Salinity impact on the life history traits of the bloody cockle (Senilia senilis) in the Sine Saloum inverse estuary: a bioenergetic modelling approach

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Abstract

The impact of extreme salinity on bivalve physiology and phenology has the potential to influence a wide range of biological processes, including food acquisition, growth, reproduction, respiration, endocrine and immune systems, and behaviour, which can ultimately result in increased mortality. The Dynamic Energy Budget (DEB) theory provides a mechanistic framework for studying the effects of stressors at the individual level and across all life stages. The present study aims to implement a DEB model on the West African bloody cockle (*Senilia senilis*). This bivalve is exposed to spatio-temporal variations of extreme salinity conditions in the Sine Saloum inverse estuary (Senegal). Its millennial artisanal fishing, which is part of the culture and traditions of local populations, is crucial for their food security and economic autonomy. The combination of extreme salinity levels and overfishing has potentially led to a decline in both stock and size of catches. Following the implementation of the Add my Pet procedure to estimate the species' DEB parameters, stylised facts were established in order to conceptualise the modes of action of salinity variations in the framework of the DEB theory. The effects of salinity are parametrized on the basis of experimental results and validated on the basis of growth measurements carried out in contrasting sites in the estuary. This model provides a powerful tool to understand population dynamics under salinity stress and will sustain the management of *S. senilis* artisanal fishery.

Keywords: Salinity, Bivalve, Stylized facts, DEB theory, West Africa

*Speaker

How acclimation to thermal variability shapes behaviour and associated energetic costs in a temperate dung beetle

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Abstract

Fluctuations in daily temperature can range beyond 20 ◦C and are projected to increase under anthropogenic climate change. Body temperature affects ectotherm performance across a range of physiological processes. The rate of reaction for physiological and biochemical processes are temperature dependent, affecting species success and spatial range. Generally, at higher temperatures more energy is needed, and terrestrial ectotherms vary in behavioural and physiological responses. We hypothesised that O. taurus beetles adjust their behaviour under thermal variability to reduce energy consumption through shifts in their locomotive strategies and activity window. We tested associated energetic trade-offs under variability for a temperate dung beetle (*Onthophagus taurus*). *O.* taurus' foraging behaviour consists of both crawling and flying. Flying is energetically demanding and only possible at higher temperatures but increases foraging speed and area. We acclimated beetles to 20 ◦C ± 12 ◦C with a 12:12 L:D cycle and maintained the control at 20 ◦C ± 2 ◦C. We recorded behaviour across a 24-hour period for all three groups following six days of acclimation. We then measured CO2 production across a range of temperatures to determine flight initiation temperature and its energetic cost. Acclimation to a higher amplitude of thermal variability increased the likelihood *O.* taurus would fly at lower temperatures and increased the level of activity at all temperatures. Preliminary DEB models suggest far greater energetic costs when incorporating differences in locomotive choices as a result of acclimation.

Keywords: Acclimation, Thermal variability, Locomotion, Energetics, Flight

*Speaker

Energy Dynamics and Life History Traits of the freshwater Three-Spined Stickleback: A DEB Approach

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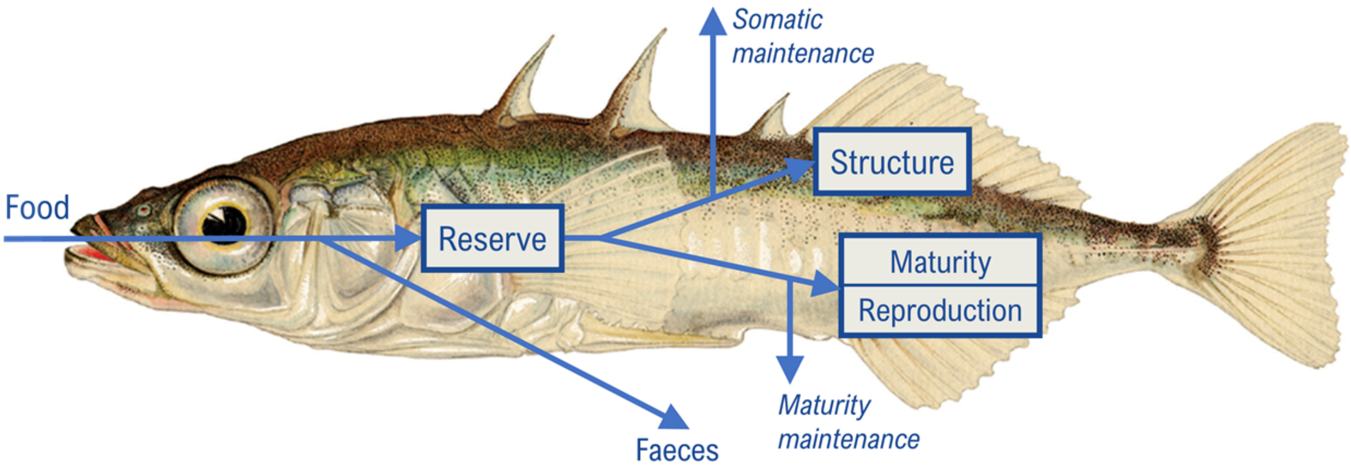
Abstract

The three-spined stickleback (*Gasterosteus aculeatus*) is a small teleost fish species widely distributed across northern hemisphere ecosystems. It can play a significant ecological role by dominating fish communities and influencing ecosystem functions. Due to its extensive distribution and ecological importance, the three-spined stickleback has become a model organism in evolutionary ecology, behavior, and evolutionary genetics studies. Additionally, it is considered an important sentinel species in aquatic ecotoxicology. The primary aim of this work is to develop a complete life-cycle model for the freshwater three-spined stickleback using the principles of Dynamic Energy Budget (DEB) theory. To achieve this, a systematic review of experimental data on growth, larval development, maturity, and reproduction from freshwater populations of the species was conducted. The model was calibrated using the method of covariation for parameter estimation from DEBtools for MATLAB. The calibrated DEB model will be used to explore the effects of multiple stressor interactions on the stickleback, as well as to simulate population dynamics in Central European streams.

