Fitting dynamic models for interacting species using both population count and interaction rate data

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Résumé

Most mechanistic modelling of the population dynamics of interacting species has attempted either parameterization from process rate data (flows) or inverse modelling, that is, identifying parameters solely from time series of population counts (stocks). Here, we take a median road: we aim at identifying the potential benefits of combining datasets, when both population dynamics and interaction processes are viewed as stochastic. We start by fitting a stochastic predator-prey model to simulated time series of densities and kill rates. We examine whether estimation would be possible solely with time series of counts. Both Bayesian and frequentist estimation are performed. While the Fisher Information Matrix suggests that models with and without kill rate data are both identifiable, we show that if the system attractor is a fixed point in the absence of stochasticity, identifying parameters in practice requires kill rate data as a complement to the time series of population sizes, due to the relatively flat likelihood. Only noisy limit cycle attractors can be identified directly from ecological count data, although we show that even in this case, adding kill rate data can make the estimates much more precise. If time allows, we will generalise these results to two-species competition models. These results contribute to a larger research programme using multiple data sources (following the ecological tradition of "integrated" population modelling) and identifiability analysis to characterize the joint dynamics of multiple species with random nonlinear maps.

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