FACULTY OF BIOSCIENCE ENGINEERING

LABORATORY OF ENVIRONMENTAL TOXICOLOGY AND AQUATIC ECOLOGY
Environmental Toxicology Unit: GhEnToxLab

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

Josef Koch, DEB2019 Symposium, 12 April 2019

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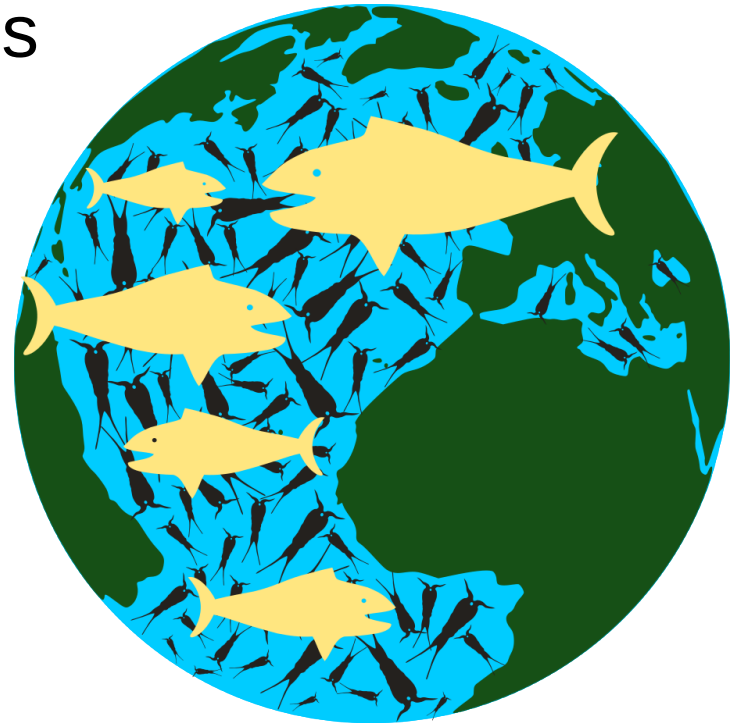
WHY COPEPODS?