Keywords: three, spined stickleback, freshwater, ecotoxicology

*Speaker



Somatic maintenance
Food
Reserve
Structure
Maturity
Reproduction
Maturity maintenance
Faeces

Empirically Parameterizing a Dynamic Energy Budget Model for the Facultatively Symbiotic Coral Astrangia poculata

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Abstract

As changes in the global environment strain existing energy limits, organisms are forced to respond to stressors more frequently and to a greater degree. Corals have become an emblematic example of environmental sensitivity in the Anthropocene– with massive die-offs resulting from the breakdown of the coral-algal symbiosis. Dynamic energy budget (DEB) models have been used to assess and predict the impacts of global change and evaluate the resilience of tropical corals. Assessing the independent energy dynamics of host and symbiont in these models is challenging, however, due to the obligate nature of the tropical coral-algal symbiosis. The temperate coral *Astrangia poculata* exhibits a facultative symbiosis; existing with (symbiotic) or relatively without (aposymbiotic) endosymbionts. This provides a tractable opportunity to disentangle the contributions of auto and heterotrophy to coral growth and metabolism. The overarching aim of this research was to leverage a laboratory experiment to parameterize a DEB model for both symbiotic and asymbiotic *A. poculata* in the Add My Pet (AmP) framework. In a 90-day experiment, we exposed host (aposymbiotic) and holobiont (symbiotic) *A. poculata* to different light and food levels. At regular intervals, we collected physiological metrics including polyp growth, grazing rate, biomass, lipid, protein, and chlorophyll content. Experimental results show that *A. poculata* biomass is more sensitive to changes in light versus food level; higher light levels correspond to higher biomass and lipid levels, especially in symbiotic corals. Comparisons of AmP parameter estimates for aposymbiotic vs. symbiotic *A. poculata* will provide critical insights into the energetics of symbiosis.

Keywords: coral, symbiosis, physiology

*Speaker

From Native Waters to Invasive Frontiers: Modeling Atlantic Blue Crab (Callinectes sapidus) Performance Under Changing Environmental Conditions

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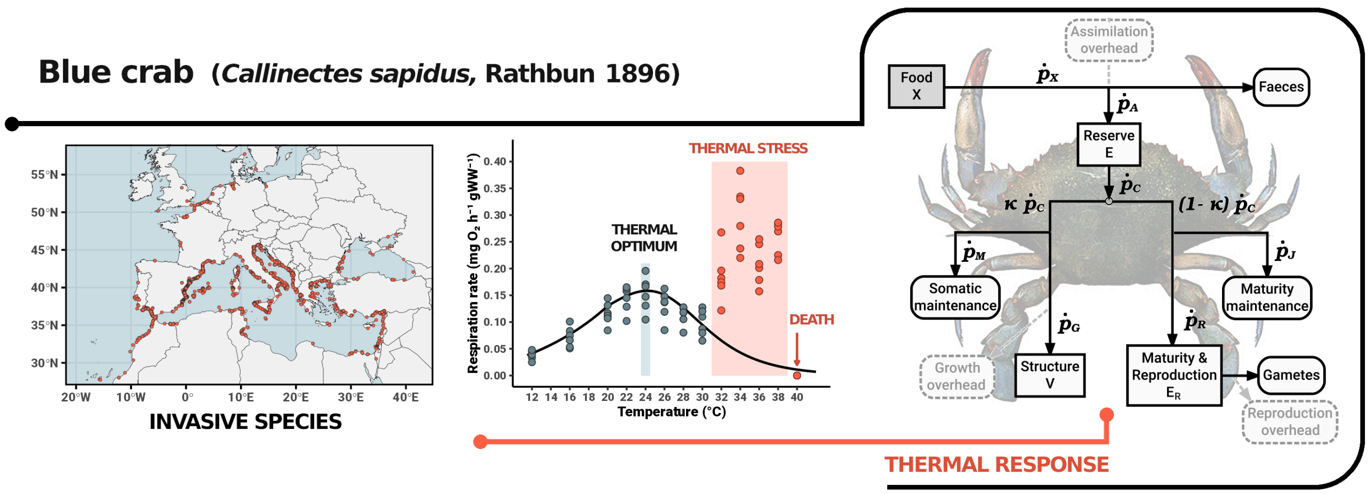
Abstract

The Atlantic blue crab, *Callinectes sapidus*, is an iconic resource in its native range (e.g., Chesapeake Bay, western Atlantic from Nova Scotia to Argentina), but has recently become invasive in the Mediterranean and Black Sea, leading to significant ecological and socio-economic impacts. Given that temperature strongly influences crustacean metabolic rates and growth, while salinity plays an important role in blue crab development and reproductive success, understanding the performance of *C. sapidus* across diverse environmental conditions is critical. Yet, no comprehensive modeling framework currently exists to predict the species' performance across varied environments. This gap hampers both the conservation and management of native stocks (e.g., Chesapeake Bay) and the containment or exploitation of invasive populations (Mediterranean). Here, we present a mechanistic model based on Dynamic Energy Budget (DEB) theory, incorporating newly measured laboratory data on thermal tolerance and oxygen consumption, biometric field measurements, and an extensive historical dataset documented in the literature, dating back to the 1920s. The model captures sex-specific differences in energy acquisition and quantifies how temperature influences growth and reproduction. Preliminary simulations indicate that *C. sapidus* exhibits a broad thermal tolerance with an optimal range near 24 ◦C, closely matching conditions in Mediterranean habitats already experiencing warming trends. Projected future temperature increases are expected to facilitate further expansion of *C. sapidus*, potentially causing cascading effects on native biodiversity. The model provides a valuable tool to evaluate suitable habitats for invasive expansion and inform context-specific adaptive management strategies-for instance, offering guidance on conservation measures in native populations or targeted harvest of males or females in newly invaded regions.

Keywords: Thermal tolerance, Environmental performance modeling, Dynamic Energy Budget (DEB) model, Conservation, Informed management

*Speaker


Blue crab (Callinectes sapidus, Rathbun 1896)
55°N
50°N
45°N
40°N
35°N
30°N
20°W 10°W 0° 10°E 20°E 30°E 40°E
INVASIVE SPECIES
Respiration rate (mg O2 h-1 gWW-1)
0.00 0.05 0.10 0.15 0.20 0.25 0.30 0.35 0.40
12 14 16 18 20 22 24 26 28 30 32 34 36 38 40
Temperature (°C)
THERMAL OPTIMUM
THERMAL STRESS
DEATH
THERMAL RESPONSE
Assimilation overhead
Food X
Faeces
Reserve E
κ ṗC
(1- κ) ṗC
Somatic maintenance
Maturity maintenance
Growth overhead
Structure V
Maturity & Reproduction ER
Gametes
Reproduction overhead

Integrating mixture toxicity in DEB-TKTD models: Understanding combined effects of pesticides on earthworm reproduction

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[2]Unité Toxicologie Expérimentale et Modélisation (TEAM), UMR-I 02 SEBIO – INERIS – France

