

CORAL REEF BIODIVERSITY

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Summary

Due to the paucity of essential nutrients such as nitrogen, phosphorus and occasionally iron, the waters of the belt of oceans on both sides of the Equator (30° N to 30° S) are known as the “Blue Deserts”. The short supply of these nutrients limits phytoplankton growth and the development of the entire food web depending on their photosynthesis. In these seas, the lush coral reefs, teeming with life are virtual oases. Coral reefs are a special case of bioherms, or wave resistant limestone structures of biological origin. Such marine formations consist of the cemented skeletons of living reef forming organisms, and their dead remains. Such reefs were constructed by various sessile organisms like oysters, vermetid gastropods, serpulid polychaets, calcifying red algae, hydrozoans and corals. The latter, namely the tropical coral reefs are by far the most extensive reef type. The 2500 species of corals form the framework of the diverse and colorful tropical reef ecosystem, which is the marine counterpart of the tropical rain forest. Besides the hermatypic species, there are various dwellers in the reef area that make up that highly diverse community, which represents the peak of the evolution of Life on our Planet in the marine domain. These reefs constitute a major repository of our Planet’s biodiversity, and are in recent years showing an alarming decrease in vitality. This spreading decline has been attributed mainly to Global warming, probably aggravated by increased UV radiation, marine pollution and human encroachment in general.

1. Introduction: Highly Diverse Community (see also Biological Oceanography)

Coral reefs are a special case of bioherms, or wave resistant calcium carbonate structures

of biological origin. Such marine formations consist of the cemented skeletons of living organisms, known as hermatypes (or reef forming), and their dead remains. Such reefs, were constructed by various hermatypes, sessile organisms like oysters, vermetid gastropods, serpulid polychaets, calcifying algae (in particular red algae, or Rhodophyta), hydrozoans and corals. The latter, namely the tropical coral reefs are by far the most extensive reef type. The 2500 species of corals form the framework of the diverse and colorful tropical reef ecosystem, which is the marine counterpart of the tropical rain forest. Besides the hermatypic species, there are various dwellers in the reef area that make up that highly diverse community, which represents the peak of the evolution of Life on our Planet in the marine domain.



Figure 1: Red Sea reef. Note school of Red sea goldfish (=scalefin Anthias), *Pseudoanthias squamipinnis*, and bicolor Chromis *Chromis dimidiata*.

2. Invertebrates

The coral reef ecosystem is inhabited by myriad invertebrates, in addition to the corals,

belonging to virtually every group found in the marine realm. Invertebrates are not a defined or related group of organisms, and they include all the diverse animal taxa, other than vertebrates. The reef invertebrates may be classified according to their ecological function: (1) the tightness of their association with the reef; (2) their trophic relations with it; (3) whether they act as builders of the reef or contribute in any way to its well-being; or (4) conversely, that they are bioeroders which dissolve the framework of the reef. The invertebrate dwellers of the reef may of course be discussed according to their taxonomic affinities. However, due to the vast numbers of organisms involved it is beyond the scope of the present chapter, and this series, to discuss or list all of them. Furthermore, due to the remoteness of the World's reefs, many of their dwellers still remain to be discovered and described. Of course, in many cases, even for those relatively few organisms that have been described, little is known about their biology, life cycle, trophic status and niche within the coral reef ecosystem. We shall therefore limit ourselves only to illustrate the ecological functions of some of the more visible or important reef organisms, classified according to their taxonomic affiliation.

2.1. Coelenterates

This group is characterized as relatively simple body scheme and almost exclusively marine origin, including some ten thousand extant species. All of these share a radially symmetrical, sac-shaped body scheme. The one opening serves as both a mouth for ingesting food, as well as an opening to excrete undigested residues. This mouth is surrounded by tentacles, which in most cases are equipped with some kind of highly specialized venomous cells. The tentacles, in addition to food capturing and protective function, also act in motile species or stages as their swimming apparatus. The coelenterates include, in addition to all kinds of corals, jellyfishes, sea anemones and hydrozoans. Besides the *Hexacorallia* themselves, which are the main builders of coral reefs, some other zooxanthellate coelenterates also make a minor contribution to the formation of reefs. Of these “false corals” *Tubipora musica*, the “organ pipe” coral belongs to the *Octocorallia*, and the common “fire coral”, the Hydrozoan *Millepora dichotoma*, are among the most prominent. The latter forms a distinct *Millepora* zone in many Red Sea reefs. Fire corals have numerous potent stinging cells used to immobilize prey, and possibly for defense, which may inflict fairly painful and long lasting burns to unaware swimmers.

