Title:	Balance of interactions determines optimal survival in multi-species communities
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Abstract:	We consider a multi-species community modelled as a complex network of populations, where the links are given by a random asymmetric connectivity matrix J, with fraction 1 − C of zero entries, where C reflects the over-all connectivity of the system. The non-zero elements of J are drawn from a Gaussian distribution with mean μ and standard deviation σ. The signs of the elements Jij reflect the nature of density-dependent interactions, such as predatory-prey, mutualism or competition, and their magnitudes reflect the strength of the interaction. In this study we try to uncover the broad features of the inter-species interactions that determine the global robustness of this network, as indicated by the average number of active nodes (i.e. non-extinct species) in the network, and the total population, reflecting the biomass yield. We find that the network transitions from a completely extinct system to one where all nodes are active, as the mean interaction strength goes from negative to positive, with the transition getting sharper for increasing C and decreasing σ. We also find that the total population, displays distinct non-monotonic scaling behaviour with respect to the product μC, implying that survival is dependent not merely on the number of links, but rather on the combination of the sparseness of the connectivity matrix and the net interaction strength. Interestingly, in an intermediate window of positive μC, the total population is maximal, indicating that too little or too much positive interactions is detrimental to survival. Rather, the total population levels are optimal when the network has intermediate net positive connection strengths. At the local level we observe marked qualitative changes in dynamical patterns, ranging from anti-phase clusters of period 2 cycles and chaotic bands, to fixed points, under the variation of mean μ of the interaction strengths. We also study the correlation between synchronization and survival, and find that synchronization does not necessarily lead to extinction. Lastly, we propose an effective low dimensional map to capture the behavior of the entire network, and this provides a broad understanding of the interplay of the local dynamical patterns and the global robustness trends in the network.
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