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Emerging Ecological Importance of Sponges on Coral Reefs

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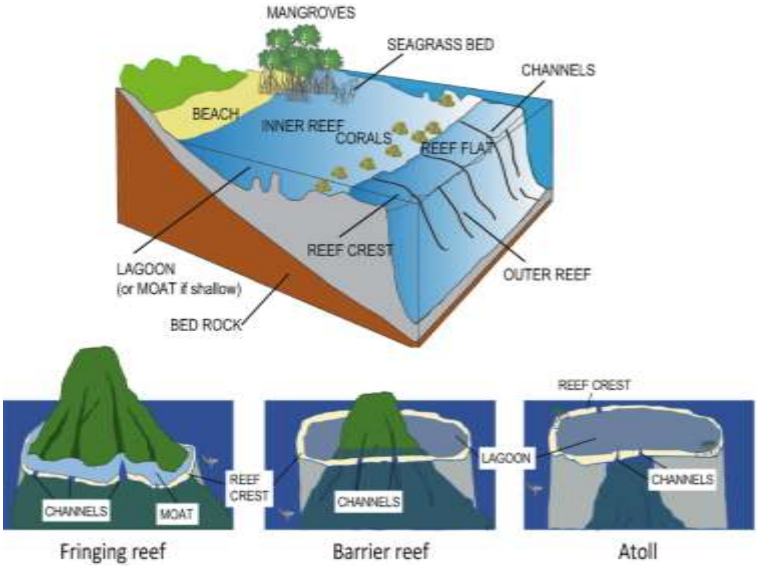
SUMMARY

Sponges (phylum Porifera) are increasingly recognized for their crucial role in maintaining the health and resilience of coral reef ecosystems. As efficient filter feeders, they enhance water quality by removing plankton, bacteria, and organic matter, while their symbiotic relationships with microorganism's aid in nutrient cycling. Sponges contribute to reef biodiversity by providing habitat and structural support for various marine organisms. In the face of coral decline due to climate change and anthropogenic pressures, certain sponge species have shown remarkable resilience, potentially sustaining key ecological functions. However, this shift could alter reef dynamics if sponges begin to outcompete corals. Understanding the ecological importance of sponges on coral reefs is essential for predicting and managing future reef health in changing ocean environments.

INTRODUCTION

Coral reefs, among the most diverse and productive ecosystems on Earth, are under growing pressure from climate change, ocean acidification, pollution, and overfishing. These stressors have caused significant coral degradation, shifting the balance of reef communities. In this evolving scenario, sponges (phylum Porifera) are gaining attention for their emerging ecological significance on coral reefs. Often overshadowed by the vibrant coral species, sponges have long played a crucial yet overlooked role in reef ecosystems. As natural biofilters, they process large volumes of seawater, capturing organic particles and recycling nutrients. This function supports the productivity of the reef and aids in maintaining water quality. Additionally, sponges contribute to the structural complexity of reefs, offering habitat for a wide array of marine organisms. Recent studies suggest that sponges may act as ecological "engineers," providing critical services, especially in reefs where coral cover is declining. However, the increasing dominance of sponges in some reef systems raises concerns about potential shifts in ecosystem dynamics. As coral reefs continue to face environmental threats, understanding the role of sponges becomes essential for managing and preserving these delicate marine ecosystems.



Marine Sponges:

They are multicellular organisms that have bodies full of pores and channels allowing water to circulate. They have a complex nervous, digestive or circulatory system. Sponges inhabit diverse habitats ranging from hard to soft-bottom communities, tropical to polar latitudes, intertidal to deep-sea environments and fresh- to saltwater's. Most of the sponges have siliceous spicules which provide a cutting edge over other calcareous organisms -ocean acidification and global warming. They number approximately 5,000 described species and inhabit all seas, where they occur attached to surfaces from the intertidal zone to depths of 8,500 meters (29,000 feet) or more. The members of one family, the Spongillidae, are found in fresh water; however, 98 percent of all sponge species are marine. Adult sponges lack a definite nervous system and musculature and do not show conspicuous movements of body parts. Sponges are also the reef's water cleaner, filtering out excess nutrients and plankton. In fact, they are so specialized for filter feeding that they are the only group of animals capable of filtering out the smallest of the plankton. Fore-reef habitats are characterized as having relatively higher flow regimes and relatively constant temperatures, salinities, and oxygen levels compared with the lagoonal habitats that are also part of the larger ecosystem.

Types of sponges:

Demospongiae (Coralline sponges):

The most diverse, containing 90 percent of all living sponges. They range in size from small, encrusting forms, through to large irregular masses. They have spicules (tiny needle-like structures that support the body's form) of silica dioxide and/or spongin. Demosponges are the sponges most commonly seen whilst diving or walking along the shore.

