FACULTY OF BIOSCIENCE ENGINEERING

Investigating metabolic acceleration in dynamic energy budget models of copepods

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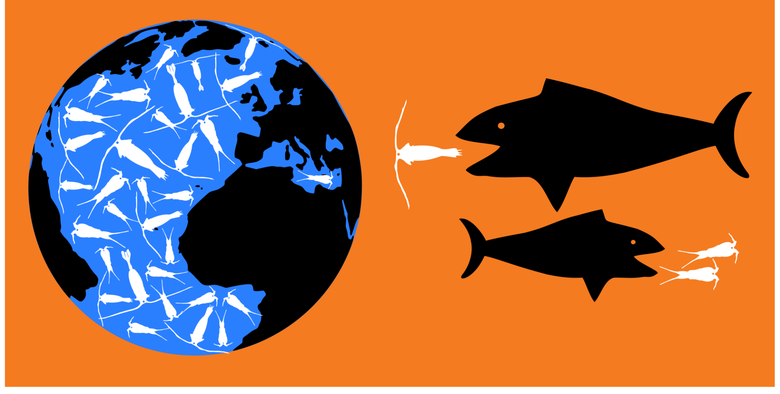
Introduction

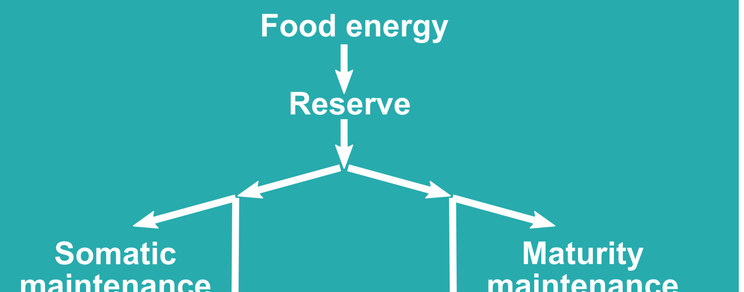
Copepods

- Potentially largest animal biomass on earth
- Important as prey for fish (trophic link)
- Small size ➔ easy lab culture & tox testing



Dynamic energy budget (DEB) models

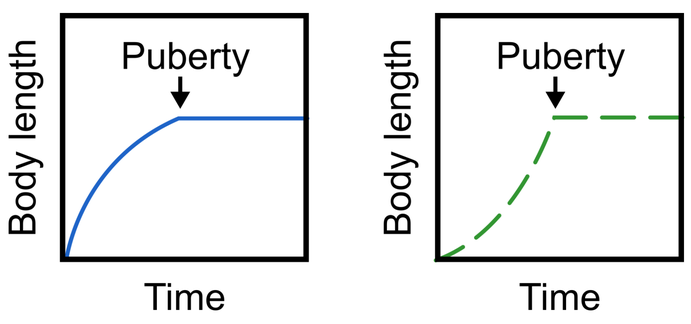
- Life history models for individuals
- Explain stress effects mechanistically



Copepods in DEB

*Life history: 6 **naupliar** & 6 **copepodite** stages*

- No growth after puberty
- Two hypotheses on growth behavior:



sbp

Standard (von Bertalanffy) growth from **b**irth to **p**uberty

Assimilation rate scales with squared body length

abp

Metabolic **a**cceleration from **b**irth to **p**uberty

Assimilation rate scales with cubed body length

Which model is most accurate?

Materials & Methods

Test species: *Nitocra spinipes*

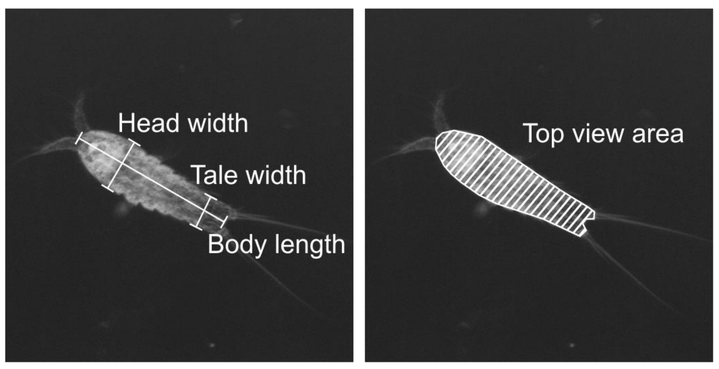
- Harpacticoid brackish water copepod
- Ecotoxicological test species* since 1970s
- New to DEB ▪ No parameters available

Nauplius **Copepodite** **Adult**

* OECD ENV/JM/MONO(2014)17 Life history toxicity test
ISO 14669:1999 Acute lethal toxicity test
ISO/TS 18220:2016 Larval development test

Growth-vs.-time experiment

- Synchronized culture of neonates (< 6 h)
- 28 days ▪ 10-20 animals per measurement
- Body length ▪ Body widths ▪ Top view area



Other data

	Control cond.	Food effects	Temp. effects
Development time	✓ [1]	✓ [1]	✓ [1]
Reproduction rate	✓ [1]	✓ [1]	✓ [1]
Longevity	✓ [2]		
Dry weight density	✓ [3]		
Respiration rate	✓ [4]		

