Dynamic Energy Budgets affect kinetics of metals in the marine mussel *Mytilus galloprovincialis*.
How a new approach could change the studies on uptake and elimination kinetics of metals ?

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1. **PhD-Project** : modelisation of metal's bioaccumulation in Mediterranean mussel, *Mytilus galloprovincialis*.

Mussel have characteristics that define it like a perfect bioindicators, particularly by its faculty of metal's accumulate with a proportional factor of concentration (1.10^3, 1.10^5), and by its large geographical repartition, its tolerance at different stress and its capability to transplate it (Cossa, 1989 ; de Kock & van het Groenewoud, 1985).
Since twenty five years, the RNO (Réseau National d'Observation de la qualité du milieu marin) use passive bioindicators (natural mussel) to follow pollution along French coast (Goldberg, 1975 ; Phillips, 1980).
Furthermore the following of coastal pollution by metals in mussel, (Mytilus), is frequently realised in many biomonitoring program in the world.
All the long of French Mediterranean coast, use of active bioindicators (transplanted mussel) had given many data available in such a way operational. This program is name RINBIO (Réseau intégrateurs biologiques).
Network vocation is to monitor, to alert, to detect contamination sources and to predict. In that way, modelisation of bioaccumulation of metals in mussel is a rich tool.

However, many difficulty appears : these value draw up only a report of bioaccumulation without contaminants dynamic. And we don' t know how we obtain this concentration at time t ; if it' s by a change of environment conditions, or by a change of the pollution. Furthermore, we can' t compare measured concentration between different sites because it' s have different environment conditions, so different growth of the indicators. It' s i take an interest in building a model issue to a coupling growth-accumulation.
The aim of my research is to coupling a growth model with a bioaccumulation model to consider the changing physiological condition of the mussel. Indeed, each changing condition will interact and affect metal concentration in mussel. So reconstruction of ambient metal

concentration based on metal body burden is only feasible when the effect of food density and/or temperature on the physiological condition of the mussel is known.

2. How Dynamic Energy Budgets affect this process ?

Interpretation of environmental monitoring and ecotoxicological data is improved by knowledge on the relationship between concentrations of metals in the environment and in tissues of mussel. Most of the studies bioaccumulation process assume implicitly steady state conditions for the other physiological processes in the organism. These models do not consider when the organism changes its physiological condition (i.e. size, energy reserves and reproductive cycle) and no not study the impact of these change on the metals concentration in the mussel.

In fact many physiological variables affect for instance the metals burden of *Mytilus* (van Haren et al., 1994). Metal body burden is affected by temperature, size, reproductive cycle, size, age, weight (Cossa et al., 1980).

It's why the coupling of growth and accumulation model is important to understand the process of metal bioaccumulation in *Mytilus galloprovincialis*.

It's here that DEB theory take place, in the growth model and in the accumulation model.

Dynamic energy Budgets theory aims to quantify the energetic of individuals as it changes during life history. The key processes are feeding, digestion, storage, maintenance, growth, development, reproduction and ageing. The theory amounts to a set of simple rules and a wealth of consequences for physiological organisation and population dynamics. Intra- and inter-specific body size scaling relationships form the core of the theory and include dividing organisms" (Kooijman, 2000).

3. Growth model : a perfect application of a DEB model to *Mytilus galloprovincialis*

The importance of the mussel *Mytilus* as a commercial species and its use in pollution studies have resulted in the collection of a large body of information on its physiological ecology. Attempts to model these data so far have been largely limited to static models which, though having some success in prescribed behaviour in a dynamically varying environment (Bayne & Newell, 1983).

Some recent models have established the feasibility of modelling energy acquisition and expenditure of ectotherms in a dynamic environment (Kooijman, 1988).
With mussels, one particular aspect of life history that merits modelling is strategy associated with timing of spawning. This period corresponds at a decreasing of the weight, that will be an elimination of metals.
The fundamental hypothesis underlying a deterministic physiological model is that a set of physiological state variables together with some environmental state variables fully determine such vital rates as growth, development, reproduction. All the parameters of DEB model must have a relationship with ultimate body volume : clearance rate, ingestion, assimilation and maintenance.

4. Metal kinetics in the mussel : accumulation model

Uptake and elimination kinetics of metals in the mussel *Mytilus galloprovincialis* can be describe by a dynamic energy budget model. A multi-compartment-pharmaco-kinetic model has been used to describe metal kinetics (van Haren et al., 1994). The contribution of physiological determined variables as body size and tissue composition are evaluated on its influence on the pharmaco-kinetics of the metals.
The uptake/elimination model that was proposed by Kooijman & van Haren (1990) has been designed to account for change in the physiological conditions of the organism. Uptake is via food and or directly from the environment and elimination is via reproduction (gametes) and or directly to the environment.
Like in growth model, all parameters will depend on body volume : uptake via food (e.g. gut), uptake via water (e.g. gills) and elimination. Indeed, uptake as well elimination are assumed to be proportional to the surface area.
The applicability of the DEB model for xenobiotic kinetics has been demonstrated.

5. Adjustement of parameters and field validation

For coupling growth and accumulation, it's essential to have different data :

- physico-chemical variable of contaminant and of water,
- biological variables of water,
- biological variables of mussel.

During my thesis, mussel sampling have be done every fortnight, with temporal follow up of allometric parameters, of contaminant concentration in mussel transplanted in two polluted site. Furthermore, environmental measures have be done : hydrological parameters (T, Ph, S, O2, MES, Chla and pheopigment) and contaminant concentration in water (dissolved and particular). All these data will be integrated at the DEB model to adjust parameters.

This type of study show us an application of DEB theory. With that, the bioaccumulation model could be an evaluation tool of metal concentration in mussel, and of water contamination. By elimination of environmental and biological mistake, this model could be an optimisation of biomonitoring and an adjustement at different environment by integration of specific data (environmental and biological).

6. Bibliography

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