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Abstract

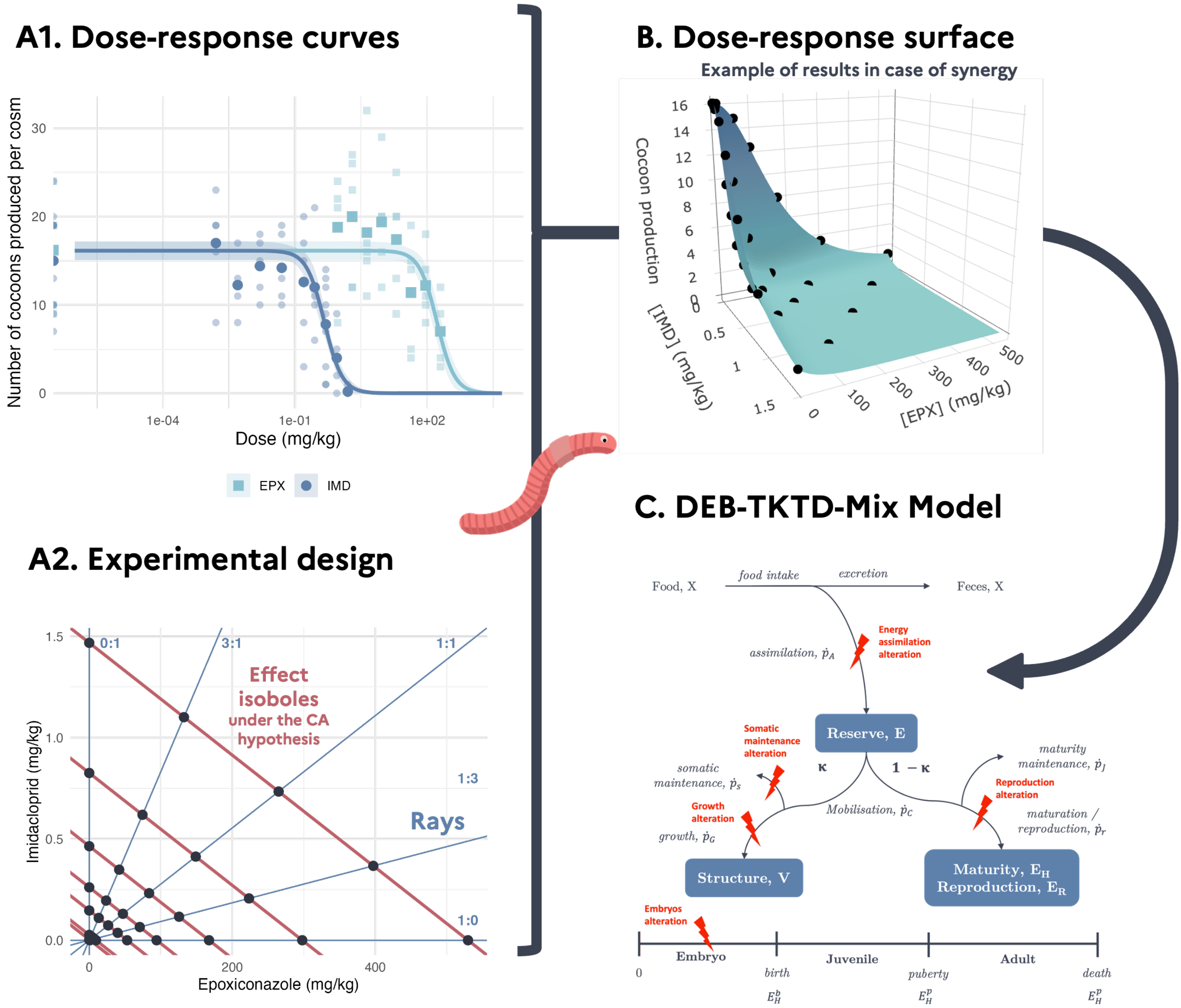
Soils play a critical role in ecosystem functioning, yet they are increasingly threatened by agricultural intensification leading to contamination with persistent mixtures of plant protection products (PPPs). While standard environmental risk assessment typically focuses on single compounds, soil organisms are exposed to complex mixtures of PPP residues, making it crucial to understand their combined effects.

Our study aims to develop a DEB-TKTD model to understand the physiological mode of action of a mixture of two prevalent PPPs in agricultural soils: epoxiconazole (fungicide) and imidacloprid (insecticide). Using the earthworm *Aporrectodea caliginosa* as a model organism, we first characterized the toxicokinetics of both compounds before examining their effects on reproduction through an adapted OECD guideline 222 experiment using a ray design (n = 7 mono-substance doses, n = 21 mixture doses, n = 3 replicates). By monitoring cocoon production, hatching success, and juvenile growth over 28 days, we will gather essential data to parameterize our DEB-TKTD model.

The integration of mixture toxicity data into the DEB framework will provide mechanistic insights into how these PPPs interact to affect earthworm life-history traits. This DEB-TKTD model will then be incorporated into an Individual-Based Model to predict long-term effects on population dynamics under realistic exposure scenarios. This multi-level modeling approach will help bridge the gap between individual and population responses to pesticide mixtures, contributing to more environmentally relevant risk assessment procedures.

Keywords: Earthworms, Pesticides, Mixture, DEB, TKTD

*Speaker



A1. Dose-response curves
Number of cocoons produced per cosm
Dose (mg/kg)
EPX
IMD
A2. Experimental design
Effect isoboles under the CA hypothesis
Rays
0:1
3:1
1:1
1:3
1:0
Imidacloprid (mg/kg)
Epoxiconazole (mg/kg)
B. Dose-response surface
Example of results in case of synergy
Cocoon production
[IMD] (mg/kg)
[EPX] (mg/kg)
C. DEB-TKTD-Mix Model
Food, X
food intake
excretion
Feces, X
assimilation, $\dot{p}_A$
Energy assimilation alteration
Reserve, E
Somatic maintenance alteration
somatic maintenance, $\dot{p}_S$
κ
1 − κ
maturity maintenance, $\dot{p}_J$
Reproduction alteration
Growth alteration
Mobilisation, $\dot{p}_C$
maturation / reproduction, $\dot{p}_r$
growth, $\dot{p}_G$
Structure, V
Maturity, E_H Reproduction, E_R
Embryos alteration
Embryo
Juvenile
Adult
birth E_H^b
puberty E_H^p
death E_H^p

Improving dynamic energy budget models of triploid oysters

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Abstract

Triploid organisms, bred to have three sets of homologous chromosomes rather than the typical two found in diploids, are common in agriculture and aquaculture. Triploid oysters have been widely adopted in aquaculture since their development roughly 40 years ago. Oyster farmers often prefer triploids primarily for their faster growth rates and reduced reproduction, which typically results in better meat condition during spawning season. Despite their commercial importance, significant gaps remain in understanding how the triploid condition affects oyster growth, physiology, and energy budgets in the face of climate change.
The enhanced growth of triploids, commonly called "triploid advantage," has been attributed to three main hypotheses: (1) reduced reproductive effort, (2) higher heterozygosity, and (3) larger cell sizes. While these pathways likely work in combination, dynamic energy budget (DEB) modeling efforts have primarily focused on adjusting the *kappa* parameter to reflect increased energy allocation to somatic growth. To further explore the other pathways and develop a more comprehensive model using the eastern oyster (*Crassostrea virginica*) as a case study, we conducted a starvation experiment to estimate structure-specific maintenance costs via respiration in diploid versus triploid oysters complemented with long-term growth studies and literature reviews to developed datasets for testing the alternative triploid DEB modeling approaches.
Preliminary results suggest that triploids starve at slower rates, but structure-specific maintenance needs are similar between ploidies despite significant differences in cell sizes. We use simulations with varied parameter sets to explore different modes of action for triploid growth focusing on allocation to structure (*kappa*), energy acquisition (ingestion and/or assimilation), and parameters beyond structure-specific maintenance costs that could be affected by cell size differences (energy conductance, costs for structural growth, and maturation thresholds).

