Networks under the microscope, buffering perturbations.

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Connectivity is an important characteristic in many systems, from landscapes to food webs. The more connected a systems is, the easier is the flow of individuals or biomass across the system. However, connectivity is a two-edged sword. When facing a perturbation, it spreads through the very same routes that in normal conditions are beneficial to the system. Therefore, how can we engineer a system that minimizes perturbation spread while keeping a high connectivity?

Theoretical approaches to this question seem to encounter the answer in systems organized in compartments or modules. The constituent nodes of those systems are organized in compartments where nodes within a compartment tend to be connected among themselves while showing much fewer connections with nodes from other compartments. However, the consequences of a modular system have never been explored empirically.

Here, we develop a microcosm experiment to measure how a perturbation spreads through a network. Hundreds of individuals of an arthropod species, Folsomia candida, live in the nodes and disperse freely between them. As a perturbation we severely diminish population size at a local patch. We record the spatiotemporal dynamics of the system before and after a perturbation occurs. For that, we use state-of-the-art image recognition techniques.

We observe that, as predicted theoretically, the perturbation gets buffered by the modular structure of the network. Specifically, at the same topological distance, the number of individuals is smaller in the nodes that belong to the module where the perturbation occurs. Moreover, the perturbation not only affects the number of individuals, it also affects the variability in population dynamics. The standard deviation of the local time series is also reduced. This effect is also buffered by the modular network structure.

One may think that the benefit of a modular structure comes at a cost. It may reduce the total number of individuals inhabiting the network, in the same way that a reduction of the landscape connectivity. However, when comparing networks of the same size but different modularity we observe no trend in the number of individuals, but we do observe an increasing benefit in the buffering effect after a perturbation. These results help us to create more robust configurations, in the context as for example designing protected areas. They can also help us to better understand the consequences of possible changes in the structure of a biological network.