Stochastic Models of Food Web Structure

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Abstract

An important problem in ecology is to depict the shape of the complex networks of feeding connections, known as food webs. Several models for food webs have been proposed in the past two decades. Those models almost all rely on two common parameters, the numbers of species and trophic links, as well as assuming that species are prearranged in some geometrical order.

We propose a model to develop food webs by a mechanism of resource transfer. Different from other model using geometrical approach, we assume that species emerge in a chronological order. Each time we choose randomly one of the existing species or let a new species enter the system. In the case of new species, it randomly takes over either an unoccupied resource or a resource already taken by another species. In the other case, we choose randomly an existing species and create a copy of the species, and then let it randomly takes a resource taken by those species in lower trophic levels. Species in each column of resource form a food chain and a food web is constructed by the combination of these food chains.

This model is based on the fish tank model we proposed previously. The original model only relies on the size of the “tank”. In the new model we freely manipulate the expected waiting time of putting a “fish” into the tank. We find out that the sequence of the expected waiting time of new species emerging strongly affect the shape of the food web generated. For instance, if the sequence is increasing then the shape is likely close to a pyramid; if the sequence increases and then decreases, then the food web is likely to have a narrow waist. We test the performance of new model with real food webs. It fits much better than the original model in many important food web properties.