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

Nitocra spinipes



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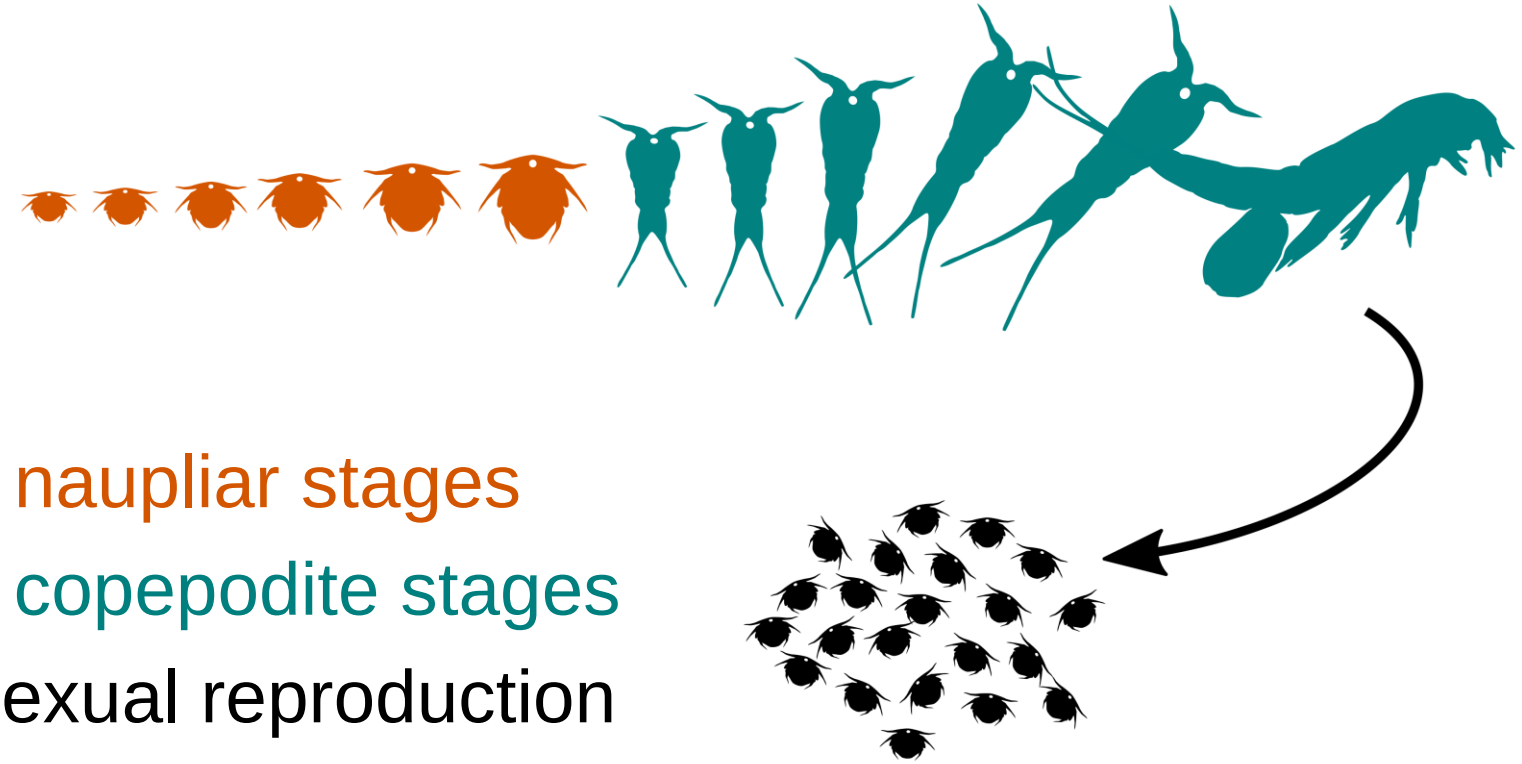
LIFE HISTORY

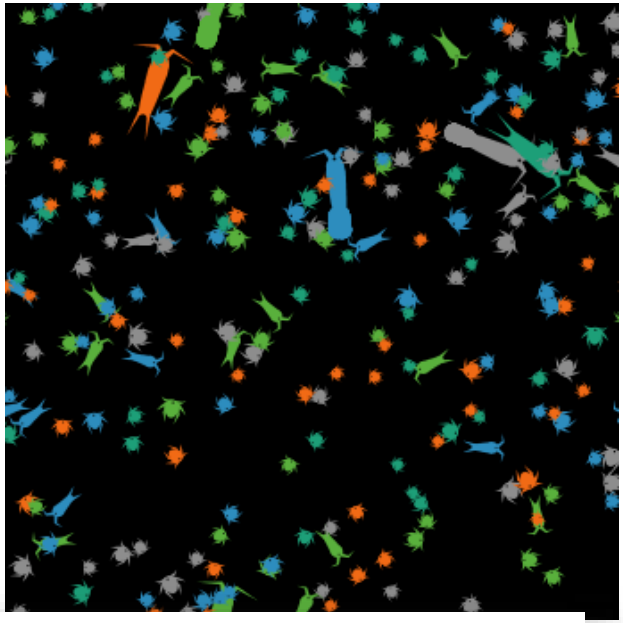


- 6 naupliar stages
- 6 copepodite stages
- Sexual reproduction

INDIVIDUAL-BASED DEB MODEL

Purpose:

Extrapolation of individual-level (toxic) effects to populations



DEB

DEB CONTEXT COLLECTION APPLICATIONS

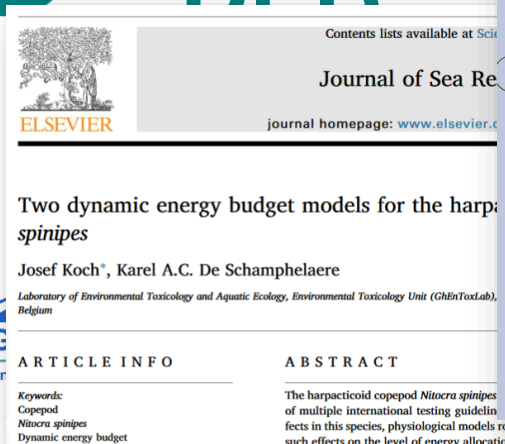
Nitokra_spinipes (Copepod): Results Code Links