Keywords: Oyster, aquaculture, triploid

*Speaker

Modelling the effects of multiple stressors on aquatic insects

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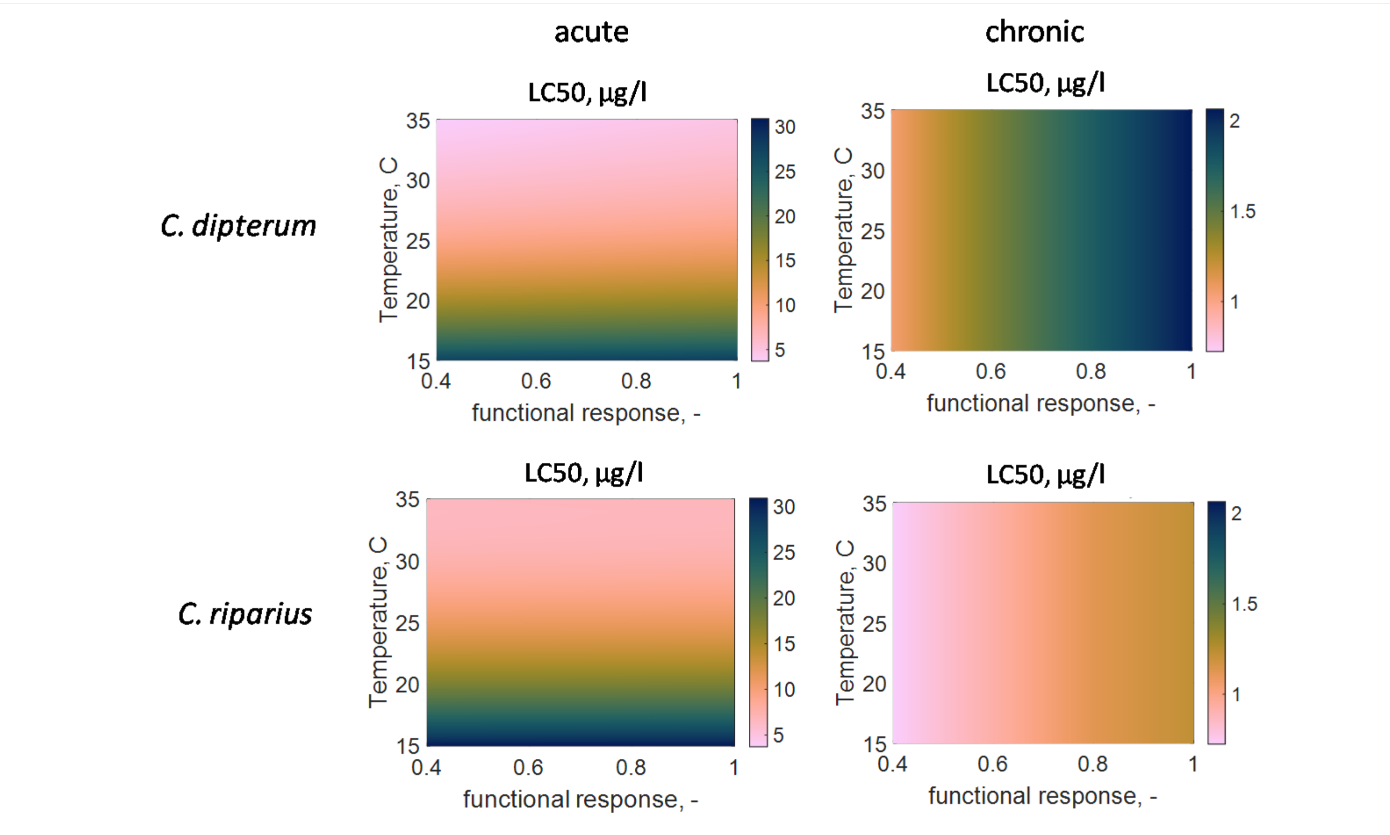
Abstract

Mayflies and other aquatic insects, known for their high sensitivity to neonicotinoid insecticides, serve as key non-target indicators in environmental risk assessments. While acute toxicity tests typically focus on lethality, it is important to evaluate sub-lethal effects, such as growth, to understand long-term toxicity. Additionally, the effects of chemical stressors in combination with environmental stressors (e.g., temperature increase and food scarcity) less well studied. To improve our understanding of how neonicotinoid insecticides and environmental stressors interact to impact aquatic insects, a Dynamic Energy Budget (DEB)-based toxicokinetic-toxicodynamic (TKTD) model was developed. The model was calibrated for two insect species, *Chironomus riparius* and *Cloeon dipterum*, using experimental data on feeding inhibition and immobility. These models were then used to assess the combined effects of multiple stressors, specifically imidacloprid exposure, temperature, and food availability, under both constant and variable exposure scenarios. Simulations from the model predicted LC50 and EC50 (50% effect concentration) values for mobility and sublethal effects, respectively. The timing and duration of exposure were found to be critical factors influencing sensitivity. In general, temperature had a greater effect in acute exposure scenarios, while food availability was more influential in chronic exposure situations. *C. riparius* showed rapid responses to changes in toxicant concentration, whereas *C. dipterum* displayed a more gradual reaction.

Keywords: Dynamic Energy Budget theory, toxicokinetic, toxicodynamic model, imidacloprid, Chironomus riparius, Cloeon dipterum

*Speaker


acute
chronic
C. dipterum
C. riparius
LC50, μg/l
LC50, μg/l
LC50, μg/l
LC50, μg/l
Temperature, C
functional response, -
35
30
25
20
15
0.4
0.6
0.8
1
5
10
15
20
25
30
1
1.5
2

Exploring the combined effects of pathogen-induced stress, temperature, and food scarcity on the bioenergetics of Pinna nobilis

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Abstract

The endangered fan mussel (*Pinna nobilis*) has historically declined mostly due to extensive overfishing, habitat destruction from trawling and anchoring, as well as pollution, and seagrass meadows degradation. More recently, the species is facing severe population decline due to mass mortality events linked to pathogens such as *Haplosporidium pinnae, Mycobacterium* spp, and *Vibrio* spp. Climate change-induced temperature increases and food scarcity pose additional threats by affecting physiological responses, immune functions and survival. To prevent extinction, conservation efforts should focus on habitat protection and disease mitigation. Furthermore, a better understanding of *P. nobilis* bioenergetics in response to environmental factors could inform recruitment strategies. This study extends a DEB model for *P. nobilis* to assess the combined effects of pathogen infection and environmental stressors, such as temperature increase and food scarcity, on growth, maturation, and reproduction. The model successfully reproduces observed growth patterns in length and weight, clearance rate and oxygen consumption across a range of temperatures. Additionally, it accurately predicts ages and sizes at developmental transitions between life stages. The exact mechanism of the effect of pathogens on the energy flow is not yet fully comprehended. Results out of several experiments indicate that pathogens affect the mechanisms of cell homeostasis and immunity maintenance. We hypothesize that the pathogen mode of action is to increase rates of somatic and maturity maintenance through a stress parameter. By exploring how these stressors impact key biological processes, this study provides critical insights to support conservation efforts for this keystone species.

