DTU Aqua
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Income versus Capital breeders

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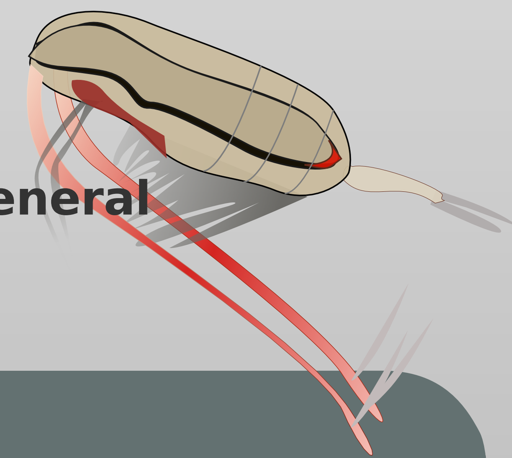
The grasshopper and the ant - Jean de Lafontaine

What is the best reproduction strategy as a function of the duration of the feeding season ?

Allocation of resources to growth, storage and reproduction are key processes in the life of an organism, and these processes form trade-offs that influence the fitness of their life-history strategy as a function of the environmental condition.

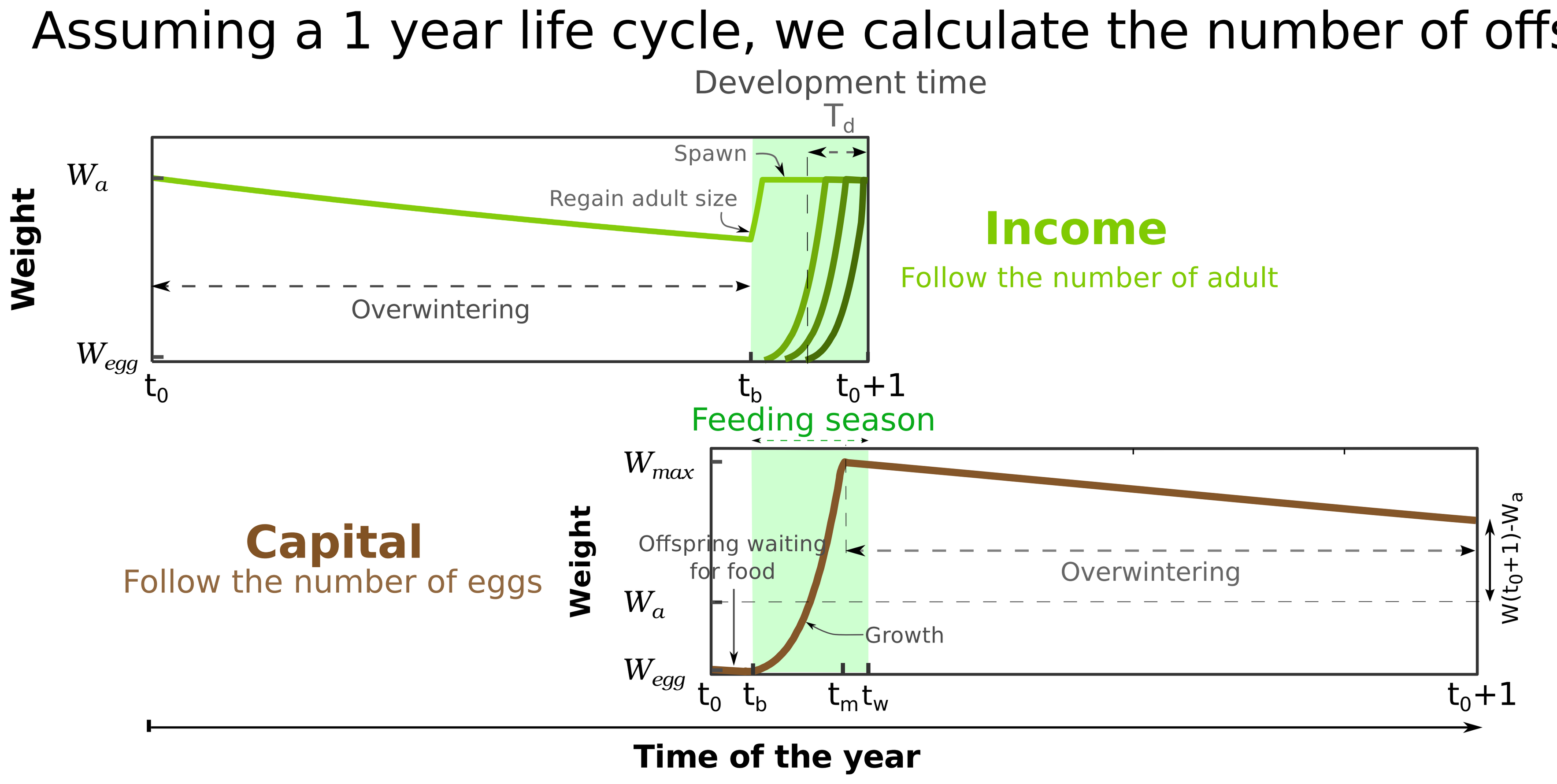
Considering the grasshopper and the ant story by Jean de Lafontaine: is it better to 'enjoy' the summer (spawn during the feeding season), or store reserves and be able to spawn at some later time ?