Coralline sponges

Glass sponges

Hexactinellida (Glass sponges):

Other sponges possess the ability to contract, hexactinellids do not. Moreover, hexactinellids possess a unique system for rapidly conducting electrical impulses across their bodies, allowing them to react quickly to external stimuli.

Calcarea (calcareous sponges):

Calcarea and Hexactinellida make up about 10 to 20 percent of the known species of sponges. pale in colour and with a tendency to be quite small in size (less than 30cm), this class of sponges lacks spongin and their skeletons are composed entirely of calcium carbonate. calcareous sponges are quite brittle to touch.

Homoscleromorpha sponges:

The rarest and simplest class, only recently recognized, with approximately 117 species sister group of the calcareous sponges

Calcareous sponges

Homoscleromorpha sponges

Distribution of sponges on coral reefs

Sponges have their own special roles to play and have been doing it for at least 600 million years. Sponges can dominate the biomass and species representation in benthic marine communities. The biodiversity of sponges on coral reefs is remarkably high; more species of sponges present in coral reef ecosystems than any other taxon of benthic macroorganism (Hooper & Levi 1994). This high diversity, combined with large numbers of rare species, morphological variation within species, similarities among species, and highly localized endemism. On coral reefs, mangrove prop roots, rocky intertidal shores, caves and crevices, subtidal hard bottoms in Antarctica and western Canadian fjords, and even some subtidal soft bottoms, sponge accumulations can be so dense that the underlying substratum appears irrelevant; but in other habitats sponges are minor members. Most of the sponges on Caribbean fore-reefs are readily identifiable (Zea et al. 2014), and the 10 most abundant species make up more than 50% of the benthic cover (Loh & Pawlik 2014). Taxonomically, most of the sponges on coral reefs belong to the class Demospongiae, with minor representation from the classes Homoscleromorpha (e.g., Plakortis and Plakina spp.) and Calcarea (e.g., Clathrina and Leucetta spp.). Caribbean (the tropical western North Atlantic) having wide variety of sponges. The sponge fauna of the Caribbean is much better taxonomically described than those elsewhere in the tropics (Zea et al. 2014).

Functions provided by sponge associated and symbiotic microorganisms:

Habitat	Lagoons (mangroves and seagrass beds), shallow fore-reefs, or deep reefs
Growth form	Encrusting, branching, massive, and shape such as barrel, tube, fan and vase
Position	On fore-reefs, sponges can be excavating (boring or burrowing in stone or sediment), cryptic (in cracks or interstices in the reef structure), or emergent (exposed on the reef surface)
Photo symbionts	HMA sponges are further categorized as being heterotrophic, mixotrophic or phototrophic foliose phototrophic sponge show the greatest morphological adaptation to photosymbiosis and are found only in the Indo-Pacific (Wilkinson 1988)
Microsymbionts	LMA sponge species have few microbes in their tissues, while high microbial abundance HMA species have a high density of symbiotic microbes in their tissues (Gloeckner et al. 2014). This is not a binary category; sponge species are distributed across a spectrum from LMA to HMA.
Chemical defense	Many sponges contain unusual metabolites (natural products or secondary metabolites) in their tissues, some of which deter feeding by invertebrate or fish predators. Three categories: chemically defended, variably defended, and consistently undefended (Loh & Pawlik 2014).

Marine sponges' functional roles in the ecosystem:

They act as link between benthic and pelagic communities due to their efficient filtration rate. They provide shelter to many invertebrates due to high porosity of body structure. Bio erosion and reef structure formation bore into calcium carbonate substrates, including dead coral, contributing to bioerosion process for the natural cycling of reef materials, aiding in the creation of habitats (like crevices and caves) that many marine species rely on for shelter and breeding grounds. Functions have been categorised into three areas:

(a)	Impacts on substrate	Bioerosion, reef creation, and substrate stabilisation, consolidation and regeneration
(b)	Bentho-pelagic coupling	Carbon cycling, silicon cycling, oxygen depletion and nitrogen cycling
(c)	Associations with other organisms	Facilitating primary production, secondary production, provision of microhabitat, enhanced predation protection, survival success, range expansions and camouflage though association with sponges, sponges as a settlement substrate, disrupting near-boundary and reef level flow regimes, sponges as agents of biological disturbance, sponges as releasers of chemicals and sponges as tools for other organisms

Ecological importance:

Climate Change: From Coral to Sponge Reefs?

As coral cover declines in response to more frequent warm-water anomalies and lower seawater pH, tropical reef systems that were previously dominated by reef-building corals may transition to those dominated by sponges (Bell et al. 2013). sponges on contemporary tropical reefs are not reef builders; indeed, excavating sponges actively erode limestone reefs and reduce reef complexity (Schonberg et al. 2017b). Biogenic reefs were built by sponges in association with microbes during the Paleozoic and Mesozoic (Bell et al. 2013, Wulff 2016), and modern deposits have been formed of glass spicules of hexactinellid (Kahnetal.2018) and lituitid sponges (Maldonadoetal.2015) deepwater of the North Pacific and Mediterranean.

