Individual mussel growth model using Dynamic Energy Budget (DEB) theory: revisiting the DEB parameter values in *Mytilus edulis*

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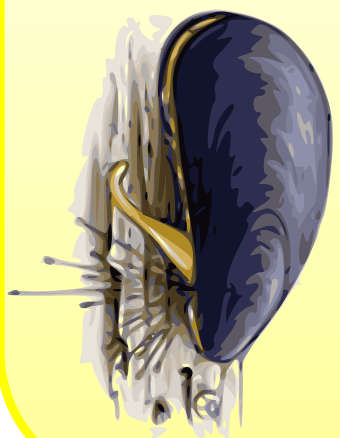


1. The BlueDEB project and its challenges

Mussel aquaculture is well developed in various ecosystems of temperate waters. In the aim of developing management predicting tools for mussel aquaculture, a better understanding of relationships between the environmental conditions and mussel growth is necessary. Development of bioenergetic models, linking environmental variables (especially food resource and temperature) and mussel growth and reproduction, are of a particular interest.

The BlueDEB project aims at developing a generic model to simulate growth and reproduction of mussels (*Mytilus edulis*) in contrasted environments under forcing of temperature and trophic resource. The model is based on the Dynamic Energy Budget (DEB) theory that provides a general framework to study energy fluxes in organisms, to maintenance, growth and reproduction.

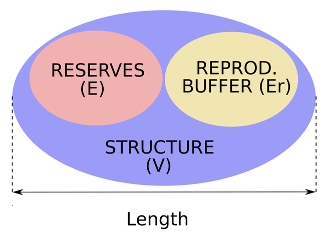
Some of the BlueDEB challenges...

- Refine the estimation of the DEB parameters for *Mytilus edulis* towards a generic parameter set.
- Identify the food sources of *Mytilus edulis*.

2.1 Refinement of parameters estimation: Shape coefficient

In the context of DEB theory, the mass of an individual is partitioned into:

- Structural volume (V)
- Reserves (E)
- Energy allocated to reproduction (E_R)



The shape coefficient ($\delta_{\mathcal{M}}$) which relates length measurement (L) to structural volume: $V = (\delta_{\mathcal{M}} L)^3$ has been re–estimated for *M. edulis* (Fig. 1)

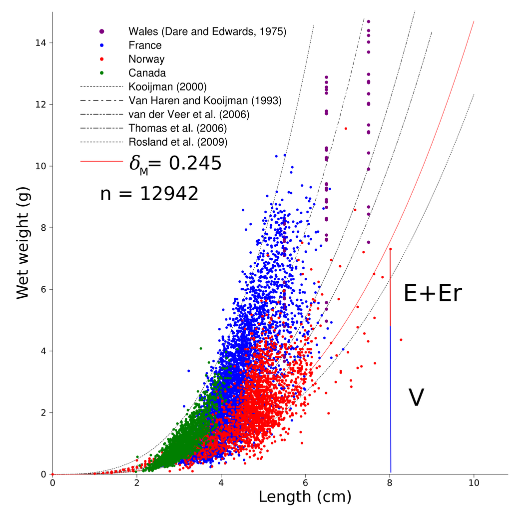


Fig. 1: *Estimation of the shape coefficient using length – wet weight data from various environments. Length – WW relationship, and plots of shape curves using shape values estimated by Kooijman (2000), van Haren and Kooijman (1993), van der Veer et al. (2006), Thomas et al. (2006), Rosland et al. (2009). Because wet mass contains both structural mass (V) and reserves (E and E_R), a good estimation correspond to a lower envelop curve. Here, the shape was estimated to $\delta_{\mathcal{M}}$ =0.245 with 10% of individuals beneath the curve.*

2.2 Refinement of parameters estimation: Maintenance costs

In the context of DEB theory the maintenance embraces all the processes that allow to maintain the homeostasis, and subsequently that allow to keep an organism alive.

During starvation, if little energy is allocated to growth and reproduction, almost all energy is allocated to maintenance. Thus maintenance costs can be estimated by the loss of weight or energy content during starvation. Four data sets from literature have been used to estimate the volume specific structural maintenance costs $[\dot{p}_M]$ (see Tab. 1)

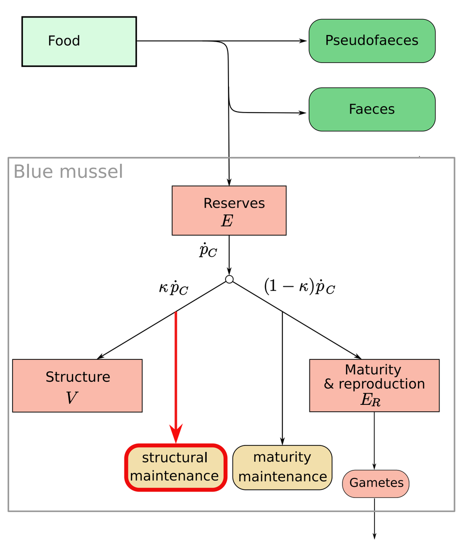


Fig. 2: *Conceptual scheme of a DEB model, allocation of energy to structural maintenance is emphasized in red.*

