Baseline energy-budget model for the marine copepod *Calanus finmarchicus*

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Scope

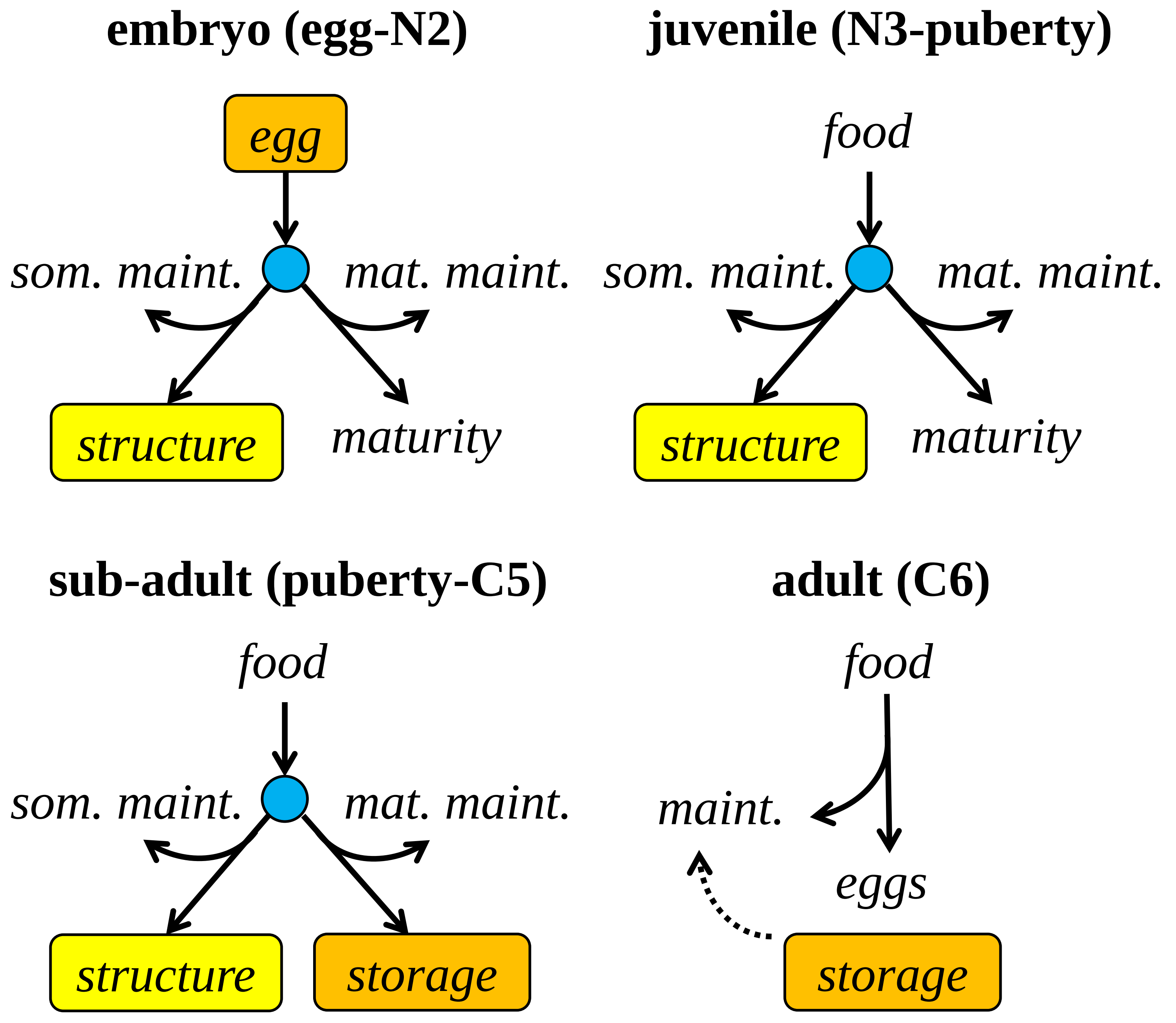
Copepods form an important part of the marine zooplankton. Interpreting and predicting the effects of stressors on their life histories requires mechanistic models. Dynamic Energy Budget (DEB) models are well suited for this task. Copepods, however, pose some specific challenges for generic energy-budget models:

- development through 6 naupliar, followed by 6 copepodite, stages,
- build up of lipid storage (oil sac) in the later copepodite stages,
- rather abrupt stop of growth after the final moult to adulthood.

Here, we present a baseline energy-budget model for *Calanus finmarchicus*, calibrated using literature data.