Interaction of sponges with corals:

Coral reef sponges are considered to be important space competitors. Competitive interactions between sponges and corals often result in overgrowth of the coral. It is assumed that sponges are even more successful in environments sub-optimal for corals. The net impact of sponges on reef-building corals and, by extension, on the ability of corals to build and maintain reefs as "ecosystem engineers" (Wild et al.2011). This mutualistic generalization about coral–sponge interactions on coral reefs, particularly in the Caribbean. Beyond the negative effects of excavating sponges on reef-building corals, sponges can negatively affect coral recruitment. Sponges are aggressive competitors with corals for space, the single most important resource for these two benthic organisms.

Chemical ecology:

Sponges are a rich source of unusual secondary metabolites due to their high abundance, longevity, plasticity and the subdiscipline of chemical ecology- to understand the function of these compounds, as well as their production, storage, costs, etc. They use their info chemicals (messenger molecules) and allelochemicals (toxic substance) in multiple ways to interact with other organisms to maintain their space, deter predator and prevent epibiont growth on their surfaces.

Competition for space:

Competition for substratum among sessile marine invertebrates is a major process, which affects diversity, abundance and zonation in an ecosystem. Sponges -longest living animals, persistent competitor of other sessile invertebrates. Sponges have high regenerative and morphological plasticity -them to grow along with other fast-growing sessile organisms

Defence against Predators:

The soft-bodied, sessile sponges lack any physical defences and are physically vulnerable to predation in their highly diverse environment. Major predators of sponges - fish species, hawsbill turtle, molluscs (e.g. nudibranch), echinoderms and sea urchins. 69 % of tropical Atlantic sponges, 100 % of Mediterranean sponges and 78 % of Antarctic sponges (starfish and nudibranch) produce chemicals to deter predator chemotactile retraction of sensory tube feet of the common predator sea star Perknaster fuscus erratic response of sensory tube feet - food pellet assays. Chemically mediated predator deterrence involved high energetic cost, and there is tradeoff among the life history processes such as growth, reproduction and defense.

Epibiotic defense:

The bacteria and diatoms are the first organisms that attach to the surface in the process of microfilm formation. this conditioned layer for the settlement of macrofouling organisms (Macroalgae, invertebrates and propagules). Dislodge the sponges from substratum by increasing hydrodynamic drag, Compete with their host for resources such as food and irradiation, Cause growth inhibition, tissue necrosis and death of host organisms.

CONCLUSION

Sponges play a vital and increasingly recognized role in maintaining the ecological balance of coral reefs. Their diverse functions, including nutrient cycling, habitat formation, and water filtration, contribute significantly to the health and resilience of reef ecosystems. Sponges help maintain water quality by filtering large volumes of water, while their ability to harbor microbial symbionts enhances nutrient availability, supporting the productivity of coral reefs. Moreover, as climate change and other anthropogenic pressures threaten coral reefs globally, sponges may serve as important buffers, mitigating some of the negative impacts by stabilizing reef structures and enhancing biodiversity. Understanding and protecting sponge populations are essential for the long-term sustainability of coral reef ecosystems, as their decline could exacerbate the challenges already faced by these vulnerable habitats. Consequently, more research and conservation efforts are needed to fully appreciate and preserve the ecological importance of sponges on coral reefs.

REFERENCES

De Goeij, J. M., van Oevelen, D., Vermeij, M. J. A., Osinga, R., Middelburg, J. J., de Goeij, A. F. P. M., & Admiraal, W. (2013). Surviving in a Marine Desert: The Sponge Loop Retains Resources Within Coral Reefs. *Science*, 342(6154), 108-110. https://doi.org/10.1126/science.1241981

Bell, J. J., Davy, S. K., Jones, T., Taylor, M. W., & Webster, N. S. (2013). Could some coral reefs become sponge reefs as our climate changes? *Global Change Biology*, 19(9), 2613-2624. https://doi.org/10.1111/gcb.12212

Pawlik, J. R., Loh, T. L., McMurray, S. E., & Finelli, C. M. (2015). Sponge Communities on Caribbean Coral Reefs Are Structured by Factors that Are Top-Down, Not Bottom-Up. *PLoS ONE*, 10(5), e0125675. https://doi.org/10.1371/journal.pone.0125675

Maldonado, M., Ribes, M., & van Duyl, F. C. (2012). Nutrient Fluxes Through Sponges: Biology, Budgets, and Ecological Implications. *Advances in Marine Biology*, 62, 113-182. https://doi.org/10.1016/B978-0-12-394283-8.00003-5

Wulff, J. (2017). Bottom-up and top-down controls on coral reef sponges: disentangling the roles of predators, competitors, and the environment. *Marine Ecology Progress Series*, 582, 77-96. https://doi.org/10.3354/meps12378