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

Most mechanistic predator-prey and competition modelling has attempted either parameterization from process rate data or inverse modelling (identifying parameters solely from time series of population counts). Here, we take a median road: we aim at identifying the potential benefits of combining datasets, when both population growth and interactions processes are viewed as stochastic. We start by fitting a discrete-time, stochastic predator-prey model of the Leslie type to time series of densities and attack rate data, simulated from the model. We examine what the attack rate data brings to the quality of the estimates, and whether estimation would be possible (for various time series length) solely with time series of counts. Both Bayesian and frequentist estimation are performed, and the Fisher Information Matrix suggests that models with and without attack rate data are both identifiable. However, our results show that if the attractor is a fixed point in the absence of stochasticity, identifying parameters in practice requires in fact attack rate data as a complement to the time series of population densities, due to the relatively flat likelihood in this case. Only noisy limit cycle attractors can be identified directly from ecological count data (as in inverse modelling), although we show that even in this case, adding attack rate data can make the estimates much more precise. If time allows, we will generalize these results to two-species competition models. In general, our framework highlights the benefits of adding interaction rate data - even in small amounts - to models that predict the population dynamics of interacting species.