IMPLEMENTING REALISTIC BIOLOGICAL VARIABILITY INTO AN INDIVIDUAL-BASED DEB MODEL FOR COPEPODS

Josef Koch, DEB2019 Symposium, 12 April 2019
WHY COPEPODS?

– Highly abundant in global oceans
– Largest animal biomass on earth?
– Essential in marine food webs

Nitocra spinipes
LIFE HISTORY

- 6 naupliar stages
- 6 copepodite stages
- Sexual reproduction
INDIVIDUAL-BASED DEB MODEL

Purpose:
Extrapolation of individual-level (toxic) effects to populations
BIOLOGICAL VARIABILITY

- Drives desynchronization of populations
- Increases resilience to stress and environmental changes
- Is key to evolution
- Generally treated as measurement error in parameter estimation
- Some DEB-IBMs include variability but it is chosen rather arbitrarily
ESTIMATING VARIABILITY

- **DEB parameter(s)**
  - Start with a default variability term

- Run Monte Carlo simulations

- Simulated data
  - Loss function: Difference between distributions
    - $(1 - \text{KS test statistic})$

- Measured data

- Adjust variability term in parameters to minimize loss function
CHALLENGES

- Variation in all parameters?
- Covariation?
- Distribution types unknown

➢ Find one-parameter solution

DEB parameters

\[ \nu, \kappa \]

\[ [\dot{p}_M] \]

\[ \{ \dot{F}_m \} \]

\[ \{ \dot{p}_{Am} \} \]

\[ \{ \dot{p}_T \} \]

\[ E^b_H \]

\[ E^j_H \]

\[ E^p_H \]

\[ \kappa_X \]

\[ [E_G] \]

\[ \kappa_R \]

\[ \dot{k}_J \]
MEASURED DATA

Copepodite development time (relative to mean)

n = 610

Brood size (relative to mean)

n = 182
GLOBAL SENSITIVITY ANALYSIS

First order effect indices:

\[ S_i = \frac{V_{X_i}(E_{X_i}(Y | X_i))}{V(Y)} \]

\[ \{ \hat{p}_{Am} \} > \kappa > [\hat{p}_M] > E_H^x > [E_G] > v \]
BEST RESULT \[ \{ \hat{p}_{Am} \} \] \[ \text{cv} = 0.18 \]

Simulation

Measured Data

Copepodite development time

Brood size

\[ n = 10^6 \]

\[ n = 10^6 \]

\[ n = 610 \]

\[ n = 182 \]
CONCLUSIONS

- Variability in DEB parameters can be estimated from experimental data using Monte Carlo simulations
- Distribution types unknown $\Rightarrow$ assumptions must be made
- Fitting variability terms to multiple DEB parameters requires extensive control data sets and computation
- Adding variability to just one parameter can already provide a good approximation of observed variation in real data
  … if the right parameter and probability distribution are selected

YOU MUST CHOOSE...

BUT CHOOSE WISELY.
Thank you for your attention

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