Parameter values for this entry

Model: abp

Primary parameters at reference temperature (20 deg. C)			
symbol	**value**	**units**	**description**
T_A	3059.96	K	Arrhenius temperature
p_Am	15.8588	J/d.cm^2	{p_Am}, spec assimilation flux
F_m	6.5	l/d.cm^2	{F_m}, max spec searching rate
kap_X	0.8	-	digestion efficiency of food to reserve
kap_P	0.1	-	faecation efficiency of food to faeces
v	0.020316	cm/d	energy conductance
kap	0.77611	-	allocation fraction to soma
kap_R	0.95	-	reproduction efficiency
p_M	592.71	J/d.cm^3	[p_M], vol-spec somatic maint
p_T	0	J/d.cm^2	{p_T}, surf-spec somatic maint
k_J	0.002	1/d	maturity maint rate coefficient
E_G	4448.08	J/cm^3	[E_G], spec cost for structure
E_Hb	0.0005939	J	maturity at birth
E_Hp	0.0328	J	maturity at puberty
h_a	3.311e-06	1/d^2	Weibull aging acceleration
s_G	0.0001	-	Gompertz stress coefficient

Parameters specific for this entry at reference temperature (20 deg. C)			
symbol	**value**	**units**	**description**
E_Hj	0.004142	J	maturity at metam
K_hs	0.21248	mug C/mL	half-saturation coeffcient
del_M	0.86409	-	shape coefficient



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ELSEVIER

Two dynamic energy budget models for the harpa
spinipes

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ARTICLE INFO

Keywords:
Copepod
Nitocra spinipes
Dynamic energy budget

ABSTRACT

The harpacticoid copepod *Nitocra spinipes* of multiple international testing guidelin fects in this species, physiological models rooted in the Dynamic Energy Budget (DEB) theory can help to explain such effects on the level of energy allocations within the organism. In previous works that aimed to capture the

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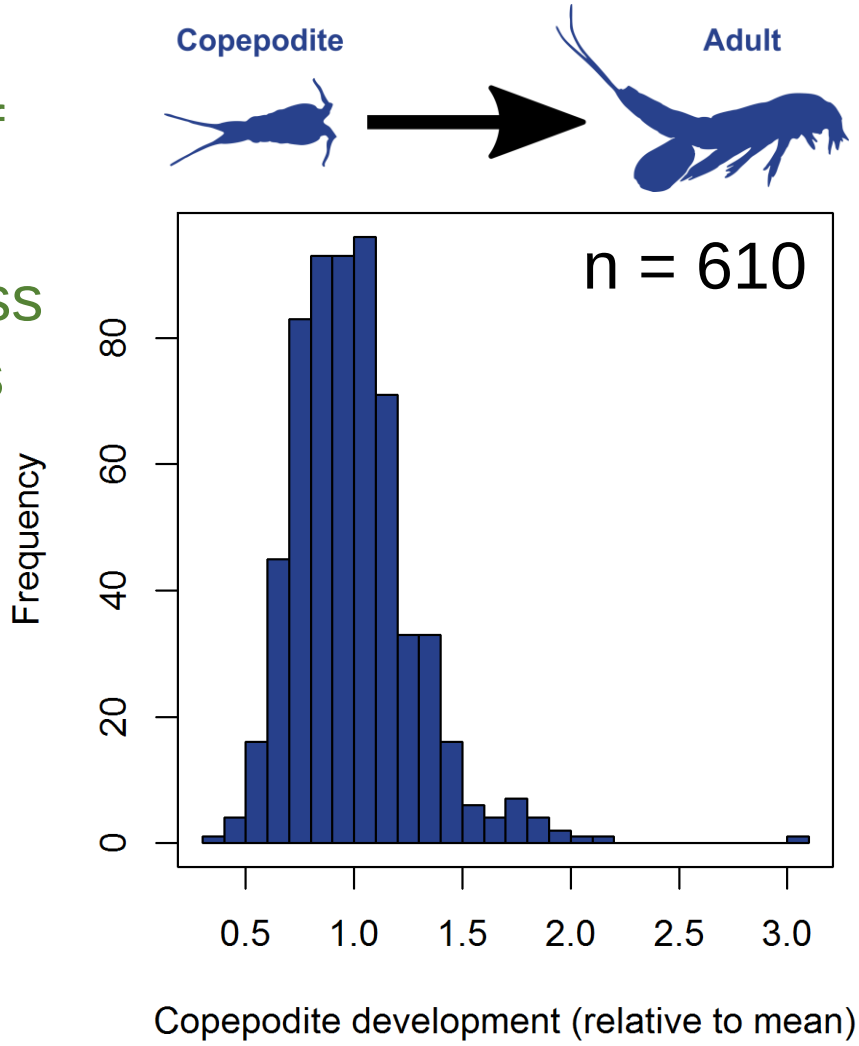
BIOLOGICAL VARIABILITY