Keywords: DEB theory, Pinna nobilis, bioenergetics, stressors

*Speaker

TOWARDS A DYNAMIC ENERGY BUDGET MODEL FOR CHIRONOMIDS

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Abstract

Chironomids or nonbiting midges are holometabolous insects of the order Diptera. Typically, holometabolous insects feed, grow and build up large pools of somatic and reproductive reserve during the larval stage, then undergo a major metabolic and morphological transformation during metamorphosis to finally emerge as adults, which reproduce and often soon perish thereafter.
Due to their ecological significance and relative ease of cultivation, they are used in standard toxicity tests for the ecological risk assessment (ERA) of chemicals. This includes a lifecycle test in which larval growth, development times, reproductive output and survival are recorded. We wish to perform ERAs within the wider DEBtox/ DEB-TKTD framework, but are faced with experimental and theoretical problems. A DEB model that satisfactorily describes important stylized facts of the energetics and the life history of chironomids, among other holometabolous insects, is missing. In particular, it is challenging to concomitantly satisfy the following three stylized facts:

- The duration of larval length growth increases with decreasing food availability, while the time from the cessation of larval length growth to the emergence of adults appears to depend marginally on feeding conditions.
- Maximum larval length does not depend much on food availability (but differs between males and females). However, the weight of adults at emergence decreases with food availability during the larval stages.
- Food limitation in the larval stage reduces adult reproduction. We will illustrate and discuss these and other challenges to develop a DEB model for chironomids that is both realistic and practical for ERA.

*Speaker

New approaches improve ecological risk assessment by incorporating omics into bioenergetic models: A case study of Daphnia exposed to a coal ash mixture

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Abstract

The ecological risk of a chemical is traditionally measured by exposing a single organism to a single chemical in idealized lab conditions through standardized toxicity testing. These tests have many drawbacks that mostly stem from the inability to use this data to predict effects outside of the specific empirical parameters of the test, such as the impacts of other chemicals or mixtures or to extrapolate effects to an ecologically relevant outcome. At the other end of biological organization, novel molecular techniques yield increasing amounts of subcellular data. This information can potentially be used to better understand the individual-level impacts of a chemical by connecting exposure to an altered molecular pathway or mode of action, agnostic of any specific chemical or organism. Here we describe a case study looking at the effect of coal ash, a mixture of numerous metals known to exert toxicological effects, on a model freshwater organism, *Daphnia magna*. We exposed *D. magna* to coal ash through dietary algal exposure and measured impacts on survival, growth, and reproduction for 28 days. We measured the transcriptomic response at multiple time points, enabling us to analyze the suborganismal response of the *Daphnia* to coal ash exposure throughout their life cycle. We then modeled the response of *Daphnia* to coal ash using a Dynamic Energy Budget (DEB) model, testing various potentially impacted physiological modes of action (pMoAs). Instead of identifying the pMoA through traditional DEBtox methods which relies on only individual-level data, we correlated these model simulations with significantly differentially expressed genes to identify the best candidate pMoA based on the molecular coal ash signal. For each state variable in the DEB model, we applied a variable selection approach (using ARACNE) to identify a set of genes predictive of the state variable. We then sorted the genes associated with this variable selection approach and added them to the ARACNE model using machine learning. The model with the best fit to the DEB state

*Speaker

variables (as measured by R2) was selected. This process using transcriptomic data and DEB modeling identified the pMoA of "increased costs of reproduction" as the best description of the impact of coal ash on *Daphnia*. This case study represents an exciting development in using suborganismal data to quantitatively identify the bioenergetic mode of action of complex chemical exposure in a model freshwater organism.

Keywords: DEBtox, physiological mode of action, transcriptomics, Daphnia magna, predictive gene sets

Dynamic Energy budget and Non-Linear Averaging reveal variation in temperature effect on Homarus americanus in the Gulf of Saint Lawrence

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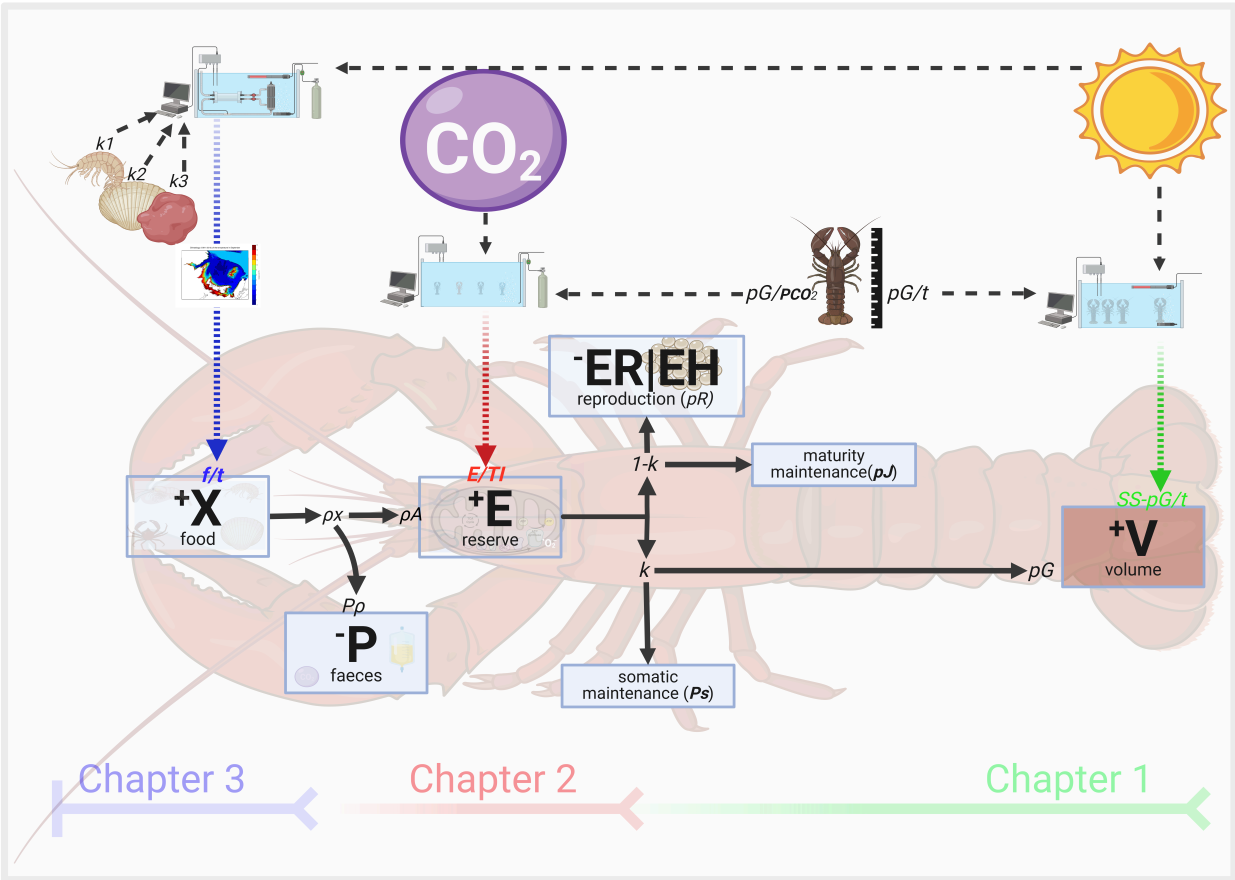
Abstract

