Simulating *Daphnia* population dynamics in a mesocosm experiment with a size-structured model

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The *Daphnia* population growth model

- Escalator Boxcar Train Model  ➔ age- and size structured (Rinke & Vijverberg 2005)

- Individual based model integrated via Escalator boxcar train into population model

- Energy allocation rules: (Kooijman 2001)

\[
M + \frac{dW}{dt} + \frac{dR}{dt} = A
\]

![Diagram of energy allocation](image)

- Driving factors: temperature and food conditions of the mesocosm experiments
Mesocosm Experiment 2005

Berger et al. 2007, Oecologia

Figure: S. A. Berger (modified)
Application of the *Daphnia* model to enclosure conditions

![Graph showing the application of the Daphnia model to enclosure conditions](image)

- **ambient**
- **cold**

**Daphnia [Ind. L⁻¹]**

Days after starting the experiment [d]

<table>
<thead>
<tr>
<th>Depth (m)</th>
<th>1</th>
<th>21</th>
<th>41</th>
<th>61</th>
</tr>
</thead>
<tbody>
<tr>
<td>ambient</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>cold</td>
<td></td>
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</tbody>
</table>
Size class distribution

exponential growth phase = increase in juveniles
Simulation results after peak

Days after starting the experiment [d]

Daphnia [Ind. L^{-1}]

ambient
cold

2m

4m

8m
Sensitivity of the model to the estimate of carbon from field measurements

Days after starting the experiment [d]

Daphnia [Ind. L⁻¹]
Size class distribution after peak

- Daphnia abundance [Ind. L⁻¹]
- Algae [mg C L⁻¹]
- Days after starting the experiment [d]
- Length [mm]
**Size class distribution after peak**

**Energy allocation**

\[
\begin{align*}
\frac{dW}{dt} &= \kappa A - M \\
\frac{dR}{dt} &= (1 - \kappa) A
\end{align*}
\]

at starvation:

\[
\begin{align*}
\frac{dW}{dt} &= 0 \\
\frac{dR}{dt} &= A - M
\end{align*}
\]
Size class distribution after peak

Energy allocation at starvation

\[
\frac{dW}{dt} = 0 \quad \frac{dR}{dt} = A - M
\]

closechange:

\[
\frac{dW}{dt} = A - M \quad \frac{dR}{dt} = 0
\]
Changing energy allocation

Daphnia length class abundance [Ind. L⁻¹]

Length [mm]

Days after starting the experiment [d]

Algae [mg C L⁻¹]
Summarize and conclusions

• **Results until peak:** good simulation (Abundance and size distribution)
  - The model can describe *Daphnia* population growth phase reasonably well
  - Differences in conditions (Temperature & Food) lead to different model outputs

• **Problems after peak** (starvation conditions):
  - Deviations during population decline
  - Size class distribution

• **Solution**
  - Approach: changing energy allocation during low food conditions
Thanks for your attention!

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