This study has been inspired by copepods but the results are general

Calculation

Assuming a 1 year life cycle, we calculate the number of offspring, by dividing the year into times of interest.



3 cases as a function of the feeding season duration:

Income :

$$r = \begin{cases} 0 & \text{(1) individuals do not regain adult weight during the feeding season} \\ 0 & \text{(2) First set of offspring do not reach adult stage} \\ P_{t_0\to t_b} P_{t_b\to t_a} P_{T_d} \exp\left(\left(\frac{\mathbb{W}(rT_d e^{-\mu_a T_d})}{T_d} - \mu_a\right)(t_0+1-t_a-T_d)\right) & \text{(3) otherwise} \end{cases}$$

Capital :

$$r = \begin{cases} 0 & \text{(1) Individual have a weight inferior to the adult size at spawning time} \\ \frac{\epsilon(W_{t_0+1}-W_a)^+}{W_e} P_{t_0\to t_b} P_{t_b\to t_w} P_{t_w\to 1} & \text{(2) Indivual do not reach maximum size during the feeding season} \\ \frac{\epsilon(W_{t_0+1}-W_a)^+}{W_e} P_{t_0\to t_b} P_{t_b\to t_m} P_{t_m\to 1} & \text{(3) Otherwise} \end{cases}$$

General equations :

Growth:

$$\frac{dW}{dt} = h(f-f_c)W^{3/4}$$

Mortality rate:

$$\mu = ahW^{-1/4} + \mu_0$$

Admit the general solutions:

