Simple energy-budget model for yolk-feeding life stages; a case study for Atlantic cod

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The early life stages of organisms are of considerable interest in ecotoxicology as they constitute a vital aspect of population dynamics and often display considerable sensitivity towards toxicants. Furthermore, embryo and early-life stage toxicity tests for vertebrates (i.e., fish and amphibians) are increasingly being suggested as alternatives for testing with the later (and legally-protected) life stages. To interpret the patterns of effects observed in toxicity test, and to extrapolate such results to field conditions, requires mechanistic models. Such models should consider both the toxicokinetic (TK) and toxicodynamic aspects (TD) of toxicity. Substantial research efforts are currently concentrating on the molecular level. However, we are convinced that molecular-level approaches need to be combined with energy-budget models to allow for a causal link between exposure and the whole-organism life-history traits (as represented by AoPs). The reasons for this are twofold. Firstly, any AoP will require knowledge about TK: how the internal concentration (in specific parts of the organism) develops over time. TK will be influenced by how the various biomass components (e.g., structure and yolk) develop over time, which is served by energy-budget models. Secondly, life-history traits are connected through the energy budget (e.g., structural growth and development are causally linked to the available yolk and to respiration rates), and feedbacks at this level cannot be explained from the molecular level up. Unfortunately, there have so far only been few attempts to apply energy-budget models to yolk-feeding stages. In this contribution, we report on the first stage of our attempts to do so, applying the simple DEBkiss model. In this first stage, we tested the basic model (in absence of toxicant stress) on extensive data for the yolk-feeding stages (and subsequent larval starvation) of Atlantic cod (*Gadus morhua*). The model provided an excellent explanation for the development of total weight, yolk content, respiration and larval length over the development of the egg and the yolk-sac fry. We include model simulations to predict how toxicant stress is expected to affect these development patterns. In a later stage, we will use our model to interpret toxicity data and to attempt a link with gene expression and metabolomics.