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On the stability of competitive ecological communities with pairwise and higher-order interactions

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The emergence of biodiversity in ecological communities remains a major open question in theoretical ecology, leading to a fundamental inquiry: what mechanisms support the stability and coexistence of species within these ecosystems? Traditional ecological models have largely been based on the assumption that species primarily engage in pairwise interactions. However, interactions in ecological systems may involve groups of three or more individuals –i.e. higher-order interactions. As a result, the question of how the combined effects of pairwise and higher-order interactions shape the stability of large ecological communities remains unresolved. With this work, we address this gap by analyzing a model of competitive communities that incorporates both types of interactions at the same time. Using analytical techniques and numerical simulations, we find that higher-order interactions alone are not always sufficient to foster and maintain coexistence. When species are identical (i.e., have the same physiological rates), even a small proportion of higher-order interactions can stabilize their dynamics. However, when more realistic factors–such as heterogeneous birth and death rates or complex interaction structures–are introduced, even a large fraction of higher-order interactions may not be sufficient to achieve stable coexistence. Our findings challenge the role of higher-order interactions as a universal stabilizing mechanism in ecological communities and open new avenues for research into the interplay of different factors that underpin biodiversity and ecosystem stability.

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