Model structure

The generic DEBkiss model (Jager *et al.*, 2013, 2015) was taken as starting point. The life cycle is divided into 4 stages (Fig. 2); the adult stage follows a modified allocation scheme. From juvenile to adult, the maximum assimilation rate was stepped-up (metabolic acceleration) to accommodate the observed increase in growth rate. Lipid storage was treated as a 'reproduction buffer'.



embryo (egg-N2)
egg
som. maint.
mat. maint.
structure
maturity

juvenile (N3-puberty)
food
som. maint.
mat. maint.
structure
maturity

sub-adult (puberty-C5)
food
som. maint.
mat. maint.
structure
storage

adult (C6)
food
maint.
eggs
storage

Fig. 2. Schematic representation of energy allocation over the copepod life cycle. The blue circle represent the 'κ-rule'.

Calibration data

Data for growth and development were taken from Campbell *et al.* (2001). These authors report N (proxy for structure) and C content (proxy for structure plus storage) over the life cycle at different temperatures and food levels. All data fitted simultaneously.

Conclusions

The modified DEBkiss model provides a useful platform to study the life history of marine copepods. It can aid interpretation of stressor effects, and predict their consequences under realistic environmental conditions. Several key questions remain; more extensive experimental work is currently undertaken in the ENERGYBAR project to develop, test and parameterise the model.

Photo: Dag Altin, BioTrix

Fig. 1. Calanus finmarchicus, with clearly visible oil sac.

Model calibration

As illustration, a small part of the data set is shown in Fig. 3, with the corresponding model fit. The model is able to capture the growth pattern over the life cycle, as well as the effect of food limitation on growth, development and storage.

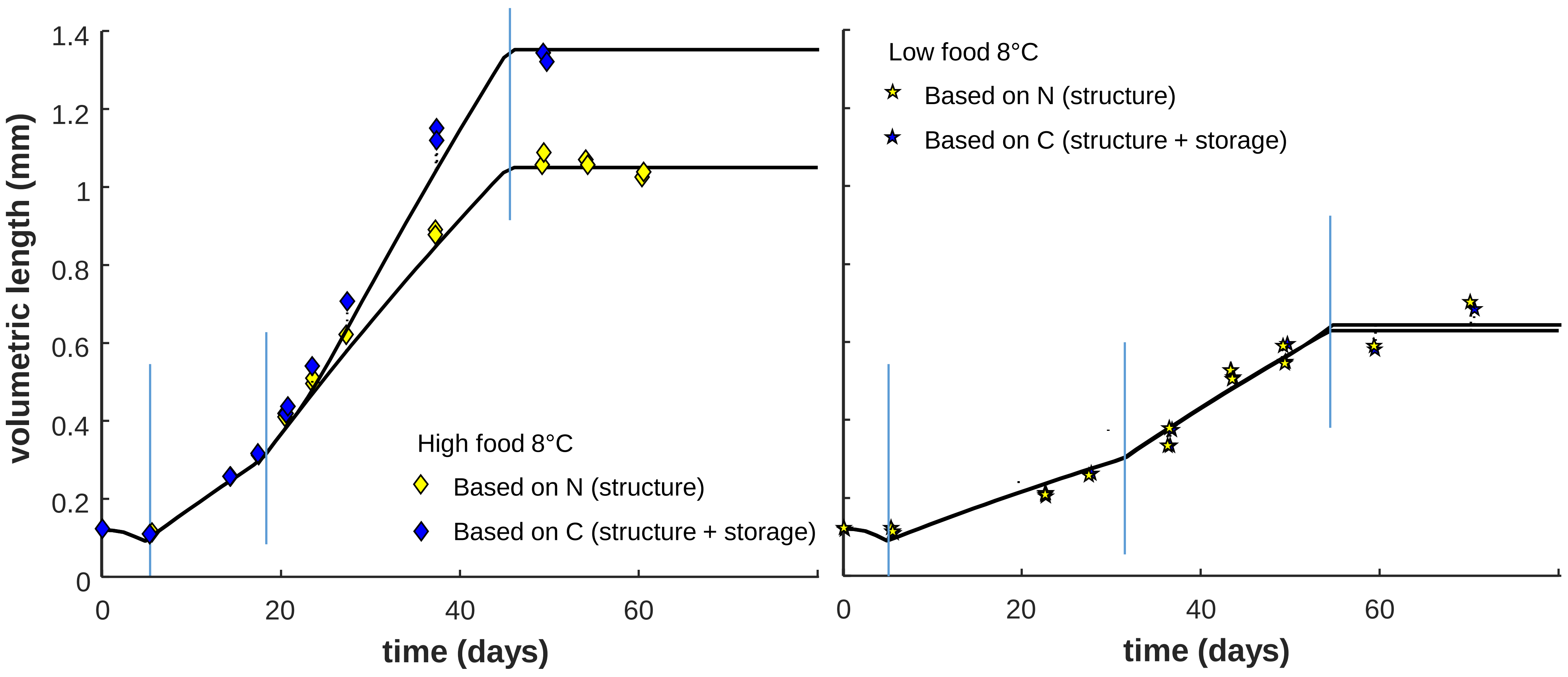


Fig. 3. Body length based on C and N content versus age at two food levels. Vertical lines demarcate the 4 stages of Fig. 2. Puberty coincides with start C2.

