Ecological Implications of Global Bifurcations

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English short summary

Mathematical ecology aims to understand the spatial and temporal dynamics of populations of living organisms, and the interactions between these populations and their a-biotic environment, by employing models. Analysis techniques are required to test the validity and behaviour of these models. In this Thesis we focus on the development and use of bifurcation analysis on food chain models. These models consist of variables representing populations of species, that form a feeding chain. By assuming that the environment is homogeneously mixed, the models are described as sets of ordinary differential equations (ODE's). The properties of the species are described with parameters, that remain fixed in time.

In Chapter 2 we focus on stability properties of food chain models. By using a normalisation method this chapter shows, that many mechanisms proposed in the ecological literature can have a stabilizing effect by avoiding the Hopf bifurcation, a switch point where oscillatory behaviour replaces a stable equilibrium.

In Chapter 3 predator-prey models with an Allee-effect are discussed, that have a trivial attractor where both populations are zero, and an internal attractor. After a decrease in the predator mortality this attractor disappears because of a global bifurcation, resulting in the extinction of both species.

In Chapter 4 and 5 techniques are developed to detect and continue globally connecting orbits and their bifurcations in three-dimensional food chain models. These techniques have been applied successfully to the 3D Rosenzweig-MacArthur model, where the region of chaos is partly bounded by the bifurcation of a cycle-to-cycle connection, while the bifurcation of a point-to-cycle connection forms the boundary of a region with bistability properties.

In Chapter 6 we have considered a small food chain of an aquatic environment with in- and outflux. The system can display bistability properties that occur through the addition of non-lethal toxicants, that in turn disappear through a global bifurcation, resulting in the extinction of one or several species.

In Chapter 7 several food chain models, and the global bifurcations that occur in them, are evaluated. In all evaluated cases multi-stability is replaced by only one type of stable behaviour after the occurrence of a homoclinic connecting orbit. In a three-dimensional food chain model it is found that the Shil'nikov bifurcation plays the organising role in the generation of chaos, while two cycle-to-cycle homoclinic connections form the boundary for the chaotic attractors.