Dynamic Energy Budget (DEB) theory summary notes

Matthew Malishev[1]*

[1] *Department of Biology, Emory University, 1510 Clifton Road NE, Atlanta, GA, USA, 30322*

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*Corresponding author: matthew.malishev@gmail.com

TO DO
- update parameter estimation section

List of parameters and variables

Table 1. Dynamic Energy Budget parameters and variables used in the standard DEB model.

Parameter	Definition
E	energy reserve
$[E]$	energy reserve per volume (reserve density)
e	scaled energy reserve
$[E_M]$	maximum reserve density
f	functional feeding response
L	structural length
$\dot{p}_{AM}$	maximum assimilation rate
$\dot{v}$	energy conductance

Overview

Summarised notes from DEB workshops, telecourses, lectures, and discussions.

Parameter estimation

From (http://www.debtheory.org/wiki/index.php?title=AmP_estimation_procedure#Parameter_estimation)

Estimating parameter values from a set of data sets is done in the AmP collection on the basis of the minimization of a parameter-free loss function, see Marques et al 2018a and 2018b, which takes the different dimensions of the various data sets into account, and penalizes over-estimation as hard as under-estimation, using all data sets simultaneously. The minimum is found using a Nelder-Mead simplex method. A simplex is a set of parameter-sets with a number of elements that is one more than the number of free parameters. One of the elements in the set is the specified initial parameter set, the seed, the others are generated automatically in its "neighbourhood". The simplex method tries to replace the worst parameter set by one that is better than the best one, i.e. gives a smaller value of the loss-function. During the procedure the parameter are (optionally, but by default) filtered to avoid that combinations of values are outside their logical domain (Lika et al 2014).

Reserve mobilisation

Conductance determines mobilisation rate from reserve to structure
The larger the surface area of reserve, the more mobilisation is possible and thus faster maintenance and growth due to more surface area.
- surface area scales slower than volume-specific energy flows.

Reserve dynamics f = 1 (max feeding rate)

$$\frac{dE}{dt} = \frac{f\{\dot{p}_{AM}\}}{L} - \frac{\dot{v}[E]}{L}$$

$[E_M]$ = max reserve. Reserve doesn't change.

$$= \frac{\{\dot{p}_{AM}\}}{L} - \frac{\dot{v}[E_M]}{L}$$

$$\therefore [E_M] = \frac{\{\dot{p}_{AM}\}}{\dot{v}}$$

Scaled reserve

$$e = \frac{[E]}{[E_M]}$$

$$\frac{de}{dt} = \frac{[E]/[E_M]}{dt} = \frac{f\dot{v}}{L} - \frac{e\dot{v}}{L}$$

$$= \frac{\dot{v}(fe)}{L}$$

Under steady state, reserve doesn't change

$$0 = \frac{\dot{v}(fe)}{L} \quad \text{or} \quad f = e$$

Length

Getting maximum length L_m

$$\frac{dV}{dt} = V\dot{r}$$

Can rewrite r using scaled reserve e

$$\dot{r} = \dot{v}\frac{\frac{e}{L} - (1 + \frac{L_T}{L})/L_m}{e + g}$$

Getting L_m

$$\frac{dV}{dt} = V\dot{r}$$

To find $V_m = Lm^3$, set $f = 1$ and $\frac{dV}{dt} = 0$, then solve for $V = V_m$

$$L_m = \frac{\kappa\{\dot{p}_{Am}\}}{[\dot{p}_M]}$$

Weak homeostasis

Structural isomorphy implies weak homeostasis
Weak homeostasis depends on ratio of reserve to structure $\frac{d[E]}{dt}$