Reefs are also inhabited by many species of sea anemones like the large *Condylactis gigantea*. This large anemone is known to live in a mutualistic symbiosis with clown fish, and also harbors zooxanthellae in its cells. On soft bottoms next to coral reefs, in atoll lagoons and in the bizarre “Jelly fish lake” in Palau, there are many jellyfish. Some of them feed on zooplankton and small fish, while others like *Cassiopeia andromeda* also harbor zooxanthellae and feed primarily on the products of photosynthesis by these endosymbiotic algae. This jellyfish basks in sunlit shallow waters, where unlike any other jellyfish, it rests in an “upside down” position exposing its zooxanthellae-packed tentacles to the sun.

2.2. Polychaeta

One of the most colorful groups of coral reef invertebrates is that of the feather-duster

worms. They are filter feeders, who following a free-living larval existence, undergo metamorphosis into a sessile adult. These worms, as adults, dwell in a calcareous tube embedded in the coral skeleton, which becomes part of the reef structure. Feeding and respiration are assisted by their whorls of arms. Some species, like *Spirobranchus giganteus*, show an unexplained rainbow of colors, unrelated to that of the host coral colony. It has been suggested that these colors actually protect the population as a whole. Since predators, which are likely to associate a given color variety with their favorite prey, will ignore individuals of a different hue. These polychaets are quite abundant in reefs and may reach densities of many tens on the same coral colony. Their distribution strongly indicates a preference for live coral over any other substrate. It may be that the motion of the cilia on their tentacles creates small currents and brings prey into the reach of the coral's tentacles as well. Furthermore, any food captured and digested by these, and any other, filter feeders enriches the waters in the immediate proximity to the reef with nutrients. These nutrients, obtained from prey residing in relatively distant waters, are assimilated by the zooxanthellae, which subsequently make them available to the coral.



Figure 2: Polychaete on coral.

2.3. Mollusks

The mollusks or Mollusca include such familiar animals as clams, oysters, snails, slugs, squids and octopus. Many of them are capable of excreting a protective calcium

carbonate shell to protect their otherwise soft bodies. This diverse phylum contributes representatives to every type of functional niches in the reef system. There are among them hermatypes integrated into the reef, like some clams, oysters and vermetid gastropods, others are bioerosive agents boring within the coral skeletons. Some species harbor symbiotic zooxanthellae or even functional chloroplasts from algae, others are herbivores, corallivores or fast aggressive carnivores. They include sessile oysters, sluggish gastropods and clams as well as agile swimming nudibranchs. They may be camouflaged with drab seaweed like patterns, or shining in vivid, iridescent poster colors, warning potential predators that they are poisonous.

One of the many striking reef bivalves are the giant clams like *Tridacna maxima*. These are the largest of all mollusks, reaching in the Pacific and Indian Oceans lengths of over one meter and weighing over four hundred kilograms. These clams were fished to the brink of extinction from the wild for their meat and shells, and now are the focus of serious efforts to bring them under cultivation in centers in Palau and other countries in the Indo-Pacific. These clams also have zooxanthellae, which unlike in corals are not endocellular, but live in the body fluids. The algae provide much of their nutrition, the remainder being obtained from plankton filtered from the water.



Figure 3: Great Barrier Reef community. The giant clam *Tridacna* harbors symbiotic algae, zooxanthellae in its mantle tissue.

