FACULTY OF BIOSCIENCE ENGINEERING

Harpacticoid copepods in risk assessment - Combining life cycle experiments with population modeling

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Introduction

- Better methods are needed to predict **population level risks**
- Combining **life cycle experiments and population modeling** can help
- Calibrating **mechanistic effect models for individuals** is a first step to develop accurate population models
- **Copepods** are an ideal test system:
  - Largest animal biomass on earth (estimate)
  - Small size
  - Easy lab culture and handling

Materials & Methods

Life cycle experiments

- Experimental setups were based on the OECD guidance document [1] for harpacticoid copepod life cycle testing

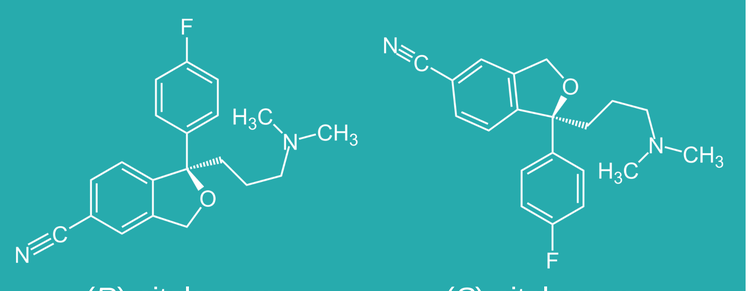
Test species: *Nitocra spinipes*

- Sexual reproduction
- Brackish water habitats
- Worldwide distribution
- Test species since 70s

- Test temperature: 22 °C
- Food source: *Rhodomonas salina* (2.5 × 10^5 cells/mL)

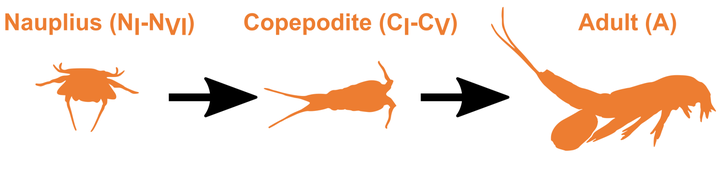
Test compound: Citalopram

- Selective serotonin re-uptake inhibitor (antidepressant)



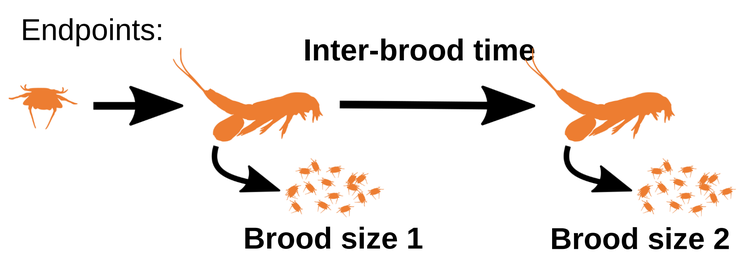
Development test (31 days)

Endpoints:



Reproduction test (35 days)

Endpoints:



Model approach

Dynamic Energy Budget (DEB) theory approach

- Generic model with a **mechanistic** quantification of **energetic processes**
- Useful to identify a chemical's **mode of action (MoA)** on energy allocation
- Integrates **combined effects** of chemical stressors and environmental factors

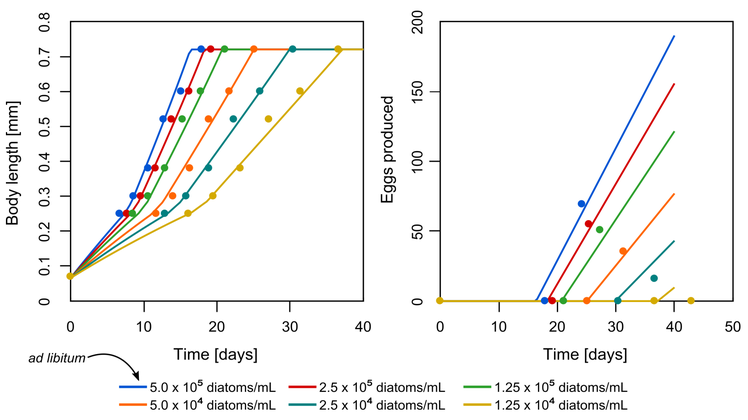


Fig. 1: DEBKiss (*'Keep it simple, stupid')* model [2] calibrated on development and reproduction data of *N. spinipes* at six food levels [3].

