Ph.D. PROPOSAL FOR THE DOCTORAL SCHOOL
"Ecologie, Géosciences, Agronomie, Alimentation"

GENERAL INFORMATION

Thesis title: Modelling trophic relations in integrated multitrophic aquaculture systems: eco-design approach for freshwater fish production	
Acronym: AMTI	
Disciplinary field 1: Agronomy	**Disciplinary field 2:** Ecology
Keywords: integrated multitrophic aquaculture, ponds, eco-design	
Research unit: INRAE UMR SAS	
Thesis director: Joël AUBIN (joel.aubin@inrae.fr) **Co-supervisors:** Michael CORSON (michael.corson@inrae.fr) and Kazi KABIR (kazi.kabir@cirad.fr)	
Sources(s) of the thesis funding: 50% INRAE (PHASE division), 50% CIRAD	
Gross monthly salary: 1874,41 €	
Funding beginning date/Funding ending date: 2022-2025	
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Recruitment process ☐ **Doctoral school contest** ☒ **Interview** ☐ **Other (indicate)**	

DESCRIPTION OF THE Ph.D. PROJECT

Socio-economic and scientific context

Fish production, which is increasing globally, often focuses on monocultures with a high intensity of inputs, which causes high environmental impacts. To decrease these impacts, fish production must be redesigned with agroecological approaches, such as ecological intensification (Aubin et al., 2019). Among these approaches, integrated multitrophic aquaculture (IMTA) (Chopin, 2013) combines human-fed aquatic species with secondary species (animals or plants) that are added to take up metabolic waste in order to optimise the use of feed inputs. This broad concept is based on trophic complementarity among aquatic species and their interactions within the system. However, most AMTI systems are developed empirically by trial-and-error, which is time-consuming and does not allow original solutions to be explored. To explore combinations of aquaculture species, modelling seems necessary to study and support design of these multitrophic systems (Zhang et al., 2016).

Assumptions and questions

Exploring the functioning of IMTA systems should help determine how to choose which species (and their initial densities) to combine, given objectives for individual productivity, total productivity of the system and species' functional roles and market values. This objective implies considering the physiology of each species in the system as well as interactions among the species. To do this, it is necessary to integrate the many data available about species that can be used in IMTA and information provided by models of growth, excretion and trophic relations. Predictions will be compared to data from the literature and experiments with combinations of freshwater species under real conditions in order to verify the combinations' relevance and applicability, while considering physical conditions of the environment.

Main steps of the thesis and scientific procedure

The first step will consist of reviewing the literature in three directions: IMTA systems and the biology of the species used, trophic modelling in ecology (Aubin et al., 2021) and simulation modelling of agricultural/aquacultural systems. After this step, an initial framework and a model structure will be developed. The model will be quantified with data previously acquired during pond experiments at Le Rheu (INRAE U3E) with different fish species (carp, roach, zander) and trophic compartments of the environment (phytoplankton, zooplankton, invertebrates). Quantified and calibrated models will be evaluated in a second series of experiments during the thesis with freshwater ponds in France and Cambodia (projects FEAMP SEPURE and EisaCam, respectively). The model will then applied by testing it with the objective of optimising systems. Species combinations recommended by the model will be evaluated by a group of experts and applied in experimental ponds. Models will then be simplified to render them operational as decision support systems for aquaculture in France and Cambodia.

Methodological and technical approaches considered

Modelling approaches will follow two axes developed at UMR SAS: (i) mass-balance approaches, which estimate the fate of nutrients in an aquacultural system (Jaeger and Aubin, 2018), using the model Ecopath to represent trophic compartments; and (ii) simulation modelling of biomass dynamics as a function of environmental characteristics. Information about species' traits will be used, especially from the TOFF database, developed by UR AFPA (Univ. of Lorraine). An optimisation method will then be chosen to explore the space of potential solutions.

Scientific and technical skills required by the candidate

- A Master's or engineering degree in Marine and/or aquaculture sciences, Aquatic Ecology, or Biology of aquatic species, or equivalent.
- Applicants will need to have a strong interest in modelling and an aptitude for mathematics and statistics. Knowledge of programming tools such as R or Python will be appreciated. Awareness of issues related to ecology and sustainable development of agricultural systems in temperate and tropical regions will be welcome. Knowledge of tropical aquacultural systems would be a plus.
- The ability to communicate in French and English (oral and written) and to work in an interdisciplinary and international research teach is essential.
- Managing a thesis project requires strong motivation for the subject, good self-sufficiency, an interest in scientific research and the ability to commit to a subject over the long term.

TO APPLY

Send a CV and a cover letter to Joël Aubin (joel.aubin@inrae.fr), Michael Corson (michael.corson@inrae.fr) and Kabi Kabir (kazi.kabir@cirad.fr)

Application deadline: 15 June 2022