Other sessile mollusks common on reefs are vermetid gastropods like *Dendropoma maxima*. This species begins life as a free-swimming, planktonic larval stage and subsequently settles in the reef to form an irregular meandering shell within the coral skeleton and on its surface. It obtains food by spreading a sticky mucus net on the surrounding surface, and ingesting it periodically with the entrapped plankton. The shells of this organism may reach diameters of 3 cm and lengths of 50 cm. Like the shells of the

giant clam, they eventually become part of the reef. Contrary to the giant clams and vermetids which become part of the calcareous reef structure, there are among the Mollusca species which actually weaken the coral skeleton, actively boring into it by dissolving the calcium carbonate of which it is built. An example of such bioeroder is the small, rice grain sized, boring clam *Lithophaga lessepsiana*, which dwells in the skeleton of living corals, such as its favorite host *Stylophora pistillata* and also in other species. This clam, like all of its relatives, feeds by filtering plankton from the water it pumps through its siphons and over its gills. Other boring clams prefer different hosts. A large sized *Stylophora pistillata* colony may contain hundreds of *Lithophaga lessepsiana* that will eventually lead to the breakage and death of the colony. Nevertheless, it seems that in healthy coral colonies the tiny currents carrying food and oxygen into the clam are actually beneficial to the coral, whose zooxanthellae also avidly take up any ammonium excreted by the clam.

Another group of far more harmful mollusks such as *Drupella cornus* actively feed on the living coral tissue. Infestations by explosively growing populations of such corallivores may have devastative effects on preferred prey species and whole reef communities. Many other colorful snails either graze on coral reef algae or prey on various animals living on or next to the reefs. Among these are the venomous cone snails whose radula evolved into a highly specialized hypodermic needle like proboscis. They use that “needle” to inject their potent venom, which may be lethal even to humans, into both prey and attacker. These beautiful snails have been prized by collectors, which have led to their extinction in many localities. Many reef snails are collected by the people living next to reefs, and sold to tourists in great numbers. Other, highly visible coral reef dwelling mollusks are various sea slugs. These gastropods lack the protection of a hard shell and in many cases rely on being poisonous or distasteful. They display vivid colors, which may function as a warning reminding any potential predator of their taste. Other species combine the excretion of unpleasant tastes with perfect camouflage, allowing them to blend inconspicuously with the reef surroundings.



Figure 4: Corallivorous snails *Drupella cornus* feeding on the coral *Acropora humilis*. The white skeleton shows where tissue has been eaten.

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Biographical Sketch

Zvy Dubinsky obtained his B. Sc., master and Ph. D. degree in Biology from Bar Ilan University. His Ph. D. thesis was about the interactions of light and algae in the Lake Kinneret. After a Post-doctoral fellowship at C.U.N.Y., New York he joined the faculty of Bar-Ilan. Prof. Dubinsky held Guest Appointments at some of the most prestigious research institutions, including Oceanography Division, Brookhaven National Laboratories, Biophysics, The Rockefeller University, New York, and recently at Marine Biotechnology, RCAST, Research Center for Advanced Science and Technology, Tokyo University. Prof. Dubinsky is a charismatic and popular teacher who has already tutored 20 Masters students and 15 Ph. Ds. At present he has ten new Ph. D. students. He also is a sought after speaker at international fora such as conferences and congresses, spanning five continents, in which he has delivered some one hundred invited lectures. The main research interests of Prof. Dubinsky could be represented by following keywords, such as geobotanical survey, dynamics of phytoplankton, energy conversion efficiencies, algal communities, algal pigments, ecology of desert, nitrogen fluxes, sewage treatment, algal protein production, pharmaceuticals, symbiosis, marine invertebrates, photoadaptation, photosynthetic apparatus, coral reef, conservation, Red Sea, salt tolerance, mangroves. In addition to the standard treatise on Coral Reefs edited by him. Prof. Dubinsky is the author of well over one hundred scientific publications in some of the leading journals, including many in the Proceedings of the Royal Society of London, Nature, Biochimica and Biophysica Acta, Limnology and Oceanography. Prof. Dubinsky, being an avid photographer also directed and filmed four movies for Israeli Educational Television, one of which was awarded the Executive Prize at the Tokyo Festival of Scientific Films.