A new **sponge** ecology

Research at the **University of North Carolina Wilmington's Center for Marine Science** is building on 25 years of analyses to develop a new conceptual model of sponge ecology for Caribbean coral reefs

SPONGES ARE NOW the dominant habitat-forming animals on Caribbean reefs, where the combined effects of climate change, pollution, and disease have decimated reef-building corals. While natural products chemists have been isolating novel secondary metabolites from Caribbean sponges for many decades, relevant studies of the ecological functions of these compounds have been more recent. Bioassay-guided surveys have revealed sponge chemical defences against predators, competitors, and pathogens, but many common sponge species lack these defences and appear to have followed a different evolutionary path, investing instead in greater reproduction or growth.

Ecological theory concerning chemical defences and the allocation of life resources to making defences comes from studies of terrestrial ecosystems, particularly plant-insect interactions. The more recent work with sponges on Caribbean coral reefs provides a simpler level of organisation from a more complete and homogenous ecosystem than previously studied in terrestrial systems. It is simpler, because on Caribbean reefs, species diversity is relatively low, which makes the ecology easier to study: coral reefs in the Pacific or Indian Oceans are much more complicated, with many undescribed species of sponges. Caribbean reefs are more complete and homogeneous, because prevailing currents transport the offspring of reef organisms in a large circle, from the coast of South America to Florida to the lesser Antilles, so that all the same players (algae, corals, sponges, fishes) have a similar chance to be represented in any location. This means that ecological differences between reefs are more likely due to specific factors, such as removal of fishes by overfishing.

This is the basis for ongoing research led by Professor Joseph Pawlik and his team at UNCW, USA. Their emerging conceptual model predicts that changes in the abundances of fish- and sponge-eating fishes on Caribbean reefs will have a cascading impact on the sponge community, with indirect effects on the broader community of corals and seaweeds. It has become clear that Caribbean sponges provide an important alternative to terrestrial plant and insect communities for testing basic ecological theories about chemical defences and resource allocation.

BREAKING WITH TRADITION

Before the mid 1990s, it was thought that sponge-eating fishes had little impact on Caribbean sponge ecology, because the available data suggested that predation on sponges was minimal. However, newer research transformed this view by demonstrating that sponge-eating fishes targeted chemically undefended sponge species, and completely excluded some preferred species from exposed locations. Pawlik has identified three distinct sponge categories: undefended preferred-sponges that are removed from reefs by fish predation; undefended palatable – sponges that persist despite being grazed by fishes like grass in a cow pasture; and chemically defended – sponges avoided by fish predators. Further research has determined that sponge species divert their energetic resources in the last two categories; either for rapid growth and reproduction or for the synthesis of chemical defences.

A NEW MODEL

Based on this new understanding of the system, as well as experiments designed to look at competitive interactions between sponges and other benthic invertebrates (particularly reef-building corals), Pawlik and colleagues have developed a conceptual model of top-down control of sponge abundance: fish-eating fishes consume sponge-eating fishes, which consume undefended sponges, which compete with other sponges, algae, and reef-building corals for space.

The wider significance of the model lies in the fact that it can be used to predict how manipulations of the system will result in changes in the sponge community. For example, on Caribbean reefs where all the sponge-eating fishes are harvested by fish-trapping, undefended sponges are expected to become more abundant and to out-compete other benthic animals, such as corals. When the sponge community of a heavily fished reef near Bocas del Toro, Panama, was compared with reefs that are better protected from fishing in the Florida Keys, there were clear differences in the relative abundance of defended and undefended sponge species.

PREDICTIVE DATA

Pawlik has been surprised that the conceptual model of sponge communities on Caribbean coral reefs has been remarkably predictive for recently obtained survey data from geographically distant reefs that are influenced by fishing to varying degrees. These results reinforce the proposition that because coral reefs in the Caribbean are relatively less complex and more homogeneous than those elsewhere in the world, they provide a better model system for testing basic tenets of ecological theory, such as the primary effects of predation and competition, and their indirect effects in other parts of the ecosystem.

COLLABORATION AND FUNDING

Collaboration has played a vital role in Pawlik's research over the past two decades. The efforts of talented organic chemists led to the isolation and structural elucidation of the secondary metabolites responsible for defending the chemically defended category of sponges on Caribbean reefs. In many cases, these compounds were new to science, and were subjected to pharmacological testing as potential new drugs. Partnerships with synthetic chemists in Germany resulted in the determination of the structure-activity relationship for the class of compounds that defend sponges of the very common genus Agelas, since they were able to synthesise a wide variety of analogous compounds for feeding experiments. An important associate from Colombia and noted sponge taxonomist, Professor Sven Zea, has been able to identify new and uncommon sponge species as reef surveys are performed and the project advances. In addition to collaborators in the US (organic chemistry, flow dynamics, microbiology), there have been international collaborations with researchers in Israel (coral physiology, microbiology), Germany (microbiology), Spain (molecular biology, phylogenetics), and Hong Kong (molecular biology, microbiology).

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Long-term funding from the US National Science Foundation's Biological Oceanography Program has provided support, primarily for student education and training. Invaluable facilities support has been provided by the US National Oceanic and Atmospheric Administration's Aquarius Reef Base (formerly the National Undersea Research Center). Additionally, Florida Keys National Marine Sanctuary and the Government of the Bahamas, respectively, provided permission to conduct research on US and Bahamian reefs.

FUTURE DIRECTIONS

Pawlik predicts future work will provide even more insights into a system that is more tractable for testing ecological theory. Future areas of research include investigations of abiotic effects on sponge communities, such as high flow due to currents and storm events. Pawlik tries to disseminate his findings into the primary scientific literature as quickly as possible; further outlets for public awareness of these studies are provided by web-based educational outreach, which is strongly encouraged by US funding agencies because the Internet offers a platform for research available to scientists and non-specialists alike. Coral reef studies in particular are amenable to broader public dissemination, because they concern popular environments, tend not to be jargon-bound, and are often accompanied by visually arresting images.

INTELLIGENCE

CHEMICAL ECOLOGY OF SPONGES ON CARIBBEAN CORAL REEFS

OBJECTIVES

Main objectives are to: (1) extend studies of top-down control of the sponge community; (2) test an alternative hypothesis that bottom-up processes – availability of picoplankton as food – control sponges on reefs; (3) expand studies of sponge life history trade-offs in resource allocation between chemical defense, growth and reproduction; (4) monitor the mortality, recruitment and growth of key sponge species, and determine how demographic shifts may affect water column filtration rates.

KEY COLLABORATORS

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FUNDING

National Science Foundation – grant no. 1029515

National Oceanic and Atmospheric Administration, USA

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