BENTHIC-PELAGIC BIODIVERSITY COUPLING

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Abstract

Coastal plankton dynamics is the driving machine of marine systems and its functioning depends on the availability of both nutrients and propagules. The incorporation of pelagic matter (either living or not) in the benthos and its resuspension to fuel the plankton, either as nutrients or as planktonic larvae (when entering in benthic organisms to be used for reproduction), are the recognised core of benthic-pelagic coupling. A complementary concept is the so called "supply-vertical ecology", stressing the importance of the bottomward flux of resting stages produced by coastal plankters from which active stages will be injected in the water column. In this framework, the nutrients that will sustain planktonic production come from both benthic resuspension (*e. g.* upwellings) and terrestrial run-offs, whereas propagules come from reproduction of active specimens leading either to immediately viable specimens, *i. e.* larvae that will grow into members of plankton (holoplankton) or of benthos and nekton (meroplankton), or from resting stages provided by benthic cyst banks. Resting stages accumulate in enormous quantities in coastal sounds, lagoons and harbours, forming veritable reserves of biodiversity. Marine canyons are at the other end of a spectrum of environments going from the littoral to the deep sea, and resting stages of both phyto- and zooplankters are being found in the millions in the sediments depositing in these widespread submarine valleys, probably to be re-shooted coastwards by the localised, canyon-driven upwellings. Benthic-pelagic coupling, thus, occurs through an almost unstudied life-cycle pathway, running parallel to both the food-web and the biogeochemical ones. If life cycles received far too little recognition in benthic-pelagic coupling, this is largely due to our ignorance of essential components of biodiversity expression such as larvae, resting stages and asexual propagules. A life-cycle oriented perception of biodiversity, highlighting the importance of intraspecific fluxes (life cycles) in benthic-pelagic coupling, is needed to complete a model of ecosystem functioning so far privileging interspecific (food webs) and extraspecific (biogeochemical cycles) fluxes. A new key to the understanding of the functioning of coastal ecosystems (a vital component of the Mediterranean and of all other seas and oceans) is now available, to challenge well established concepts and provide further insights in marine ecology.

Key-words: Plankton, Life cycles, Benthic-pelagic coupling

What is biodiversity?

Biodiversity is now a buzz word whose meaning ranges from the genetic diversity within species, to the number of species in a biotope (intended as a simple list of names), to the links among the living components of an ecosystem. The concept of biodiversity, thus, covers all aspects of biology and so, meaning almost everything, ends up meaning almost nothing. With the new concern on biodiversity, however, biologists are trying to gain more scientific respect for their discipline, showing the relevance of all its facets. This attitude stems from the widespread success of physico-chemical approaches, usually attracting more attention and resources than the biological ones within the framework of the wide scale study of the environment. It is paradoxical (and both ridiculous and tragic), furthermore, that biology becomes "attractive" again when dealing with extraterrestrial living beings. And non-biologists use the remote possibility of extra-terrestrial life to get enormous funding, leaving the exploration of terrestrial life at an almost amateurish level, due to fund shortage (1).

Coming back on Earth, and to the biological-abiological approach to the study of the environment, it appears logical, in fact, that it is not enough to, let's say, measure temperature and discover that it is rising (or falling). If this would not affect life at all, it would be almost meaningless for us. If a correlation exists between this change (better if on a global scale) and changes in genetic expression, species spectra and community organisation, the whole issue becomes more relevant to our perception of the change. Of course it is easier to measure the global temperature from a satellite than to transfer the study to biodiversity, but the quality of the information is much higher when having this second type of information.

The "classical" study of biodiversity starts with the inventory of the many ways life expresses itself. This exploration started from the very beginning of culture, due to the extreme interest that we have in the organisms around us. Our species cannot survive by itself, we interact with other organisms, using them as food, as source of materials, as amusement aids. And they use us too, we still are the "food" of many parasites and micro-organisms. It is easy to understand that our species would not survive much if it would remain alone on the planet.

In spite of the overwhelming importance of other living beings, our scientific interest in them is fading since several decades. This is due to the entry of new disciplines in the hit-parade of science, but it is also linked to sociological and psychological attitudes. We have removed most wild creatures from our everyday landscapes, we have even removed from our sight the creatures we use for our everyday purposes. We do not like to see the slaughter of a cow or of a pig, so we pretend that these things do not happen. We are happy to see wild creatures on a TV screen or in a museum/aquarium, maybe when we are on vacation. But when we are "serious", there is no space for wild-life. To our common perception, an engineer who builds cars is surely more important to society than a zoologist who studies jellyfish. This attitude has been reinforced by the way zoologists and botanists work. They have a good time, and this is not serious. They like what they do as a job: they have the luck of having had the possibility of transforming their hobby into their job. This is seen with some sort of diffidence even by other scientists, who have to perform standardised experiments, often for innumerable times. These people, unfortunately, are right. Science evolves, and what was the right thing to do one hundred years ago can't be right nowadays. To go around the world, collect specimens, put them in jars and give them a name, arriving to have a nice collection of organisms, is still OK, but cannot be considered the avant-garde of research. It was so at the time of Aristotle, at the time of Linnaeus, even at the time of Darwin, but can't be so today, even though May's fundamental question (How many species are there on Earth?) (2) is very far from being answered. Deep sea environments, as hydrothermal vents recently showed us, are far from being fully known and understood, so we have still to "explore" many parts of the Earth. And also the explored ones still have many surprises, as shown by the diversity of the interstitial fauna, or of symbiotic communities.

In spite of this, however, when knowing that it is possible to read the code of a creature and modify it, making a brand new type of creature, or copy it, producing innumerable replicas of the original creature, it is obvious that those who make the inventory have a lower status, in terms of scientific prominence.

In one of his last editorials for Nature, the former director of one the two most influential scientific journals made a lapidary statement: life is chemistry (3). What I will try to argue is that there is more than chemistry in life, and that, for instance, a full appreciation of biodiversity can lead to revolutionary concepts, widening our understanding of essential aspects of the functioning of the biosphere. To develop my arguments, I will choose one of the most important areas of the planet, the coastal zone, and I will try to show that our understanding of how it works is biased by the lack of consideration of the diversity of biological patterns and processes occurring in it.

Benthic-pelagic coupling

a - Extraspecific cycles (biogeochemical cycles)

The study of marine systems has been divided into two main approaches, one centred on the water column (the pelagic domain) and one centred on the sea bottom (the benthic domain). The tools and the concepts utilised to understand these two systems have been different. The pervading reductionist approach to science produced more and more specialised researchers, focusing on restricted topics. Syntheses were made mainly in textbooks, so that it is obvious that benthic organisms produce planktonic larvae and feed on plankton, as it is obvious that the things that fall on the bottom can be resuspended. But