Mathematical Ecology: Theory and Applications (META)

Joint Research Group in the UK - LMS Scheme 3

META WORKSHOP

Uncertainty and predictability in ecology

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ABSTRACTS

Ludek Berec
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Happy but frustrated: Allee effects help control pests but are hard to estimate

Allee effects occur when fitness declines as population size or density decrease. This long-existing, population-level concept has got an increased attention in the last two decades, and affected a view on many ecological and evolutionary issues, including pest control. Recent theoretical work suggests that key to the success of pest eradication may lie in Allee effects that are strong enough to implicate a negative per capita population growth rate once the population falls below a critical size or density, referred to as an Allee threshold. Unfortunately, it turns out that is quite difficult to estimate the Allee threshold even if we have a suspicion there is one. In this talk, I will present the basic concepts behind exploitation of Allee effects in pest control, show a specific example, and demonstrate how neglecting uncertainty behind Allee effect estimation may generate false predictions of population extinction risk.

Robert Holt
University of Florida, USA

Reflections on apparent competition: a 40-year anniversary

Abstract to be available soon.

Natalia Petrovskaya
University of Birmingham, UK

\`Heads or tails': choosing between deterministic and probabilistic approaches to evaluation of the population abundance from sparse data

Many biological and ecological problems require accurate evaluation of the total population size. We discuss a sampling procedure used for evaluation of the population abundance from information collected on a grid of spatial sampling locations. It will be shown in our talk how

insufficient information about the spatial population density obtained on a coarse sampling grid affects the accuracy of evaluation. The insufficient information is collected because of inadequate spatial resolution of the population density on coarse grids and this is especially true when a heterogeneous spatial population density is sampled. It will be argued in the talk that the evaluation error is a random variable on coarse sampling grids because of the uncertainty in sampling spatial data and a probabilistic approach should be employed in the evaluation procedure. We also show that there exists a threshold number of sampling locations on a regular sampling grid where we can guarantee desired accuracy of evaluation. Information about the threshold number of sampling locations allows one to reconcile the probabilistic approach based on the assumption about randomness of sampling data with the deterministic approach based on the requirement that spatial data are collected only once as the sampling procedure cannot be repeated under the same conditions.

Sergei Petrovskii
University of Leicester, UK

Catching ghosts with a coarse net: use and abuse of spatial sampling data in detecting synchronization

Synchronization of population dynamics in different habitats is a frequently observed phenomenon. A common mathematical tool to reveal synchronization is the (cross-)correlation coefficient between time courses of values of the population size of a given species where the population size is evaluated from spatial sampling data. The corresponding sampling net or grid is often coarse, i.e. it does not resolve all details of the spatial configuration, and the evaluation error - i.e. the difference between the true value of the population size and its estimated value - can be considerable. We show that this estimation error can make the value of the correlation coefficient very inaccurate or even irrelevant. We consider several population models to show that the value of the correlation coefficient calculated on a coarse sampling grid rarely exceeds 0.5, even if the true value is close to 1, so that the synchronization is effectively lost. We also observe `ghost synchronization' when the correlation coefficient calculated on a coarse sampling grid is close to 1 but in reality the dynamics are not correlated. Finally, we discuss a simple test to check the sampling grid coarseness and hence to distinguish between the true and artefactual values of the correlation coefficient.

Axel Rossberg
Queen Mary University of London, UK

What can we and what can't we predict in community ecology?

When John H. Lawton asked in his highly cited paper from 1999 "Are There General Laws in Ecology?" (Oikos 84:177-192), he made noteworthy distinctions between levels of abstraction in ecology at which predictions are possible, and others where predictions appear difficult. Into the former, he grouped changes in the population sizes of individual species and patterns relating local to regional species richness. The intermediate level, ecological communities, appeared much less controlled by general laws. This sentiment persisted stubbornly, e.g. in Mark Vellend's labelling of the "black box of community ecology" (2010, Q Rev Biol 85:183-206). Since then, however, theoretical ecology made tremendous progress in understanding the causes of this unpredictability, so permitting a much sharper distinction of what can be predicted, what can't, and why. Ecological communities, as they assemble, naturally reach a state of high structural instability, where small changes in the biotic or abiotic environment can have large impacts on equilibrium population sizes and the populations forming communities are a mixture of some that are doing well and others that do barely survive. The theory reveals that this structural instability arises because complex indirect interactions (of which Lawton and others were long suspicious) overwhelm community dynamics (Rossberg 2013, ISBN 9-780470973-55-4). The theory of structural instability leads to many new predictions at community level, e.g. for invasion probability, the time scales of invasion and extinction processes, the relative contribution of indirect interactions to perturbation responses, within-community patterns in species richness, and the mechanisms controlling changes in ecosystem functioning under biodiversity loss in food webs.

Max Souza
Universidade Federal Fluminense, Brazil

Predator-prey dynamics: mass action models, functional responses, and the PDE viewpoint

Predator-prey dynamics is most simply and commonly described by Lotka-Volterra-type ordinary differential equations (ODEs) for continuous population density variables in the limit of large population sizes. Nonlinear ‘functional responses’ in which interaction rates between the populations depend on the prey concentration were originally proposed by Holling in the 1950s and have been discussed frequently ever since. In this talk we first derive, from the individual level, a three variable mass action model for the simplest-possible formulation of predator-prey dynamics. We discuss carefully how it reduces to Holling's functional responses in specific asymptotic limits. In the second part of the talk we discuss the description of predator-prey dynamics for large but finite populations, extending the usual mass action ODEs into a coupled collection of differential equations that describe the behaviour both in the interior and on the boundaries of the state space. This is joint work with J.H.P. Dawes (University of Bath).