Multistate phenomena in ecological systems

J.V.Greenman [1] and T.G.Benton[2] .

Even simple phenomenological models have surprising behaviour. Cycles with massive amplification can be excited from stable equilibrium states and stable equilibrium states out of unstable ones. n trophic-web models subpopulations can be switched on and off by spikes in population at other levels and extinction can result from excitation of stable coexistent states. We study such multistate phenomena in both stage-structured [1,4] and multi-layered systems [3,5] using nonlinear matrix models. The bifurcation structure of these models is studied in a model-independent parameter space to establish its generic nature. Accessibility to particular bifurcations is limited by biological relevance constraints embedded in the inverse mapping from model-independent to model-dependent parameter space. Of special importance in the analysis is the family of Arnold's tongues and its connection with other bifurcation structures in 2x2 models and its generalisation to 3x3 and higher dimensional models. Trophic-web models have added complexity due to the overlapping of unstable states at different levels. The impact of this complexity on robustness against extinction is studied in both 2 and 3 level communities. Switching between states is encouraged by the presence of both deterministic and stochastic forcing [2]. Both effects have been analysed. In particular, rules governing the impact of periodic forcing on natural oscillatory states have been identified.

[1]University of Stirling, Department of Computing Science and Mathematics, Stirling, Scotland, FK9 4LA, UK (e-mail: j.v.greenman@stir.ac.uk).

[2]University of Stirling, Institute of Biological Sciences, Stirling, Scotland, FK9 4LA, UK (e-mail: t.g.benton@stir.ac.uk).

References

[1] Cushing, J. M. et al., 1998, Nonlinear population dynamics: models, experiments and data, *J. theor. Biol.*, 194, 1-9.

[2] Greenman, J. V. and Benton, T. G., 2003, The amplification of environmental noise in population models: causes and consequences, *AmNat*, 161, 225-239.

[3] Kaitala, V. et al., 1999, Dynamic complexities in host-parasitoid interaction.,*J. theor. Biol.*, 197, 331-341.

[4] Neubert, M. G. and H. Caswell, 2000, Density-dependent vital rates and their population dynamic consequences, *J. Math. Biol.*, 41, 103-121.

[5] Turchin, P. et al., 2002, Population cycles of the Larch Budmoth in Switzerland, in Berryman, A. (ed) *Population cycles*, OUP, Oxford, UK.