Table 1. *Results of the estimation of the parameter $[\dot{p}_M]$ using starvation data sets from literature. The average of the estimations is compared with the value previously estimated by Wildgust et al. (1999). All values are given for a reference temperature of 15°C.*

Source	duration (d)	$[\dot{p}_M]$ (J cm^{-3} d^{-1})
Riisgård and Randløv (1981)	47	51 – 82
Bayne and Thompson (1970)	86	36 – 46
Diehl et al. (1986)	58	50
Wildgust et al. (1999)	65	70
Average (15 °C)	–	51.8
van der Veer et al. (2006)	–	17

Although this value is supposed to be little variable between species of a same taxa, the estimated value is much higher than for other species (van der Veer et al., 2006; Pouvreau et al., 2006).

⇒ There is a need for new experiments to refine the estimation of this key DEB parameter.

3. A new approach to reconstruct food conditions

DEB models are appropriate to develop reverse approaches:

⇒ Standard DEB model: Temperature + Assimilation → Evolution of the length over time

⇒ Reversed DEB model: Evolution of the length over time + Temperature → Assimilation

As the same equations are used, the reconstruction is theoretically exact (Fig. 3)

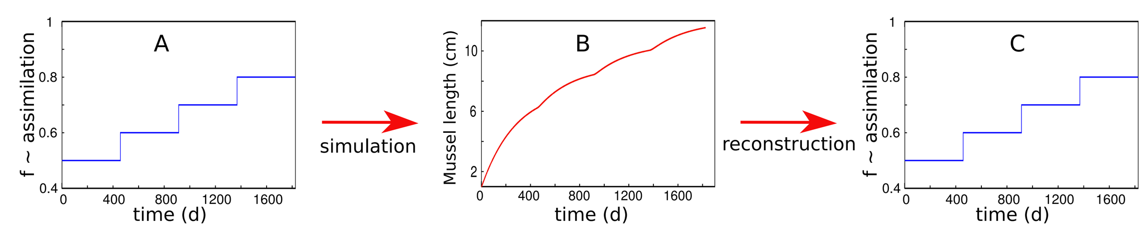


Fig. 3: *Theoretical example of reconstruction of the scaled functional response (f, proportional to the surface specific assimilation rate). Here length is simulated (B) with a known dynamics of f (A), length is then used to reconstruct the dynamics of f (C).*

Application to real individual growth data (Fig. 4):

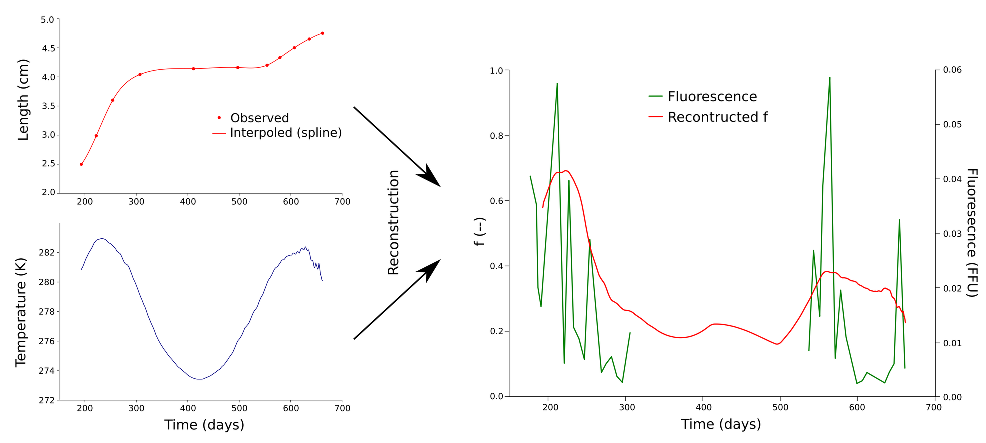


Fig. 4: *Example of reconstruction of f from observed growth data: individual growth and temperature data are needed. Length observations are interpolated using the spline method. The reversed model is then used to reconstruct the time series of f, which can be compared to the fluorimetric measurements performed during the growth experiment (experimental data from Alunno-Bruscia et al., 2000).*

⇒ Trophic conditions can be assessed by correlation between the reconstructed time series of f and the times series of different potential food sources proxies (Chl$_a$, POM, phytoplanktonic composition ...)

Acknowledgments

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