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Appendix B from V. Le Bourlot et al., "Interference versus Exploitative Competition in the Regulation of Size-Structured Populations"

(Am. Nat., vol. 184, no. 5, p. 609)

Individual Level Model

The κ Rule and Individual Rates

Individual interactions being defined as previously described, the individual rates depend directly on a dynamic energy budget chosen. The choice we made is based on the κ rule (Kooijman and Metz 1984; De Roos 1997; fig. B1), which assumes that a fixed proportion (κ) of the energy intake (fig. B1, thick solid arrow) is allocated to maintenance plus growth while the remainder ($1 - \kappa$) goes to reproduction. This implies that when the energy intake goes down, energy will be rechanneled from growth to maintenance, until growth eventually stops while reproduction still goes on (fig. B1, thin dashed arrow). For even lower energy intake, energy will be rechanneled from reproduction to maintenance. This rule implies that individuals continue reproducing after reaching their maximum size, a scenario that is realistic for a wide range of species, including collembolans. When the energy intake is insufficient to cover maintenance, the individual is assumed to die.

Assuming that the intake rate scales with l^2 and the metabolism scales with l^3, the individual rates can then be derived and are the same as in the original KM model except for the resources replaced by the resource access function. In an environment $\eta(t, l)$ felt by an individual of length l, we define mortality as a constant background rate μ. The growth rate g follows the equation

$$g(t, l) = \gamma(l_m \cdot A(t, l) - l), \tag{B1}$$

and the reproduction follows the κ rule (De Roos 1997), with

$$b(t, l) = \begin{cases} 0 & l < l_j, \\ r_m \cdot A(t, l) \cdot l^2 & \text{otherwise,} \end{cases} \tag{B2}$$

with l_j the length at maturity and r_m the reproduction rate.

Population-Level Integration

At the population level, the number of individuals at time t is given by the integral

$$\int_{l_b}^{l_m} n(t, l) dl, \tag{B3}$$

where $n(t, l)$ is the number of individuals of length l at time t. The population dynamics is described by the following partial differential equation and limit conditions (Kooijman and Metz 1984; De Roos 1997):

$$\frac{\partial n(t, l)}{\partial t} + \frac{\partial g(t, l) \cdot n(t, l)}{\partial l} = -\mu \cdot n(t, l), \tag{B4}$$

$$g(t, l_b) \cdot n(t, l_b) = \int_{l_b}^{l_m} b(t, l) \cdot n(t, l) dl, \tag{B5}$$

and the initial condition for the population $n(0\ , l) = \Psi(l)$, where $\Psi(l)$ is a chosen size distribution. Because the i state determines the state of an individual, the state of the population, or *p* state, characterizes the composition of the structured population modeled, using a density function over the *i* state's space.

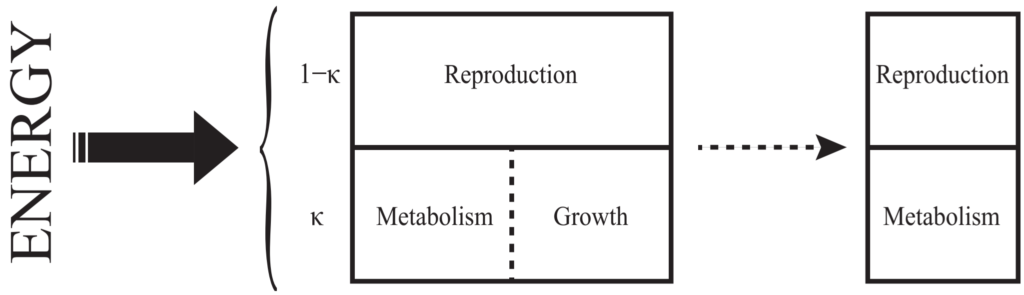

Figure B1: Description of the κ rule and its implications.