Scientists find universal rules for food-web stability

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The findings, published in this week's issue of *Science*, conclude that food-web stability is enhanced when many diverse predator-prey links connect high and intermediate trophic levels. The computations also reveal that small ecosystems follow other rules than large ecosystems: differences in the strength of predator-prey links increase the stability of small webs, but destabilize larger webs.

Natural ecosystems consist of interwoven food chains, in which individual animal or plant species function as predator or prey. Potential food webs not only differ by their species composition, but also vary in their stability. Observable food webs are stable food webs, with the relationships between their species remaining constant over relatively long periods of time.

Understanding complex systems such as food webs present major challenges to science. They can either be examined by observing natural environments, or by computer simulations. To enable computer simulations of such systems, scientists often have to make simplifying assumptions, keeping the number of model parameters as low as possible. Yet, the computational demands of such simulations are high and their relevance is often limited.

Innovative methodology

Scientists from the Max Planck Institute for the Physics of Complex

Systems (MPIPKS) in Dresden, Germany, have developed a new method that allows them to efficiently analyze the impact of innumerable parameters on complex systems.

"By using a method called generalized modeling, we examine whether a given food web can, in principle, be stable, i.e., whether its species can coexist in the long term," says Thilo Gross from MPIPKS. Complex ecosystems can thus be simulated and analyzed under almost any conditions. "In this way we can estimate which parameters will keep ecosystems stable and which will upset their balance."

The method can also be used for examining other complex systems, such as human metabolism or gene regulation.

Generalists stabilize, specialists destabilize

Applying this innovative modeling approach together with colleagues at the International Institute for Applied Systems Analysis (IIASA) in Laxenburg, Austria, and Princeton University, USA, the scientists have succeeded in discovering not just one, but several universal rules in the dynamics of ecosystems.

"Food-web stability is enhanced when species at high trophic levels feed on multiple prey species and species at intermediate trophic levels are fed upon by multiple predator species," says Ulf Dieckmann of IIASA.

The scientists have also identified additional stabilizing and destabilizing factors within ecosystems. Ecosystems with high densities of predator-prey links are less likely to be stable, while a strong dependence of predation on predator density destabilizes the system. On the other hand, a strong dependence of predation on prey density has a stabilizing impact on food webs.

Differences between small and large systems

A further important finding is that food webs consisting of only a few species behave qualitatively different from webs consisting of many species.

"Small ecosystems apparently follow different rules than large ecosystems," says Ulf Dieckmann. "Systems with fewer species are more stable if there are strong interactions between some species, but only weak interactions between others. For food webs with many species, exactly the opposite is true. Extremely strong or weak predator-prey links in nature should therefore be the rarer the more species a food web contains," he concludes.

Source: Max-Planck-Gesellschaft (news : web)

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