

Meta-analysis using new methods for three-stressor combinations reveal substantial higher-order interactions and emergent properties

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Abstract

Although natural populations are typically subjected to multiple stressors, most past research has focused on single stressors and two-stressor interactions, with little attention paid to higher-order interactions among three or more stressors. However, higher-order interactions increasingly appear to be widespread. Consequently, we used a recently introduced and improved framework to re-analyze higher-order ecological interactions. We conducted a literature review of the last 100 years (1920-2020) and reanalyzed 151 ecological three-stressor interactions from 45 published papers. We found that 89% (n=134) of the three-stressor combinations resulted in new or different interactions than previously reported. We also found substantial levels of emergent properties—interactions that are only revealed when all three stressors are present. Antagonism was the most prevalent net interaction whereas synergy was the most prevalent emergent interaction. Understanding multiple stressor interactions is crucial for fundamental questions in ecology and also has implications for conservation biology and population management.

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