Tropical Indo-Pacific is the most diverse seagrass region with *Cymodocea*, *Enhalus*, *Halodule, Halophila*, *Syringodium*, *Thalassia* and *Thalassodendron* as important genera. The South-East Atlantic/West Africa region has only one species, *Halodule wrightii*. Though not tropical, the Mediterranean and South African seagrass regions contain both temperate and tropical species.

The marine algal flora can be distinguished by the proportion in the numbers of species of the three algal groups according to pigment contents in their thallus: red algae (Rhodophyta), brown algae (Ochrophyta, Phaeophyceae) and green algae (Chlorophyta). In the tropical regions red and green marine algal species dominate in contrast to cold temperate regions where brown algae are more diverse. The large number of red algae species in the tropics can be illustrated by the red:brown algae ratio used on a latitudinal gradient in the northern hemisphere, showing an increase from high to low latitudes of 0.6 to 3.9 in the Western Atlantic Ocean and from 2.4 to 4.6 in the Eastern Pacific Ocean. On the tropical Atlantic coasts, the diversity of red algae is remarkable high on biogenic reefs and rocky shores, but seasonal coastal upwelling brings cold water to the surface, allowing many brown temperate algae species to co-occur. On the tropical coast of Brazil, for instance, this ratio is 4.7 but where under the upwelling influence such as in the Cabo Frio region the ratio is reduced to 3.2.

The distribution of many species of marine algae can be understood not only by latitudinal temperature ranges but also by geographical isolation. The Atlantic and Pacific oceans were separated by the land bridge of Panama after continental shelf drifts during geological time (Tertiary) and, consequently, algae were separated by this geographical barrier. More recent, the Panama Canal was opened and although algae can be transported attached to ship hulls they do not survive due to the high activity of herbivorous fishes. The second barrier is the land bridge of Suez that separated the tropical Eastern Atlantic from the tropical Indo-West regions. Several algae species are commonly found in the tropical Indo-Pacific and the Caribbean because they migrated, either using currents along the coast of the Cape of Good Hope (South Africa) or through the Suez Canal in the Mediterranean. Many other algae species were able to cross the Atlantic Ocean from American to West African coasts because they were transported by ocean currents such as the Equatorial Countercurrent.

Some algal genera and species have a wide pantropical distribution in the world oceans. Many examples come from the green algae within the orders Caulerpales, Cladophorales, Dasycladales and the brown Dictyotales and Fucales, such as the genera *Dictyota*, *Dictyopteris*, *Padina*, *Sargassum* and *Turbinaria*. Endemic and rare species are restricted to certain areas and quite often are a result of geographical isolation or localized oceanographic conditions. Upwelling waters in the tropics impose limits to the distribution of species with warm water affinity.

One interesting aspect of the seagrass distribution is the occurrence of “twin species” in different regions. These are congeneric species present in different floras. A tropical example is the Caribbean region assemblage of *Thalassia testudinum-Halodule wrightii-Syringodium filiforme* which twins with the Indo-Pacific region assemblage of *Thalassia hemprichii-Halodule pinifolia-Syringodium isoetifolium*. These twin assemblages may have formed due to the rearrangement of the continents. *Halophila decipiens*, a small deeper water seagrass species has the most widespread distribution throughout the tropical seagrass regions, although it co-occurs with outer *Halophila* species with more restricted regional distributions.

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Biographical Sketches

Joel C. Creed was born in the United Kingdom in 1967 and obtained his BSc in Botany and Marine Botany (University of Wales Bangor, 1989) and PhD in Marine Ecology (University of Liverpool Port Erin Marine Laboratory, 1993). In 1995 he moved to Brazil where carries out research and teaching to the present day, first at the Rio de Janeiro Botanical Garden, then the National Museum (Universidade Federal do Rio de Janeiro). Since 1998 he has been an Associate Professor of Ecology at the Universidade do Estado do Rio de Janeiro, teaching Ecology and Marine Ecology at undergraduate and graduate level. He was Director of the Centro de Estudos Ambientais e Desenvolvimento Sustentável, Ilha Grande, Head of the Departament of Ecology and is currently a researcher of the Nacional Research Council of Brazil (CNPq). He has published forty scientific articles and book chapters dealing with the biology and ecology of marine plants and animals.

Marcia A. O. Figueiredo was born in Brazil in 1959 and obtained her BSc degree in Biology (Universidade Santa Úrsula, 1981), MSc in Botany (Universidade Federal do Rio de Janeiro, 1989) and PhD in Marine Ecology (University of Liverpool Port Erin Marine Laboratory, 1993). In her earlier career she worked on the taxonomy of marine algae in Project Cabo Frio run by the Brazilian Navy Research Institute and later on at the Rio de Janeiro Botanical Garden. Since 1983 she has been a Researcher in Botany at the Instituto de Pesquisas Jardim Botânico do Rio de Janeiro, where she has also served as the Director of the Botany Museum and Director of the Botany Research Department. Since 2000 she has been an invited lecturer at the National Museum (Universidade Federal do Rio de Janeiro). She has published thirty scientific articles and book chapters on the taxonomy, biology and ecology of marine algae.