- 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



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ESTIMATING VARIABILITY

DEB parameter(s)

Start with a default variability term

Run Monte Carlo simulations

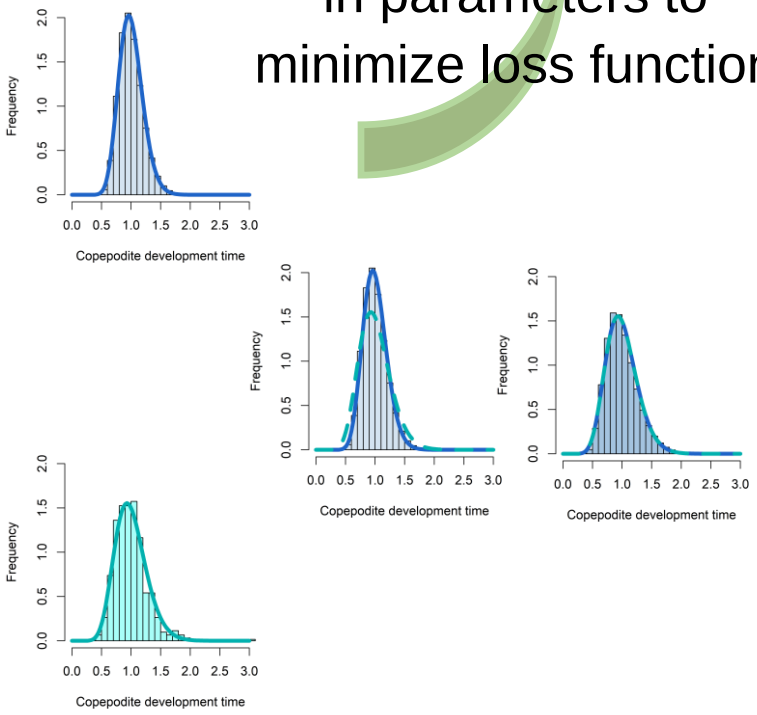
Adjust variability term in parameters to minimize loss function

Simulated data

Loss function: Difference between distributions

(1 - KS test statistic)

Measured data



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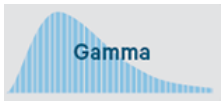
CHALLENGES

DEB parameters

κ_X $\{\dot{p}_{Am}\}$ v κ $[E_G]$ $[\dot{p}_M]$ $\{\dot{p}_T\}$ E_H^j E_H^b E_H^p $\{\dot{F}_m\}$ κ_R $\dot{k}_J$

- Variation in all parameters?
- Covariation?
- Distribution types unknown
  - ➢ Find one-parameter solution



