147

Estimating density dependence using Integrated Population Models: an evaluation of current and alternative methods

Population size can influence life history traits that will typically in turn affect population size. Such limitation of population size at high density can lead to to population trajectories tending towards an equilibrium population size which is of central interest from both theoretical and management perspectives. Integrated population models (IPM) represent an elegant and logical way to study density dependence as they model jointly demographic traits and population size accounting for uncertainty and demographic and environmental stochasticity, and allow to estimate density dependence of the demographic traits and derive its strength on population growth.

However, it is not well known in which situations IPMs provide unbiased estimates of density dependence. Notably, while density dependence on demographic parameters can be assessed and evaluated explicitly within the IPM, density dependence on population growth rate is typically assessed ad hoc and its accuracy may depend on the method used (e.g. correlations or regressions). Its bias may be assessed in cases where density dependence is absent, yet, bias and precision in estimates of density dependence using IPMs in absence of density dependence has not been evaluated.

The aim of our study is first to assess how common and strong are biases in the estimated density dependence of demographic parameters and population growth when using IPMs, and second how do detect, and best deal with such biases. To this aim, we simulate various scenarios manipulating factors that likely affect bias (strength of density dependence, length of the time series, life history pace, presence of immigration, sample sizes and strength of environmental stochasticity). We then compare estimates of density dependence using density-dependent-explicit IPM versus using IPMs that account for environmental stochasticity but do not model density dependence. We assess density dependence on population growth using the classically used regression and correlation methods, but also i) adapting suggestions from Lande's work to estimate density dependence as well as the equilibrium population size, and ii) building on transient Life Table Response Experiment contributions to estimate the proportion of variance in population growth rate explained by density dependence on the demographic parameters.