Insights into resource consumption, cross-feeding, system collapse, stability and biodiversity from an artificial ecosystem

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Community ecosystems at very different levels of biological organization often have similar properties. Coexistence of multiple species, cross-feeding, biodiversity and fluctuating population dynamics are just a few of the properties that arise in a range of ecological settings. Here we develop a bottom-up model of consumer-resource interactions, in the form of an artificial ecosystem "number soup", that reflects basic properties of many bacterial and other community ecologies. We demonstrate four key properties of the number soup model: (1) Communities self-organise so that all available resources are fully consumed; (2) Reciprocal cross-feeding is a common evolutionary outcome, which evolves in a number of stages, and many transitional species are involved; (3) The evolved ecosystems are often "robust yet fragile", with keystone species required to prevent the whole system from collapsing; (4) Non-equilibrium dynamics and chaotic patterns are general properties, readily generating rich biodiversity. These properties have been observed in empirical ecosystems, ranging from bacteria to rainforests. Establishing similar properties in an evolutionary model as simple as the number soup suggests that these four properties are ubiquitous features of all community ecosystems, and raises questions about how we interpret ecosystem structure in the context of natural selection.

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[1] Yu Liu, David Sumpter, J. R. Soc. Interface 2017 14 20160816; DOI: 10.1098/rsif.2016.0816