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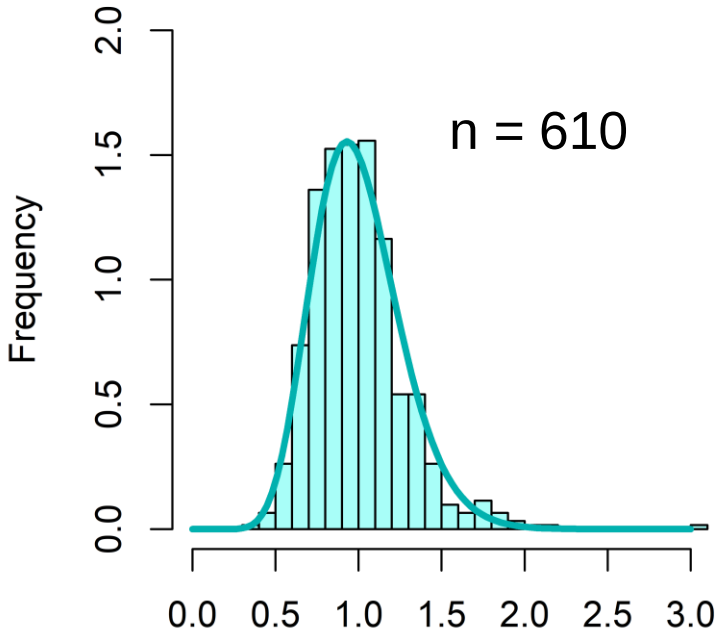
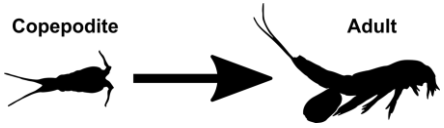
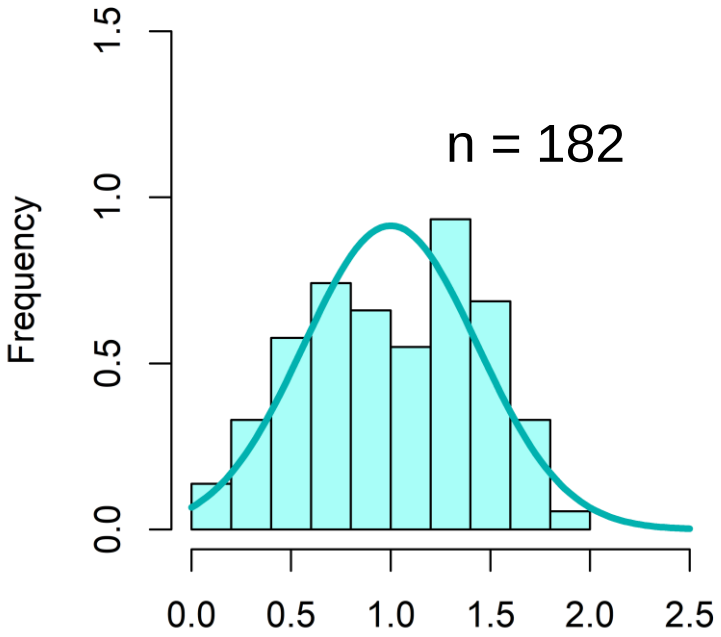
MEASURED DATA

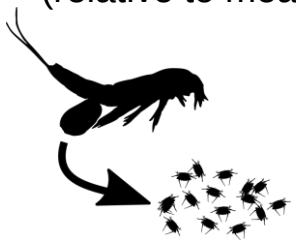


Copepodite development time
(relative to mean)





Brood size
(relative to mean)



