Notes on fitting DEBkiss model with early life only

December 2022 – January 2023

Data

* Length to \_\_\_ days post fertilization ()
* No reproduction?
* Egg buffer dry mass at day 0 and hatching (Klahre 1997)
* Survival of embryos and larvae, leave out juvenile data point ()
* Maintenance rate (sJM) – can we approximate it using change in dry weight under starvation? Would need to be weight not length.
  + For larvae of *M. beryllina* (7, 14, and 21 dph):
    - Feeding required to maintain basal metabolism: 0.064 mg food mg dw-1 day-1
    - Dry weight lost during starvation at 21°C is 2.6% day-1, at 28°C is 10.6% day-1
    - This translates to 0.026 mg dw per mg of initial weight per day (and 0.106 mg dw).
  + For adults of *M. menidia* at winter temperatures:
    - Depending on temperature and size, remaining body mass after 60 days of starvation ranges from 53% to 80%.
  + For embryos and larvae I have metabolic rates in terms of oxygen consumption:
    - Embryos at 24°C:
    - Larvae (1 dph) at 24°C:
    - Larvae (5 dph) at 24°C:
    - How to convert to Joules or mg of carbon?

Steps

1. Manual fitting (trying different parameters and visually assessing fit of predicted to observed data)
2. Fit one parameter at a time, then two.
   1. Record NLL, AIC, and correlations
3. Determine which parameters improve fit most and are not highly correlated, and therefore can/should be left free.

Manual fitting notes

* We can get closer to the early life data when the sparse later-life datapoints are not also informing the fit.
* Decreasing assimilation rate (sJAm) and increasing yield of structure on assimilates (yVA) gets growth slope less steep to fit data.
* Increasing mortality for larvae (mu\_lar) brings survival down to match data but survival past ~150 days approaches zero which is unrealistic. How to slow mortality down after initial high mortality?

Fitting one parameter at a time

AIC and NLL table

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | **Initial parameters** | **Parameters estimated from ODE** | **AIC** | **Negative Log-Likelihood** | **Notes** |
| delM | 0.1066 (data) | - |  |  |  |
| dV | 0.1 | - |  |  |  |
| sJAm | 0.2 | 0.2128 | 195.22 | 96.61 | TL and repro improved |
| sJM | 0.0062 (data) | 0.003061 | 196.25 | 97.12 | Growth very fast |
| WB0 | 0.15 (data) | 0.1500 | 204.00 | 101.00 | Nothing changed |
| Lwp | 115 (data) | 115.0 | 204.00 | 101.00 | Nothing changed |
| yAV | 0.8 | 0.8 | 204.00 | 101.00 | Nothing changed |
| yBA | 0.95 | 0.95 | 204.00 | 101.00 | Nothing changed |
| yVA | 0.11 | 0.1181 | 195.24 | 96.62 | TL improved, egg depleted faster |
| kappa | 0.8 | 0.8510 | 195.35 | 96.68 | TL improved, egg depleted slower |
| f | 1 (ad libitum) | 1.068 | 195.66 | 96.83 | TL improved, repro higher |
| fB | 1 |  |  |  | Egg depletion perfect |
| Lwf | 0 | 0 | 204.00 | 101.00 | Nothing changed |
| mu\_emb | 0.07 | 0.05866 | 202.69 | 100.34 | Hatch surv higher |
| mu\_lar | 0.02 | 0.02006 | 204.00 | 101.00 | Nothing changed |

* Initial negative log-likelihood was 101.001 (AIC=202.002).
* sJAm, yVA, and kappa have nearly identical effects on fit – how to decide which one to fix? Can I use efficiency data from the starvation paper?
* Most influential: fB, f, kappa, sJM, yVA, and sJAm.

