Evolution of Cannibalism – I

(Adaptive Dynamics Project 2016)

A cannibalistic species spends a fraction $x \in [0,1]$ of time searching for a resource R, whereas the remaining fraction $1-x$ is spent attacking those conspecific individuals that are searching for the resource. Thus, $x=1$ is a non-cannibalistic strategy which consumes only the resource, and the other extreme $x=0$ corresponds to full cannibalism. We assume that the resource dynamics are logistic, and that the attack on foraging individuals has a Holling type II functional response with a handling time that depends on the strategy x. The latter reflects the assumption that the more time individuals spend attacking others, the better they learn the technique and the faster they can process their conspecific prey.

Consider a resident population of strategies $x_1,\dots,x_k$ with corresponding population densities $n_1,\dots,n_k$, and let the population dynamics be given by

$$\dot{n}_i = \lambda\nu R x_i n_i - \beta x_i n_i \sum_{j=1}^{k} \frac{(1-x_j)n_j}{1+\beta T(x_j)\sum_{h=1}^{k} x_h n_h} +$$

$$+\frac{\gamma\beta(1-x_i)n_i\sum_{j=1}^{k} x_j n_j}{1+\beta T(x_i)\sum_{j=1}^{k} x_j n_j} - \delta n_i$$

and

$$\dot{R} = rR\left(1-\frac{R}{K}\right) - \nu R\sum_{j=1}^{k} x_j n_j.$$

Assuming that r are ν large and λ is small compared to all other parameters, the resource dynamics becomes fast compared to the dynamics of the n_i. The stable quasi-equilibrium of R then is

$$R = \begin{cases} K\left(1-\frac{\nu}{r}\sum_{j=1}^{k} x_j n_j\right) & \text{if } \sum_{j=1}^{k} x_j n_j < \frac{r}{\nu} \\ 0 & \text{otherwise} \end{cases}$$

Make sure you understand the model, and study the adaptive dynamics of x. For the handling time take

$$T(x) = T_0 x^p \quad (p \geq 0)$$

where different values of p correspond to different rates of learning how to handle conspecific prey.