Lecture 7: Life Tables

Definitions
x = Age interval
w = Maximum age-class
n_x = Number of individuals alive at start of age x
l_x = Percentage of individuals still alive at start of age x
m_x = number of female offspring per female of age x
p_x = Age-specific survival rate from age x to age x+1

Basic calculations

$$l_x = \frac{n_x}{n_0} \qquad p_x = \frac{l_{x+1}}{l_x} = \frac{n_{x+1}}{n_x}$$

Life-table calculations

Gross reproductive rate: GRR = $\sum_{x=0}^{w} m_x$

The net reproductive rate (R_0) is the average number of female offspring per female per generation. Usually assumes a 1:1 sex ratio at birth. Indicates population status: increasing ($R_0 > 1$) or decreasing ($R_0 < 1$).

Net reproductive rate: $R_0 = \sum_{x=0}^{w} l_x m_x$

Generation time (T) is the number of time units it takes an average female to produce one female offspring. The numerator is divided by R_0 to control for whether the population is increasing or decreasing.

Generation time: $T = \dfrac{\sum_{x=0}^{w} x l_x m_x}{R_0}$

The intrinsic rate of population growth (r) is interchangeable with the finite rate of population growth (λ). Population growth is stationary if $r = 0$ and if $\lambda = 1$. The two metrics can be converted as: $\lambda = e^r$ and $r = \ln \lambda$. Calculations of r based on the below equation assume a stable age distribution and a stationary population size.

$$r = \frac{\ln R_0}{T}$$

The Euler equation is an improved method for estimation of r from life-table data. It is not an analytical solution because r cannot be isolated by algebra and iteration must be used to solve for r.

$$1 = \sum_{x=0}^{w} l_x m_x e^{-rx}$$

Age-specific Life History Parameters

Life expectancy (E_x) is if an individual has survived to a particular age-class, what is the expected number of time units they will survive in the future. If juvenile mortality is high, life expectancy may be greatest for individuals of intermediate age.

$$E_x = \frac{\sum_{y=x}^{w} l_y}{l_x}$$

Reproductive value (v_x) is the age-specific expectation of future offspring, and is measured in units of female offspring per female. For a stable population at equilibrium:

$$v_x = \sum_{y=x}^{w} \frac{l_y}{l_x} m_x$$

Reproductive values are then usually scaled by dividing each v_x value by the reproductive value of the youngest age-class (v_0). One of the greatest insights of evolutionary ecology is that reproductive value can be partitioned into current vs. future reproduction:

$$v_x = m_x + \sum_{y=x+1}^{w} \frac{l_y}{l_x} m_x$$

In applied ecology, management activities are often targeted at age-classes with high reproductive value. Conservation biologists might protect those age-classes in a declining population, whereas wildlife managers might target those age-classes for fertility control in pest species.