The application of experimental observations to predict physiological states in the field is critical and gaining momentum due to the ongoing impact of climate change. The American lobster, *Homarus americanus*, is an economically and ecologically important fishery resource for the Gulf of St. Lawrence (GSL), Canada. Their bentho-pelagic and eurythermal life-cycle facilitates their distribution despite exposure to current temperature gradients in the GSL. The warming-induced latitudinal shift in *H. americanus*' distribution was positive for the Gulf but may also harm the fisheries disproportionately. The goal of this research is to use temperature response experiments to discern variations in the physiology and behaviour of *H. americanus* so that uncertainties about the ongoing warming effect are minimized. To do so, the Scharpe-Schoolfield and Arrhenius temperature response equations were fitted to experimental data acquired from GSL-acclimated individuals and were separately incorporated into the DEB framework for a 30-year period using GSL temperatures. The Carapace Length for both models was compared with the parameterized DEB model without accounting for temperature effects, a standalone cumulative sum of growth rates from the Scharpe-Schoolfield growth rate estimation, and a tag-based mark and recapture data of *H. americanus* over the same area and time in the GSL to identify which methods best represent the physiological response to temperature in the GSL. These methods can be tailored to estimate area-specific temperature-based performance, to include other environmental effects, and, most importantly, to create Hovmöller-type figures that reveal variation in performance as environmental gradients evolve.

Keywords: DEB, Scharpe Schoolfield, Arrhenius, cumulative sum, H. americanus

*Speaker


k1
k2
k3
f/t
CO2
pG/PCO2
pG/t
E/TI
ER|EH
reproduction (pR)
maturity
maintenance(pJ)
1-k
X
food
ρx
ρA
E
reserve
k
pG
SS-pG/t
V
volume
Pp
P
faeces
somatic
maintenance (Ps)
Chapter 3
Chapter 2
Chapter 1

A full life cycle Dynamic Energy Budget (DEB) model for Peruvian anchovy Engraulis ringens in the northern Humboldt Current system (NHCS) with a focus on early-life history traits

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Abstract

The environmental conditions of the northern Humboldt Current system (NHCS) are highly variable and remain uncertain in the context of climate change. It is essential to understand how these environmental conditions affect the life history traits the Peruvian anchovy (Engraulis ringens), a keystone species, and the world's most valuable fish stock species. To do so, we have developed the first comprehensive dynamic energy budget (DEB) model for Peruvian anchovy, describing its development, growth and reproduction in response to temperature and food availability. Model parameters were estimated using larval length growth data from laboratory experiments at different temperatures, von Bertalanffy growth curves for juveniles and adults, and batch fecundity data. The model accurately reproduced observed growth patterns in length and weight of larvae, juveniles and adults, as well as

*Speaker

the ages and sizes at developmental transitions between life stages. We were particularly interested in early-life stages in terms of growth and survival under food deprivation and as a function of temperature, as the model was integrated into a Lagrangian drift model to simulate recruitment variability.

Keywords: DEB model, growth acceleration, larval shape correction function, Engraulis ringens

A Dynamic Energy Budget (DEB) model of anchovy (Engraulis ringens) growth and reproduction in the southern Humboldt ecosystem

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Abstract

The Dynamic Energy Budget (DEB) model describes energy flow in individual organisms, integrating food assimilation, maintenance, growth, development, and reproduction as functions of environmental factors such as temperature and food availability. Recently, it has been successfully applied to the Peruvian anchovy *Engraulis ringens* in the northern Humboldt ecosystem, providing insights into biological processes across different life stages. In this study, we developed a DEB model for anchovy in the southern Humboldt, where this neritic species plays a crucial ecological and economic role. The model enhances understanding of how environmental variability influences development and survival during the embryo and larval stages, as well as growth and reproduction during the juvenile and adult stages, essential for assessing spatiotemporal population responses in a changing environment.

Additionally, this model enables the investigation of local adaptation in small pelagic fish. Given the species' wide latitudinal distribution, from a permanent tropical upwelling system in the north to a seasonal subantarctic river-influenced upwelling system in the south, populations are expected to differ in thermal ranges and reproductive timing. Comparing DEB parameters between these populations may reveal local adaptation in other physiological traits.
The model was calibrated using experimental and long-term biological monitoring data to estimate core parameters and examine the effects of environmental conditions on energy allocation for growth and reproduction. Finally, we demonstrate its integration with a Lagrangian larval drift model as a mechanistic approach to studying early-life survival and recruitment variability under changing food supply and temperature conditions.

Keywords: Anchovy, Engraulis ringens, southeastern Pacific, local adaptation, DEB model

*Speaker

Forecasting impacts of ocean acidification and warming (OAW) on Abalone growth and reproduction: A dynamic energy budget approach for contrasting climate scenarios.

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Abstract

In the face of ongoing global climate change, understanding the impacts of ocean warming (OW) and ocean acidification (OA) on marine biodiversity has become crucial. This study introduces a novel Dynamic Energy Budget (DEB) model for mollusks, focusing on the European abalone, to mechanistically predict the effects of OW and OA on their growth and reproduction under different Shared Socioeconomic Pathway (SSP) scenarios and varying food quality levels. The model incorporates high-frequency empirical data on sea surface temperature (SST), pH, four European coastal locations, in addition to food availability, with future projections extending to 2100. Algal biomass data were analyzed using Fourier transforms to capture seasonal food availability patterns, while SSP-based projections of SST and pCO2along with reduced food quality quantity levels were used to simulate daily environmental conditions over time. Key findings reveal that while abalone length remains relatively unchanged across different locations and climate scenarios when food quality is high, significant effects are observed on weight ($p < 0.05$) and reproductive performance under low food quality conditions. The gonadosomatic index ($p < 0.001$) shows marked declines, with fewer spawning events and a shorter spawning season projected by the end of the century under climate change scenarios. These results suggest that abalone might experience reduced body weight and reproductive output in future food quality deprived ocean conditions, underscoring their vulnerability to environmental stressors. The DEB model provides a robust framework for predicting biological responses and emphasizes the urgent need for adaptive strategies in marine conservation and aquaculture management as ocean conditions change.