Model prediction

Fig. 4 shows literature data and model predictions for filtration and reproduction rate. Left panel indicates that the proposed step-up in feeding rate is consistent with observations. Right panel shows that storage is likely used to cover maintenance costs during reproduction.

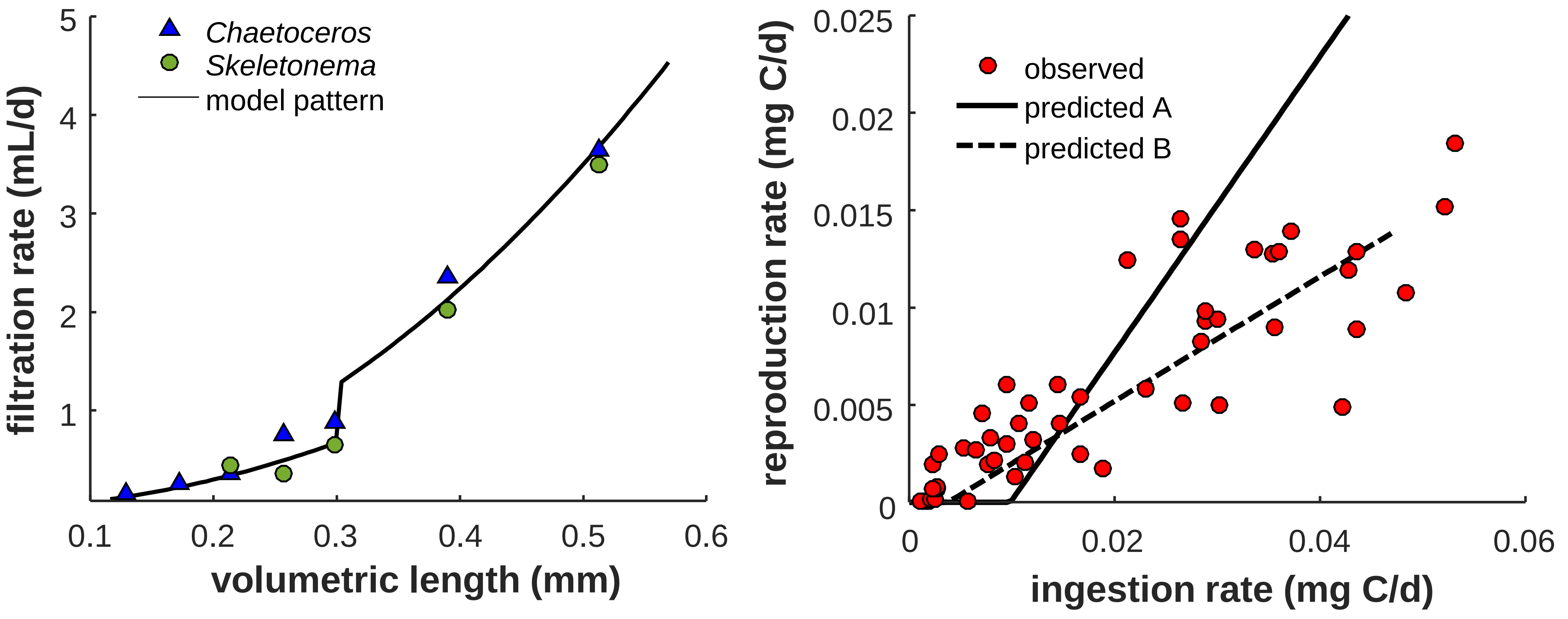


Fig. 4. Filtration vs. body length (left) and two predictions for reproduction (right): A) eggs from assimilates after paying all maintenance costs, and B) eggs produced from assimilates after paying maturity maintenance only, and with a reduced efficiency.

References

Campbell *et al.* (2001). MEPS 221:161-183.
Jager *et al.* (2013). J. Theoret. Biol. 328:9-18.
Jager *et al.* (2015). Ecol. Model. 299:114-120.

Acknowledgements

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