Appendix E. An example illustrating population inertia sensitivities across life history strategies.

The study of patterns in population dynamics across populations and species is important because it aids in the understanding of life history evolution (Harvey and Pagel 1991, Stearns 1992), and in the development of demographic policy as well as conservation and management plans (Bos et al. 1994, Fagan et al. 2001). Adding to the repertoire of methods used in comparative demography, our formulas allow one to compare the functional relationship between vital rates and population inertia across populations and across species. Furthermore, the analytical formulae provide a consistent means for comparison that alleviate some pitfalls of numerical simulation.

To provide a brief example of such an application, we used the bird data with stationary growth ($\lambda = 1$) provided in Koons et al. (2006). We parameterized the life history variables for each species into a partial life-cycle projection matrix using a 1-yr time step (A; Oli and Zinner 2001). We assumed birth-pulse reproduction and used a pre-birth census, where fertility (F) equaled the product of fecundity ($m$, the number of female offspring produced per female each year) and age-class 1 survival ($F = m \times P_1$), $P_{sa}$ equaled sub-adult survival, and $P_a$ equaled adult survival

$$A = \begin{bmatrix}
0 & \cdots & 0 & F \\
\vdots & \ddots & \ddots & \vdots \\
0 & \cdots & 0 & 0 \\
0 & \cdots & P_{sa} & P_a
\end{bmatrix}$$

(Model A for each avian species is provided in the Supplement). We further assumed that each population initially had a stable population structure and stationary growth, hence the SER = 1. This served as a nice starting point because any perturbation to these equilibrium conditions produces a SER $\neq 1$, and it is this ‘change’ in population inertia that we were interested in comparing across species with different life history attributes. Specifically, we applied Eq. 13 to the population model (A) for each species and calculated the sensitivity of SER to changes in fertility, sub-adult survival, and adult survival. The Supplement contains Matlab scripts for calculating the SER sensitivities in this example.

Across the avian life histories, we found that the sensitivity of SER to changes in fertility increased with the life history generation time ($P < 0.01$, $R^2 = 0.94$, Fig. E1a) as did sensitivity of SER to changes in sub-adult survival ($P < 0.01$, $R^2 = 0.86$, Fig. E1b). Interestingly, sensitivity of SER to change in sub-adult survival was negative for species with a generation time < 10 years but positive for species that mature later in life and have a longer generation time. Thus, whether changes in sub-adult survival produced inertia leading to an enlarged or reduced population size relative to an otherwise equivalent population in its stable population structure depended on the duration of the sub-adult stage. On the other
hand, sensitivity of SER to change in adult survival decreased with life history generation time and was always negative (Fig. E1c). Although statistical support for the latter relationship was weak ($P = 0.12, R^2 = 0.27$), this brief analysis indicates that the functional relationship between vital rates and population inertia does tend to vary with life history, which is consistent with Koons et al’s more in-depth numerical analysis of population momentum across vertebrate life histories (2006). Our equations can be used for analysis following a population’s transition to stationary growth, which would be of interest when studying population momentum, but can also be used to study non-stationary conditions as well. We suggest use of these new tools to examine population inertia dynamics in a wide variety of populations and species.

LITERATURE CITED


FIG. E1. The relationship between life history generation time and the sensitivity of the Stable Equivalent Ratio (SER) to changes in (a) fertility, (b) sub-adult survival, and (c) adult
survival for initially stationary populations of selected avian species. The scale of the y-axes differ among graphs a, b, and c. (Life history data comes from Koons et al. 2006).