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Keywords: Ocean warming (OW), Ocean acidification (OA), Dynamic Energy Budget (DEB) model, European abalone, Shared Socioeconomic Pathways (SSP)

Integrating AI and DEB-otolith models for enhanced fish age and growth estimation

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Abstract

Accurate fish age and growth estimates are crucial for understanding population dynamics and ensuring sustainable fisheries management. Traditional methods involve manual interpretation of otolith structures, which is time-consuming and prone to inter-reader variability and misinterpretation. Artificial intelligence (AI), particularly deep learning, has emerged as a promising tool for automating otolith image analysis, improving efficiency, and reducing subjectivity. However, we foresee several limitations that may still lead to uncertainty in fish age and growth: (i) AI-based approaches primarily rely on statistical correlations and may overlook key physiological and environmental mechanisms underlying otolith growth and opacity; (ii) they are trained on datasets that may contain errors.

To address these limitations, we propose a hybrid approach that combines AI-driven otolith analysis with an existing DEB-otolith model, which integrates temperature- and metabolically dependent biomineralization processes. First, AI extracts growth parameters from otolith images and flag cases with high uncertainty. For uncertain cases, we extract grayscale variations along a transect of the otolith. The DEB-otolith model then reconstructs fish age and growth that best reproduce these grayscale variations, reducing AI prediction uncertainty.

As a first step, we will simulate synthetic otolith under controlled environmental conditions to assess how DEB modeling can improve AI-derived estimates. This methodological framework lays the foundation for a mechanistic integration of AI and DEB modeling, providing a biologically coherent approach to fish age and growth estimation. Future research will focus on validating this approach with real otolith datasets and assessing its applicability across different species and ecological contexts

Keywords: Fish Age and growth Estimation, Dynamic Energy Budget theory, Otolith Analysis, Artificial Intelligence, DEB, otolith model, Fisheries Management

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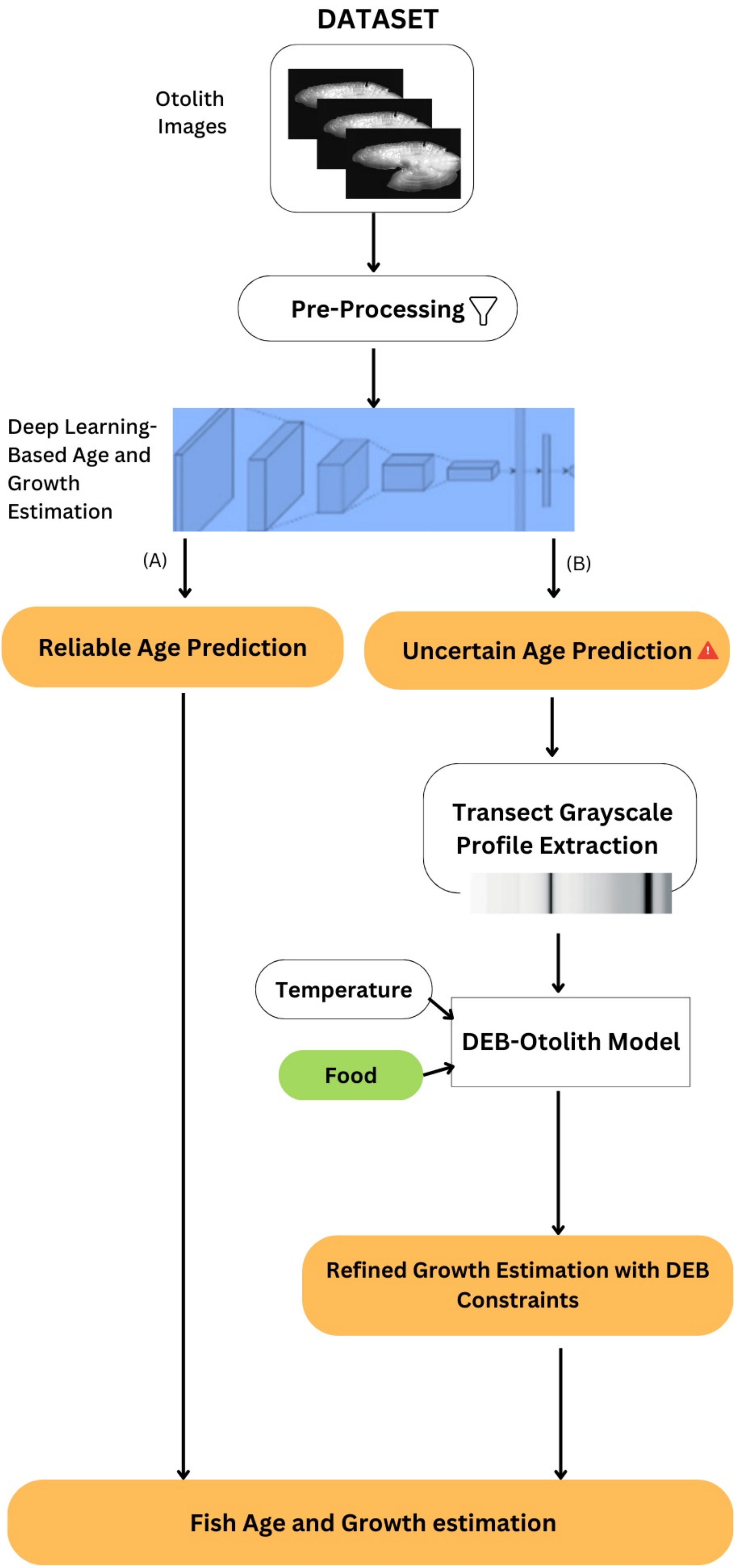
DATASET
Otolith Images
Pre-Processing
Deep Learning-Based Age and Growth Estimation
(A)
(B)
Reliable Age Prediction
Uncertain Age Prediction
Transect Grayscale Profile Extraction
Temperature
Food
DEB-Otolith Model
Refined Growth Estimation with DEB Constraints
Fish Age and Growth estimation

Applying a DEBkiss Model to Acartia tonsa to Predict Physiological Responses to Environmental Stress

