**Ph D project (September 2022 – September 2025)**

**Title:** Obligate free-living Parasites in a rush for Infection: Needs and Strategies for surviving and finding a host (PINS)


## Abstract:

*Amoebophrya ceratii* is a specialist parasite of marine dinoflagellates, actively participating in the demise of their host populations. A temporary stage, corresponding to highly specialized flagellated zoospores, allows for transmitting the parasite from one generation to another. The main objective of the PhD project is to define how metabolism of these free-living stages sustain costs of swimming activity for their survival finding a compatible host. The analysis of nutrition and energetic metabolism pathways and the characterization of swimming behavior will allow for defining potential traits and trade-offs involved in the infection success.


## Context and objectives:

Earth's biota is entering a sixth mass extinction with unprecedented extinction rates [1]. Parasites, which account for half of all species richness, could make up the unseen majority of species extinctions [2]. From an anthropomorphic perspective, parasites and pathogens are mostly known as biological agents that cause human, animal, or plant diseases. However, parasites have essential ecological roles by limiting species invasions and the growth of opportunistic species and mediating the biomass transfer between trophic levels [3–5]. Their maintenance is therefore key to the resilience of ecosystems.

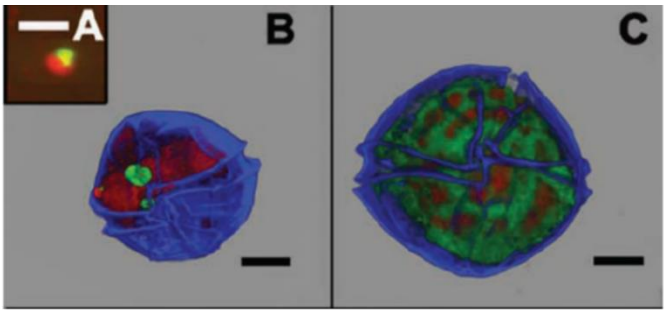


Figure 1. The toxic dinoflagellate *Alexandrium minutum* infected by the microeukaryote parasite *Amoebophrya* sp. (from Chambouvet et al. 2008). Green: parasite cytoplasm targeted by FISH. Red: nucleus. Blue: host theca. (A) Dinospore (free-living stage). (B) Early stage of infection. (C) Late stage of the infection (sporulating individual). Scale bars: 3 µm.

Dinoflagellates (Alveolata), which are significant components of marine phytoplanktonic diversity [6], have numerous intracellular parasites. Among these, *Amoebophrya ceratii* is a specialist parasite of dinoflagellates, actively participating in the demise of their host populations [7] (Fig. 1). It belongs to syndinids (or Marine ALVeolate lineages, MALVs), which represented one of the most hyperdiverse lineages (>1,000 OTUs) recovered in the metabarcoding dataset collected during the Tara Oceans expedition. Such specialist parasites of marine phytoplankton are transmitted from one generation to another via highly specialized and short-lived flagellated zoospores (called dinospores in *Amoebophrya* spp.). This temporary stage, which survives for only a few hours to a few days, does not divide [8]. Its unique purpose is to find a host as fast as possible within a complex and diverse microbial community that includes resistant hosts, grazers, pathogens, and competitors.

**The main objective of this PhD project is to define how dinospore metabolism sustain costs of swimming activity for their survival finding a compatible host.**

This will be addressed using three main questions:

**1- Is dinospore internal energy derived from resources acquired only from the host or does it rely on the uptake of extracellular metabolites?**

**2- What is the relationship between internal energy (ATP) and the essential metabolic functions in the free-living stage?**

**3- Is infection success constrained by trade-offs involving nutrition or swimming behavior?**

## Methodology:

Most of experiments will be conducted from established cultures of *A. ceratii* strains and of some of their potential dinoflagellate hosts, available at the RCC (Station Biologique de Roscoff). Among the main technical approaches, flow cytometry will be used to detect and characterize spores of parasite (*A. ceratii* has a natural green autofluorescence that allows for their accurate numeration) and host cells (easily detected by their pigments' autofluorescence), as well as for monitoring some specific biological functions using fluorescent probes. Microscopy will allow for the observation of specific intracellular fluorescent signals and for the study of swimming activity. Nutritive fluxes will be monitored by the use of stable ($^{13}C$, $^{15}N$) or radioactive isotopes ($^{33}P$). Analyses of transcriptomic data will correspond to a complementary approach aiming at deciphering some of the metabolic pathways of interest.

## Geographic location of the project (research unit):

The main location of the project will be at the Ifremer Centre Bretagne (Plouzané, France; DYNECO-Pelagos laboratory). Frequent exchanges, with physical visits, will be done at the Station Biologique de Roscoff (Roscoff, France; ECOMAP laboratory, "Ecology of Marine Plankton").

## Regional, national and international partnership:

This funded PhD project is part of the ANR EPHEMER project that started in January 2022 (Ephemeral swimmers of marine parasites), and will be conducted during the whole duration of this thesis. This project proceeds from a strong collaboration between the Pelagos team (Ifremer, Centre Bretagne, Plouzané, France) and the ECOMAP team (Station Biologique de Roscoff, Sorbonne Université, CNRS, UMR7144, France). The Pelagos team has a strong expertise in the study of marine protists, in particular phytoplankton species, using various approaches ranging from large scale (ecosystem/ecology) to small scale (cell/ecophysiology). In this project, the ECOMAP team brings a strong expertise in marine parasite and biotic interactions. The PhD student selected will also benefit from the partnership of the EPHEMER project, including, in France, the PCV (CNRS/Grenoble University; lipid characterization and imagery) and two international collaborations, one with the Pohnert laboratory (Friedrich Schiller University, Jena, Germany; metabolomic approaches) and one with the Center for Marine Sciences of the University of North Carolina Wilmington (USA; parasitism and ecology).

## Contact information

- Mickaël LE GAC (Ifremer, Pelagos team): mickael.le.gac@ifremer.fr
- Cécile JAUZEIN (Ifremer, Pelagos team): cecile.jauzein@ifremer.fr
- Claire LABRY (Ifremer, Pelagos team): claire.labry@ifremer.fr
- Laure GUILLOU (Station Biologique de Roscoff, CNRS, ECOMAP team): lguillou@sb-roscoff.fr

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