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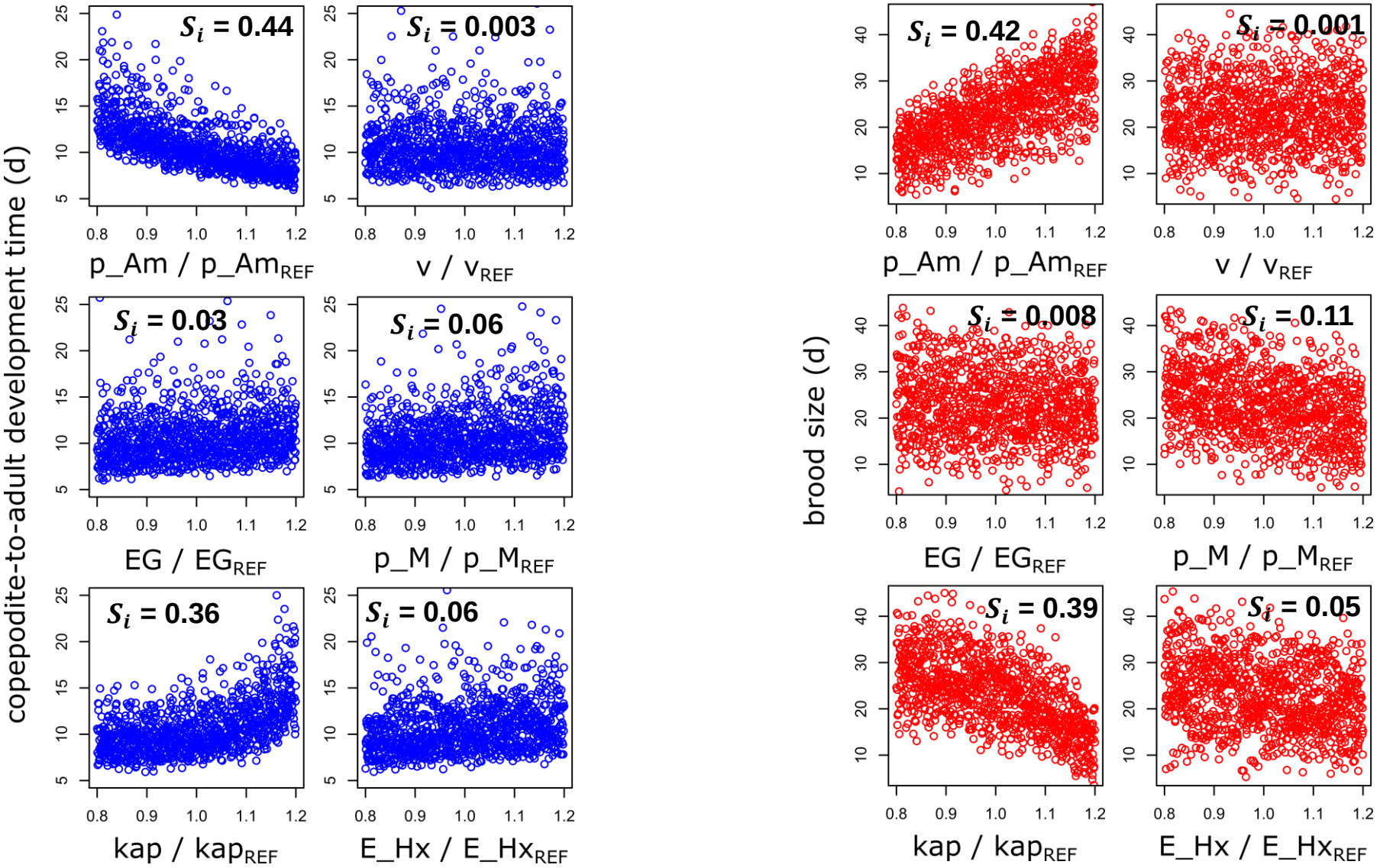
GLOBAL SENSITIVITY ANALYSIS



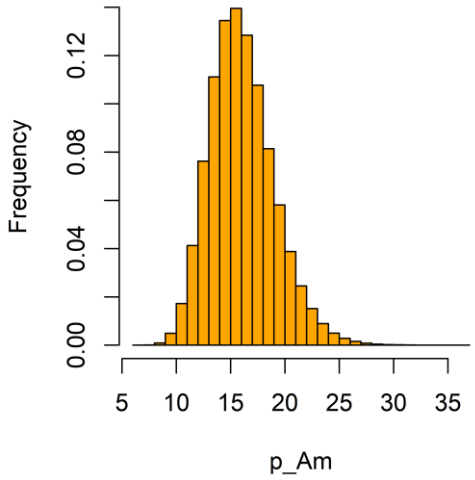
First order effect indices: $S_i = \frac{V_{X_i}\left(E_{\mathbf{X}_{\sim i}}(Y \mid X_i)\right)}{V(Y)}$