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Abstract

Acartia tonsa is a key marine copepod species, crucial in trophic dynamics and ecosystem functioning. It is also commercially significant as a live feed in aquaculture. While Dynamic Energy Budget (DEB) models have been applied to some copepod species, *A.tonsa* has not yet been explicitly modeled. Unlike some copepods, *A.tonsa* lacks lipid reserves but follows the typical molting sequence from nauplius to copepodite to adult, and a lack of growth after reaching adulthood. To investigate *A.tonsa*'s physiological responses to environmental stressors and assess the suitability of a DEB framework, we collected metabolic data from literature. We conducted experiments on respiration rates at temperatures exceeding the species' upper thermal limit. Results demonstrated that respiration rates increased with temperature up to an optimum, then declined, indicating thermal stress. Given the need for a simplified but effective modeling approach that takes into consideration the unique development of copepods, we applied the DEBkiss model, which has been previously used for copepods. Our findings indicate that DEBkiss captures the metabolic trends observed in *A.tonsa*, providing a valuable tool for predicting its responses to environmental change. This work enhances our understanding of copepod physiology under stress and supports the use of DEB models for future ecological and aquaculture applications.

Keywords: Acartia tonsa, DEB model, thermal stress, respiration, copepod ecology

*Speaker

Reconstructing environmental trajectories by combining growth and chemical information

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Abstract

In many fish species, and particularly in migratory species, monitoring the environmental conditions experienced by an individual during its life remains a challenge. However, it is essential to identify the causes of declines in population size and individual condition. Calcified pieces (vertebrae, otoliths, scales) constitute a valuable record, but they integrate the many sources of variation, particularly metabolic, which are often difficult to disentangle. Our aim is to use chemical and micro-chemical data to complement existing reconstruction approaches based on the growth of calcified pieces to improve our ability to distinguish the effects of different types of stress (thermal, hypoxic, metabolic) on these pieces. This requires a complementary model of elemental (such as Mg, Mn, P, Zn) and isotopic variations in otoliths. The main challenge comes from the fact that chemical and microchemical markers provide semi-quantitative information, reliable for tracing relative variations but more difficult to transpose into absolute values between different species or even populations. The performance of this model should be evaluated on the basis of chemical and environmental datasets. As a first step, we conducted preliminary analyses on samples of eels (*Anguilla anguilla*) from Mediterranean lagoons for which environmental conditions (temperature and oxygen concentration) are measured at high frequency and on salmon subjected to controlled emersion stress in experimental conditions. This will evaluate our capacity to detect acute environmental stresses (temporal resolution) as well as our capacity to distinguish intense acute stress from more moderate chronic stress (discrimination).

Keywords: environmental reconstruction, bones, acute stress

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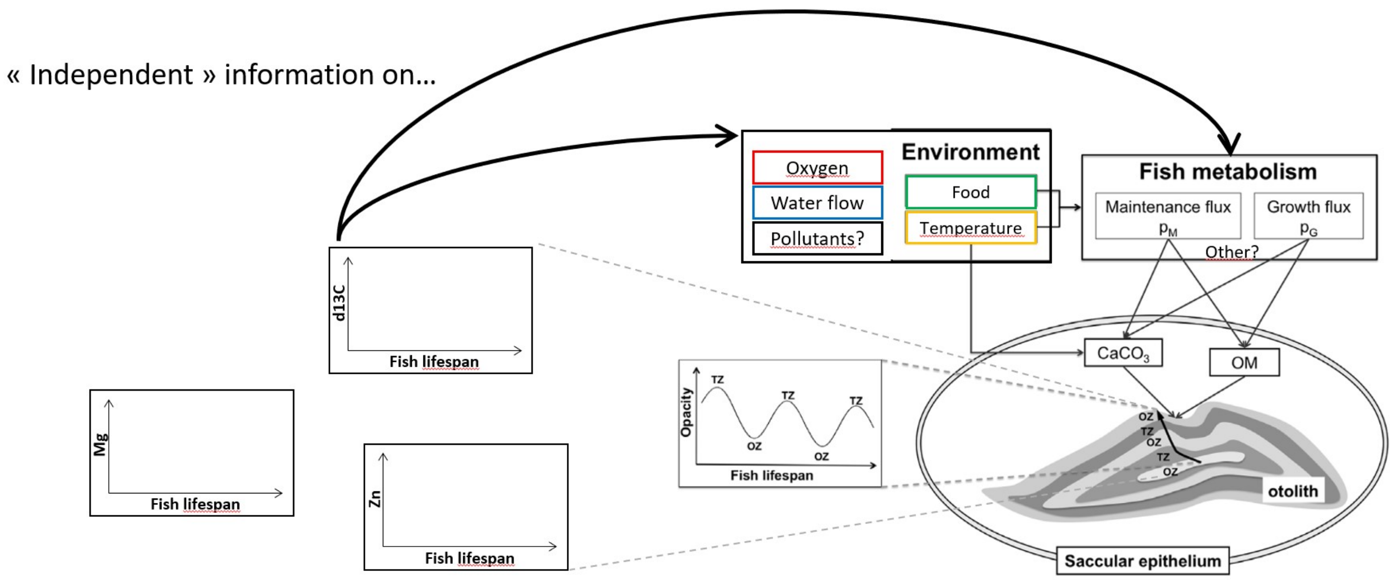

« Independent » information on…
Environment
Oxygen
Water flow
Pollutants?
Food
Temperature
Fish metabolism
Maintenance flux
p_M
Growth flux
p_G
Other?
$CaCO_3$
OM
d13C
Fish lifespan
Mg
Fish lifespan
Zn
Fish lifespan
Opacity
TZ
OZ
Fish lifespan
otolith
Saccular epithelium

Dynamic Energy Budget model predicts physiological traits in polymorphic species

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Abstract

The prawn species *Macrobrachium amazonicum*, Heller 1862 (Decapoda: Caridea), exhibits polymorphism, resulting in different morphotypes with distinct physiological traits. This species has great importance in aquaculture and occurs in two major wild populations-continental and coastal-both exhibiting high individual diversity. Understanding the mechanisms driving this intraspecific growth variability is crucial. The Dynamic Energy Budget (DEB) theory is applied here to investigate the different physiological traits of *M. amazonicum*. Two DEB models were developed for each morphotype: one with varying assimilation rates and another with different somatic maintenance costs. These models were parameterized with weight and length data from the literature and used to simulate physiological characteristics such as mass gain, daily growth, ingestion, feces, excretion, and respiration rates. Both models exhibited similar patterns, though at different rates, when compared with experimental data. The morphotype-specific somatic maintenance model aligned more closely with experimental findings. We demonstrate that growth-based models can yield reasonable estimates for other physiological traits. This research aims to provide insights into intraspecific growth variability and physiological diversity in *M. amazonicum* using the DEB theory. Unraveling these underlying mechanisms improves our understanding of this species' polymorphism.

Keywords: Polymorphism, Calorimetry, Macrobrachium amazonicum

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