Results & Discussion

Development test

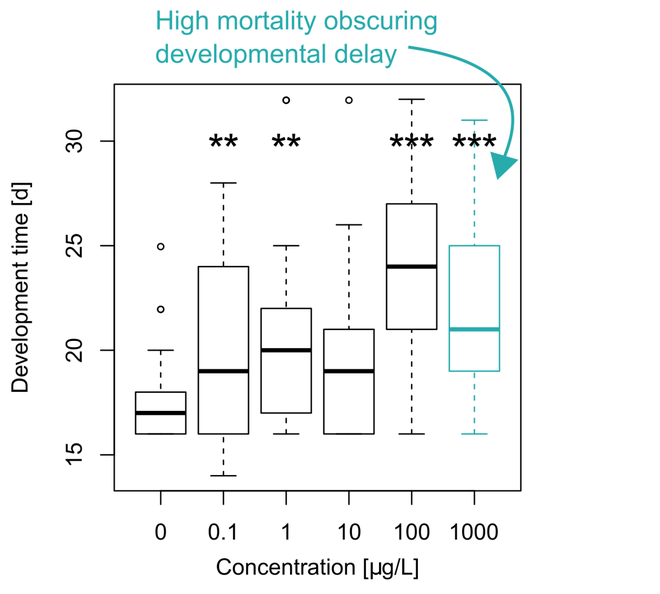


Fig. 2: Development time from nauplius to adult. Data were analyzed in one-way ANOVA with a one-sided Dunnett's test (***p < 0.001 **p < 0.01 *p < 0.05).

- **Developmental delay** already at 100 ng/L (environmentally relevant)
- Stronger effects at and above 100 µg/L

Reproduction test

- No effects on **inter-brood time**

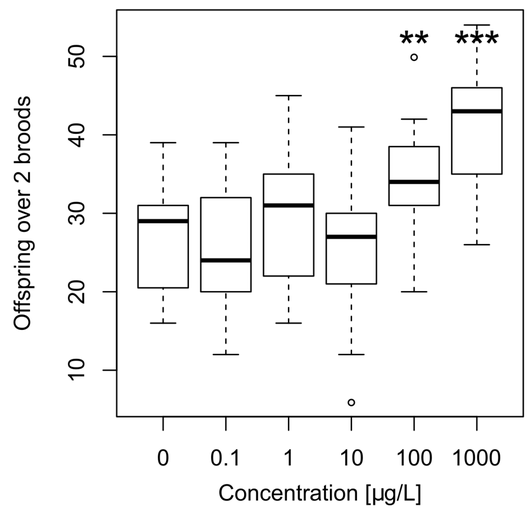


Fig. 3: Offspring over two broods per female. Data were analyzed in one-way ANOVA with a one-sided Dunnett's test (***p < 0.001 **p < 0.01 *p < 0.05).

- **Stimulation effects** at and above 100 µg/L

Identification of DEB-MoA

- Presence of two individual MoAs likely:

(a) Effect on growth costs

(b) Effect on reproduction costs

- Stress function with shared parameters

$$s = \frac{1}{c_T} \times \max(0, c_V - c_0)^{\,a}$$

s = Stress factor on MoA parameter
c_0 = No-effect concentration
c_T = Tolerance concentration
a = Slope parameter
c_V = Scaled internal concentration

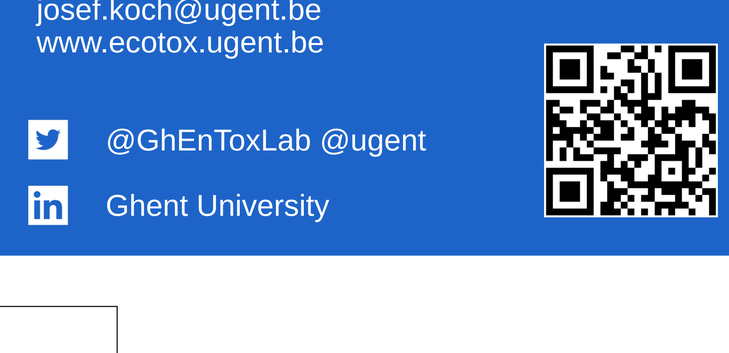


Fig. 4: DEBKiss model fits for observed effects.

Conclusions

- Development delayed at 100 ng/L
- Stimulation of egg production at 100 µg/L
- DEBKiss allowed for effect identification of MoAs on energy allocation

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References

[1] OECD. New Guidance Document on Harpacticoid Copepod Development and Reproduction Test with *Amphiascus*. Environmental Health and Safety Publications. Series on Testing and Assessment No. 201. Env/Jm/Mono(2014)17. Paris. 2014.

[2] Jager T, Martin BT, Zimmer EI. DEBkiss or the Quest for the Simplest Generic Model of Animal Life History. J Theor Biol. 2013;328: 9-18.

[3] Koch J, Bui TT, Lundström Belleza E, Brinkmann M, Hollert H, Breitholtz M. Temperature and Food Quantity Effects on the Harpacticoid Copepod *Nitocra spinipes*: Combining *in Vivo* Bioassays with Population Modeling. PLOS ONE. 2017;12(3): e0174384.

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