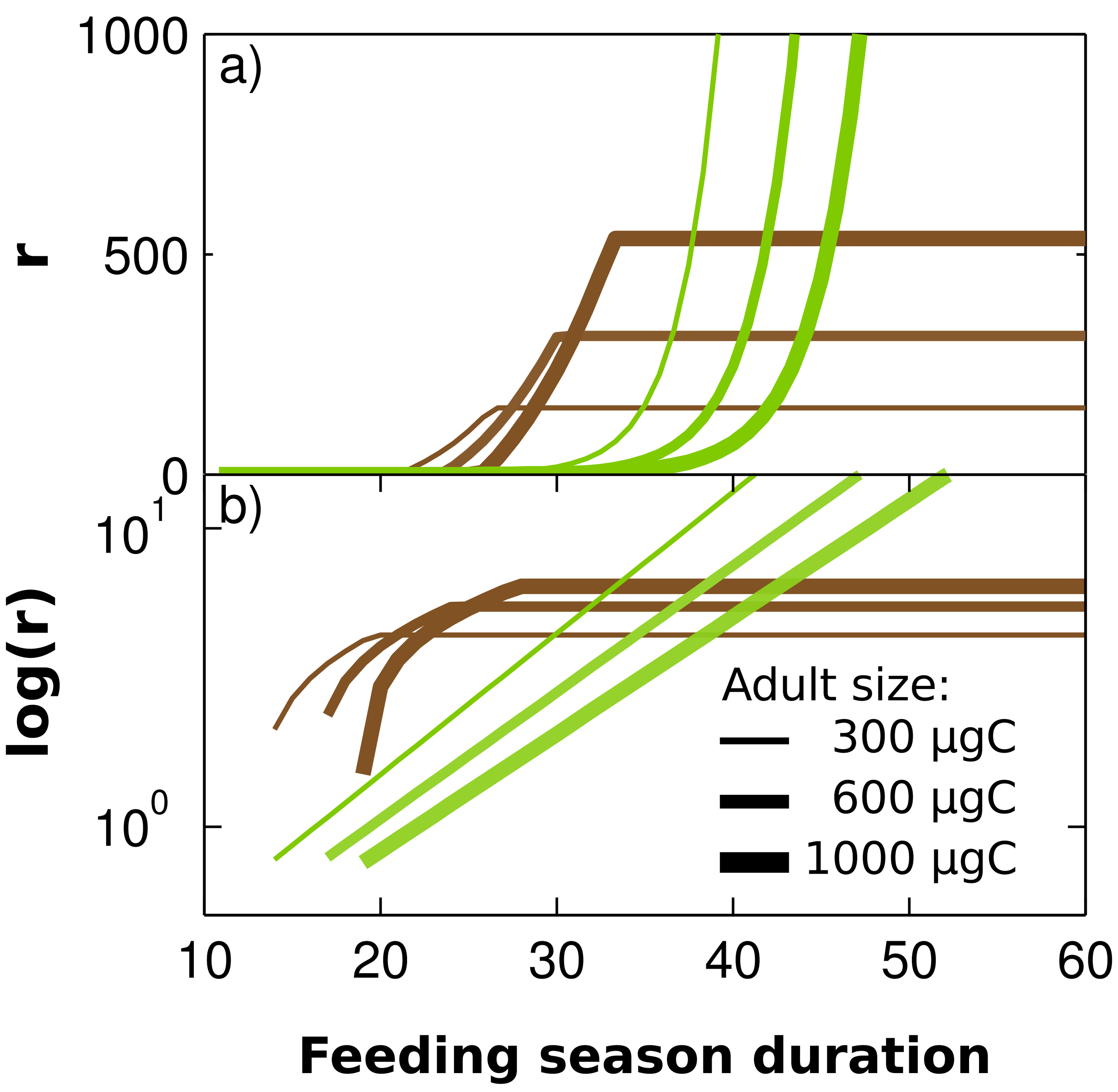
$$W_{t_2} - W_{t_1} = \left(\frac{hf_c}{4}(t_2-t_1) + W_{t_1}^{1/4}\right)^4 - W_{t_1}$$

$$P_{t_1\to t_2} = \left(\frac{W_{t_1}}{W_{t_2}}\right)^{\frac{a}{f-f_c}} e^{-\mu_0(t_2-t_1)}$$

- $\mathbf{W}$ Weight [μgC]
- $\boldsymbol{W_a}$ Adult weight [μgC]
- $\boldsymbol{W_{egg}}$ Egg weight [μgC]
- $\boldsymbol{W_{max}}$ Maximum weight [μgC]
- $\boldsymbol{P}$ Probability to be alive
- $\boldsymbol{h}$ Carbon uptake [μgC$^{1/4}$d^{-1}]
- $\boldsymbol{f}$ Feeding level [0,1]
- $\boldsymbol{f_c}$ Critical feeding level [0,1]
- $\boldsymbol{\epsilon}$ Reserve to egg conversion efficiency
- $\boldsymbol{a}$ Loss due to predation mortality
- $\boldsymbol{\mu_0}$ Natural mortality [d^{-1}]

Income/Capital - Feeding season duration

Population growth rate, r [ind.year]:



Adult Size \ Feeding season	Short	Long
Small	X	Income
Large	Capital	X

Conclusion :

For short feeding seasons, individuals should choose a capital breeding reproduction strategy, with a size at maturity as large as the feeding season allows.

For long feeding seasons, income breeding is preferable, with a size at maturity as small as possible.

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