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Symbiosis in mytilids from chemosynthetic ecosystems: relationship between symbiont diversity and environmental conditions

Sébastien Duperron (1,2,3), Myriam Sibuet (2), Nicole Dubilier (3), Françoise Gaill (1)

(1) Present address: UMR 7138, Adaptation aux milieux extrêmes, Université Pierre et Marie Curie, 7 quai St Bernard, 75005 Paris, France, (2) Ifremer, Laboratoire Environnement Profond, Centre de Brest, BP 70, 29263 Plouzané, France, (3) Max Planck Institute for Marine Microbiology, Celsiusstr. 1, D-28359, Bremen, Germany,

Deep-sea mussels of the genus *Bathymodiolus*, which inhabit cold seeps and hydrothermal vents worldwide, harbour chemosynthetic symbiotic bacteria in their gills. Mussels with sulfide-oxidizing symbionts generally occur at vents, while mussels with methanotrophic bacteria occur more often at seeps or methane-rich vents. Although environmental parameters are thought to influence symbiosis in mytilids, the relationship between these parameters and symbiont diversity and abundances remain poorly investigated.

Our work focuses on mussel species from the Atlantic area which harbour both sulfide-oxidizing and methanotrophic symbionts, and in one case even display four distinct bacterial phylotypes. Relative amounts of symbionts were shown to vary between and within species. Methanotrophic bacteria dominate over sulfide-oxidizers in gills of mussels from seep areas such as the Gulf of Mexico, or methane-rich vents like Rainbow (Mid-Atlantic Ridge, MAR). Sulfide oxidizers are more dominant in gills of mussels from methane-depleted vent sites like Snake Pit and Lucky Strike (MAR). Relative abundances of symbionts seem to be influenced by chemical parameters of the environment.

Our next objective was to investigate whether environment also influences the diversity of symbionts, and why is multiple symbiosis restricted to species from the Atlantic area. To get insights into the evolution of symbiosis, and to investigate the ancestral

state of *Bathymodiolus* (single or multiple symbiosis), symbiotic associations of an *Idas* species from cold seeps in the eastern Mediterranean were described. *Idas* are small mussels inhabiting cold seeps, whale caracasses and sunken woods, and are considered as evolutionary intermediate forms between coastal symbiont-free species and deep sea *Bathymodiolus*. Six distinct bacterial 16S rRNA phylotypes were identified. Three are close relatives to sulfide oxidizing and methanotrophic symbionts of *Bathymodiolus*, and three belong to new clades previously not shown to include symbiotic bacteria. One of these phylotypes, a CFB, is related to cellulose-degrading bacteria and would probably be beneficial in the context of sunken woods.

Some mytilids are able to establish symbiosis with a wider diversity of bacteria than previously thought. According to this observation, multiple symbiosis might have been the ancestral state of *Bathymodiolus*, which would then have retained only bacteria able to use sulfide and methane which are abundant at vents and seeps. To test the hypothesis that bacteria are selected depending on environmental parameters, accurate descriptions of the physico chemical environment must be obtained, using for example *in situ* analyzers along with colonization experiments, in parallel with exhaustive descriptions of symbiont diversity and quantitative estimates of abundances.