Fitting two parameters at a time

* Just using most influential: sJAm, sJM, yVA, kappa, and mu\_emb

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | **Initial parameters** | **Parameters estimated from ODE** | **AIC** | **Negative Log-Likelihood** | **Notes** |
| sJAm | 0.2 | 0.2962 | 62.04 | 29.02 | Good fit to egg buffer, everything else bad |
| sJM | 0.0062 | 0.02329 |
|  | | | | | |
| sJAm | 0.2 | 0.6703 | 75.00 | 35.50 | Length almost linear, unrealistic estimates |
| yVA | 0.11 | 0.03171 |
|  | | | | | |
| sJAm | 0.2 | 0.5702 | 63.98 | 29.99 | Early length good, unrealistic estimates |
| kappa | 0.8 | 0.2951 |
|  | | | | | |
| sJAm | 0.2 | 0.2127 | 196.21 | 96.10 | Pretty good |
| mu\_emb | 0.07 | 0.05968 |
|  | | | | | |
| sJM | 0.0062 | 0.01493 | 195.55 | 95.78 | Never reaches puberty length |
| yVA | 0.11 | 0.1515 |
|  | | | | | |
| sJM | 0.0062 | 0.01502 | 195.79 | 95.90 | Very slow growth |
| kappa | 0.8 | 0.9999 |
|  | | | | | |
| sJM | 0.0062 | 0.003060 | 196.94 | 96.47 | Almost linear growth |
| mu\_emb | 0.07 | 0.05869 |
|  | | | | | |
| yVA | 0.11 | 0.3647 | 195.55 | 95.78 | Never reaches puberty length |
| kappa | 0.8 | 0.3323 |
|  | | | | | |
| yVA | 0.11 | 0.1180 | 196.15 | 96.08 | Pretty good |
| mu\_emb | 0.07 | 0.05945 |
|  | | | | | |
| kappa | 0.8 | 0.8508 | 196.24 | 96.12 | Pretty good |
| mu\_emb | 0.07 | 0.05937 |

Correlation table

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | sJAm | sJM | WB0 | Lwp | yAV | yBA | yVA | kap | f | fB | Lwf | mu\_emb | mu\_lar |
| sJAm | 1 |  |  |  |  |  |  |  |  |  |  |  |  |
| sJM | s | 1 |  |  |  |  |  |  |  |  |  |  |  |
| WB0 | S | S | 1 |  |  |  |  |  |  |  |  |  |  |
| Lwp | S | S | S | 1 |  |  |  |  |  |  |  |  |  |
| yAV | S | S | S | S | 1 |  |  |  |  |  |  |  |  |
| yBA | S | S | S | S | S | 1 |  |  |  |  |  |  |  |
| yVA | s | 0.9937 | S | S | S | S | 1 |  |  |  |  |  |  |
| kap | s | s | S | S | S | S | -0.9984 | 1 |  |  |  |  |  |
| f | s | 0.9947 | S | S | S | S | s | s | 1 |  |  |  |  |
| fB | s | s | s | s | s | s | s | s | s | 1 |  |  |  |
| Lwf | 6.7e-8 | 0 | s | s | s | s | -6.2e-8 | S | 0 | s | 1 |  |  |
| mu\_emb | 0.02768 | -1.2e-3 | S | S | S | S | 0.02109 | 0.01904 | 4.4e-7 | s | S | 1 |  |
| mu\_lar | 0.04276 | -1.8e-3 | S | S | S | S | 0.03215 | 0.02893 | 6.4e-7 | s | s | -0.625 | 1 |

-cant estimate kappa without repro data

-fix fB as 1,

slope can give parameter relating to uptake

\*\*send the Letcher paper\*\*

Ben Martin developed deblipid model

the Schultz overwintering papers could give a lower bound on maintenance rate

look for papers that cite the Letcher paper - look for others that measured early life growth rate

to convert oxygen consumption need to know respiration quotient for particular fish and food. can get bound on carbon change by imagining that metabolism completely converts O2

some of the molecules have o2 so dont need exactly 2 oxygen molecules. pretend that the reaction is exactly how it is written out, using atomic weights.