Parameter estimation

- Software package DEBtool in Matlab
- Nelder-Mead method
- sbp and abp optimized independently

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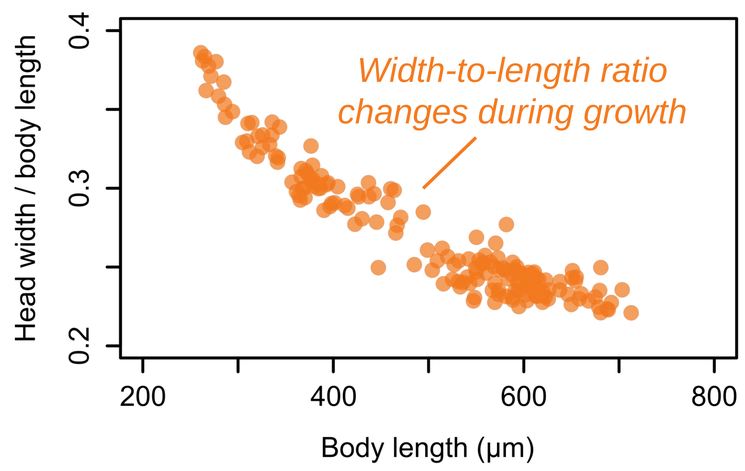
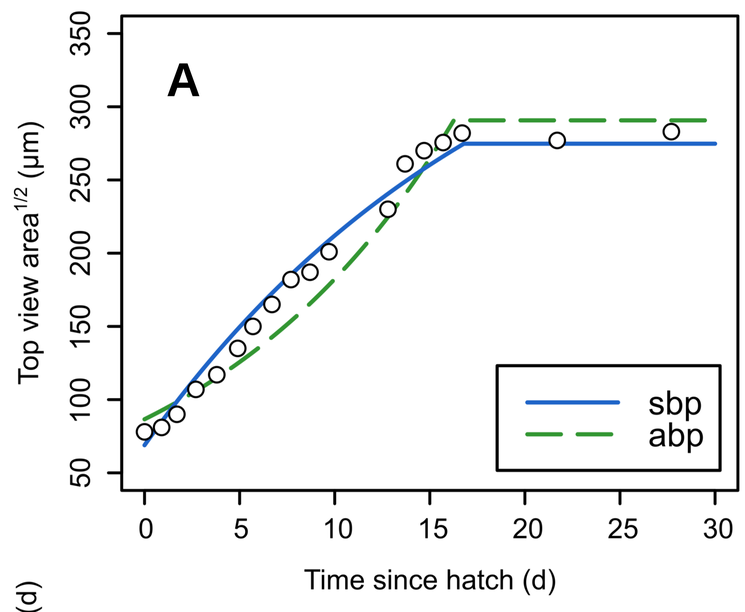
Results & Discussion

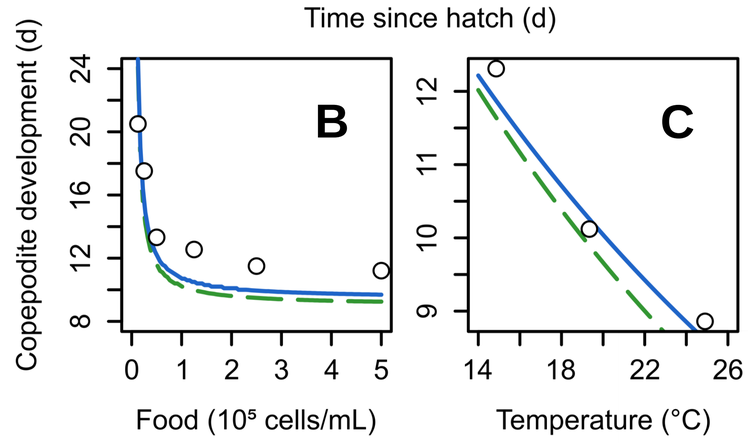
Body length ∝ structural volume$^{1/3}$?



… No! Bad approximation.

- Body proportions change (no isomorphy)
- Better: Top view area$^{1/2}$ ∝ structural volume$^{1/3}$
  - ❖ Integrates changes in length vs. width





- Both models give good predictions for:
  - **A**: Length (top view area$^{1/2}$) vs. time
  - **B**: Development time vs. food quantity
  - **C**: Development time vs. temperature

Conclusions

Both models are equally accurate!

- More data needed to identify “true model”
- Both models may be useful in various approaches (e.g. individual-based models)
- Our code [5] can serve as a template to calibrate DEB models for other copepods

References

[1] Koch, J., et al. 2017, PLoS ONE. 12(3): p. e0174384.
[2] Uye, S. 1988, Hydrobiologia. 167(1): p. 285-293.
[3] Goodman, K.S. 1980, Hydrobiologia. 72(3): p. 253-259.
[4] Herman, P.M.J. & C. Heip 1983, J. Exp. Mar. Biol. 71(3): p. 249-256.
[5] Koch, J. & K.A.C. De Schamphelaere 2018, J. Sea Res. DOI: https://doi.org/10.1016/j.seares.2018.02.003

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