Modelling population dynamics of organisms using Dynamic Energy Budget models : application to risk assessment of chemical mixtures

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Introduction

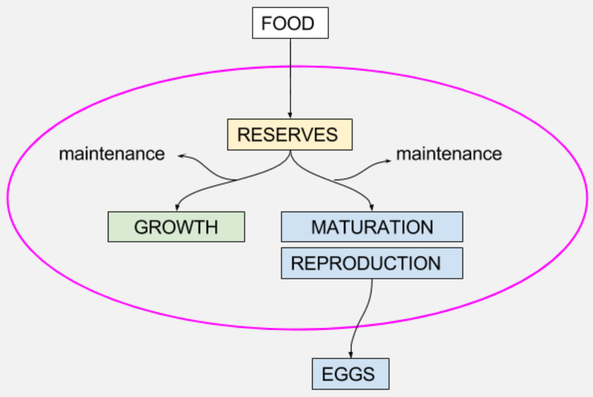
Daphnia cucullata (S.A.L:M: Kooijman)

Toxic stress is typically assessed in biological tests with daphnids, fish, small insects etc. The aim of these tests is to uncover which amount of a compound is safe. These tests are highly standardized and are used as surrogate tests as it is not possible to directly measure effects on something like local biodiversity and/or things like our food safety. Especially, since there are innumerable species from microscopic to macroscopic while some 2000 new chemical enter the market each year in Europe.

This project aims to integrate biological processes and knowledge on how mixtures impair those processes into modern population models of species that are vital for our food security. This will be done to shed new light on an old, deceptively simple, yet crucial ecotoxicological question:

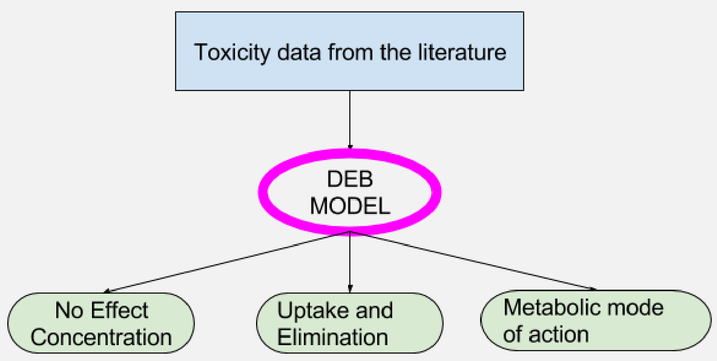
"If a daphnid due to toxic stress would not have say 600 young but 300 what would be the real societal consequence?"

STEP 1: Effects on individualsc



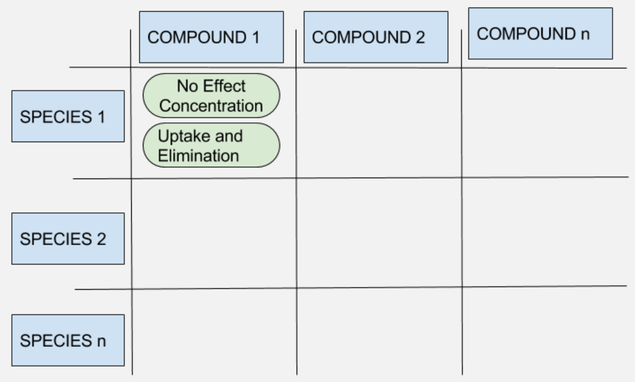
<u>The standard Dynamic Energy Budget (DEB) model.</u> Every living organism takes up resources from the environment. The resources are transformed into work and biomass in order to grow, develop, and reproduce. An extraordinarily simple set of rules governs these processes which are given by the standard DEB model.

STEP 2: Estimate parameters



Compounds in the environment accumulate inside the organism. When the "No Effect Concentration" is exceeded then one of the processes of the standard DEB model (e.g. maintenance - see model scheme on the left) is impaired. The impaired process (metabolic mode of action) affects growth or reproduction (or survival) over time in specific ways.

STEP 3: Database



We will build a data base with all of the No Effect Concentrations, Elimination rates, and metabolic modes of actions for the different species and different compounds.
Such a database might help identify patterns in the way toxicity relates to properties of species (e.g. size) or compounds (e.g. solubility).

Step 4: From individuals to populations

Acantholeberis curvirostris (S.A.L.M. Kooijman)

The approach of DEB theory with a process-based description of the individual allows for its use as a starting point in population dynamics (or **basically tracking the changes of the number of individuals over time**), and also allows for the **integration of toxic effects**, but no longer interpreted in terms of effects on an individual but as effects **on a population**.

Application to risk assessment

One of European Food Safety Authority's Science Strategy 2012-2016 is to strengthen scientific evidence underlying risk assessment and risk monitoring. In this context, the harmonization and **development of new methodologies for risk assessment is considered to be of critical importance**.

From its initiation, this EFSA* project tender "Modelling population dynamics of aquatic and terrestrial organisms using Dynamic Energy Models (DEB): application to risk assessment of chemical mixtures" (2015-2017) responds to one of the three research priorities: Physiology-based modeling. The reason being that **DEB models integrate effects on organisms on the basis of what might be the best tested unifying biological principles to date.**

*This work is a tender funded by the European Food Safety Authority (EFSA). EFSA is the keystone of European Union (EU) risk assessment regarding food and feed safety. In close collaboration with national authorities and in open consultation with its stakeholders, EFSA provides independent scientific advice and clear communication on existing and emerging risks. Read more here: http://www.efsa.europa.eu/en/aboutefsa

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