$\{\dot{p}_{Am}\} > \kappa > [\dot{p}_M] > E_H^x > [E_G] > v$

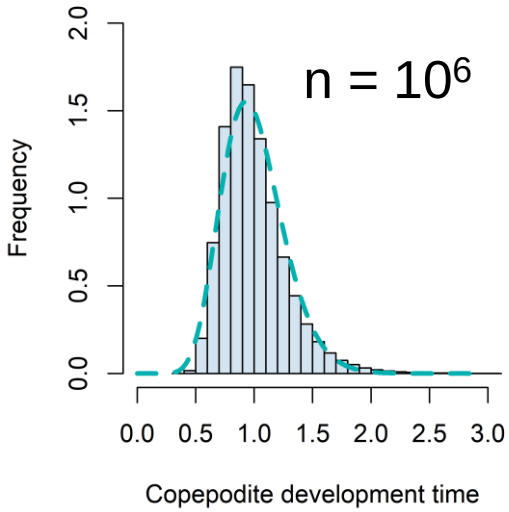
BEST RESULT

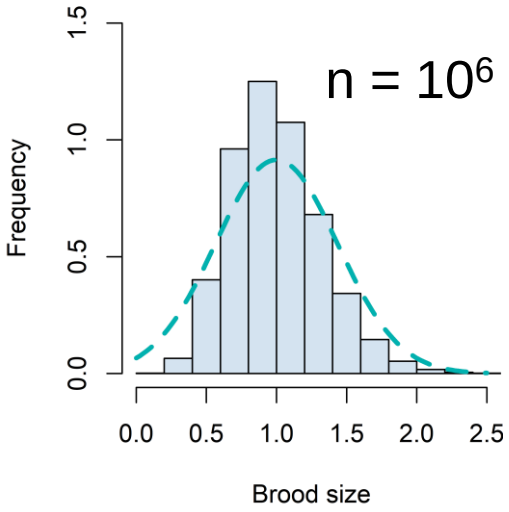
$\{\dot{p}_{Am}\}$ 

cv = 0.18

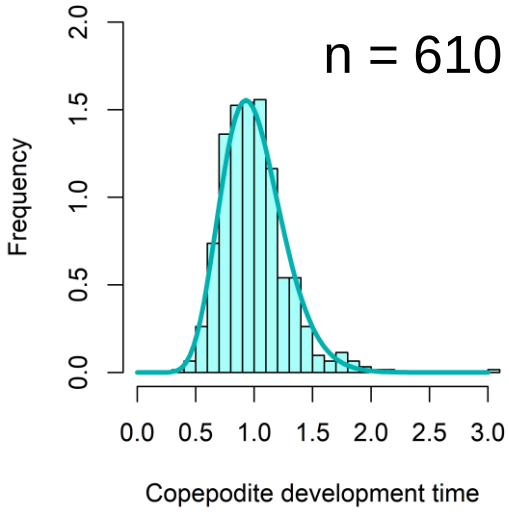


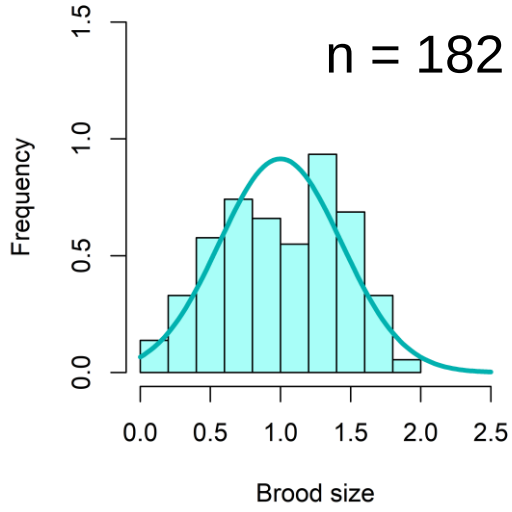
Simulation





Measured Data





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CONCLUSIONS

- Variability in DEB parameters can be estimated from experimental data using Monte Carlo simulations
- Distribution types unknown ➔ 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

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Thank you for your attention

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