PhD Thesis proposal 2019

Acquisition of symbiotic partners: modalities and consequences on establishment, distribution and ecology of vent species.

Research Unit : Etudes des Ecosystèmes Profonds, Ifremer

Doctoral School : Sciences de la Mer et du Littoral (SML)

Laboratory : Laboratoire de Microbiologie des Environnements Extrêmes (LM2E)

PhD Supervisor : Marie-Anne Cambon-Bonavita
contact : Marie.Anne.Cambon@ifremer.fr, 02 98 22 47 56

Co-supervisor : Florence Pradillon : Laboratoire Environnement Profond (LEP), Unité Etude des Ecosystèmes Profonds (EEP), Ifremer
contact : Florence.Pradillon@ifremer.fr, 02 98 22 49 57

Project summary: The main contributors to hydrothermal ecosystem productivity develop symbiosis with micoorganisms, through which they benefit from local chemosynthesis and get protection from vent fluid toxicity. This partnership is crucial for the development of these animals that are often foundation species for more diverse communities. Several examples of such species that are closely related to each other, and coexist on the same vent sites, but exhibit differences in their symbiotic relashionships (integration level or identity of the microorganism partners) point at the role of these relationships in host micro-distribution and ecology (niche partitionning) with consequences on the functionning of the whole community. In particular, the establishment and the proliferation of symbionts in early life-stages (before and after recruitment) may be a key point of vent communities' development. This thesis will build on well-studied models in our laboratory: *Rimicaris* shrimps living on the Mid Atlantic Ridge (Bicose cruises), and *Alviniconcha* snails from south-west back-arc basins (Futuna 2012 and Chubacarc 2019 cruises). The study will focus on the establishment of the symbiosis during early life-stages of these species. The two models will be compared in order to evaluate the universality of processes between endosymbiosis (*Alviniconcha*) and ectosymbiosis (*Rimicaris*).

Key-words: Hydrothermal vents, *Rimicaris*, *Alviniconcha*, symbiosis acquisition, recruitment, colonisation

Context & scientific interest : The major part of vent ecosystem biomass comprises species developing symbiotic relationships with microorganisms that provide their host with nutrition or protection against toxic fluids. These symbioses influence the host distribution across micro-habitats in relation with the metabolic capacities of the holobionte (the host-symbiont system). They can show flexibility allowing a given host species to develop symbiotic relationships with different symbionts according to local environmental conditions. The acquisition and selection of the symbionts at the beginning of the life cycle of the host is thus a key point to understand how foundation species establish symbiotic relationships and colonize vent sites. This key step is particularly challenging to study as early life stages are difficult to collect, thus few data are available on symbiotic acquisition in vent species (bathymodiolin mussels and siboglinid tubeworms have been studied). Alvinocaridid shrimps, and more recently, *Alviniconcha* snails are both model species that have been studied in our laboratory regarding symbiosis through the host life-cycle. These studies provided the basis on which we propose to tackle symbiosis initiation and proliferation in early life stages of *Rimicaris* and *Alviniconcha*, thus expanding our knowledge on symbiotic development in vent ecosystems, from both taxonomic and geographic perspectives.

Rimicaris shrimps and *Alviniconcha* gastropods are highly abundant foundation species in vent communities around vent sites on the Mid Atlantic Ridge (MAR) and in western pacific back arc basins respectively. Both are areas of particular interest for the mining industry due to the existence of mineral deposits. On the Mid-Atlantic Ridge, *Rimicaris* shrimps dominate at vent sites included in the French

license area granted by ISA for massive sulfide exploration, whereas in the western Pacific, *Alviniconcha* snails dominated newly discovered vent sites in the Wallis and Futuna EEZ. Expected results of this project on the symbiosis initiation and proliferation in major organisms of the communities living on or near the targeted mineral resources will help predict impacts of potential exploitation and develop mitigation strategies.

On the MAR, two species of *Rimicaris* shrimps coexist, and show differences in their life-cycle and symbiotic development (Theses V. Apremont, and P. Methou). Whereas *Rimicaris* shrimps are associated to microorganisms through an ectosymbiosis, *Alviniconcha* snails in the western Pacific have endosymbiotic microorganisms in their gills, and also exhibit associated microorganisms in their digestive tract. Our recent results (post-doc S. Laming) suggest that symbiosis initiation and proliferation is different between *Alviniconcha* species present in the Wallis and Futuna area, which may influence future adult distribution. A comparison of the processes of symbiont acquisition and proliferation in these model species will help evaluate the universality of the mechanisms between endo- and ectosymbiosis, as well as the role of symbiosis in the coexistence of species with similar functional traits.

Objectives & Approaches: The main objective of this thesis is to better understand symbiosis initiation and proliferation in 5 vent species : *Rimicaris spp*. (*R. exoculata* et *R. chacei*) from the MAR and *Alviniconcha* snails(*A. kojimai*, *A. boucheti* et *A. strummeri*) from the Wallis and Futuna area. The role of local environmental conditions in symbiotic development of host species as well as consequences on species ecology, particularly mechanisms allowing coexistence will also be analyzed in collaboration with colleagues specialists of vent geochemistry (C. Cathalot, GM Ifremer). Specific objectives are :

1) To characterize microbial communities associated with post-larval and juvenile stages, in comparison with already described microbiome of adults
2) To evaluate the influence of environmental conditions on holobiont microdistribution at different life stages;
3) Assess universality and particular traits in endo- (*Alviniconcha*) and ecto-symbiosis (*Rimicaris*).

The project involves imaging approaches (FISH, electronic microscopy, histology and (micro-)CT scan) to characterize the distribution of the main bacterial lineages, describe host morphological modifications due to symbiotic proliferation during development, and identify when the host truly turn into a functional holobiont. Molecular approaches will be used to characterize symbiotic diversity, and functional aspects will be tackled through isotopic and meta-transcriptomic approaches.

Collaborations : The project will benefit from collaborations already established with colleagues from the Laboratoire de Géosciences Marines at Ifremer (C. Cathalot) on habitats characterization, as well as from the ABICE group in the biological station of ROSCOFF (D. Jollivet, S. Hourdez) on the ecology of vent communities, more specifically through the Chubacarc cruise and the ANR project Cerberus. We also have long-lasting collaborations with the AMEX team in Paris (M. Zbinden) on MAR shrimps.

Possible collaboration will also develop with this project with several US teams (Roxanne Beinart : Rhode Island university, Craig Young : Oregon Institute for Marine Biology, et Shawn Arellano : Western Washington University) developing a project on symbiosis and connectivity of *Alviniconcha* and *Ifremeria* snails in the Lau Basin.

Expected profile

- Master in biology, microbiology, ecology, or biological oceanography with background in marine biology.
- Experience in molecular biology techniques (DNA extraction, PCR, in situ hybridization), microscopy and/or bio-informatic analysis of NGS data appreciated.
- Interest for multidisciplinary research involving biology, microbiology and geochemistry.
- Interest or ability for field work at sea.
- Good command of the English language.