Microbial community ecosystem network model for chemical energy transport

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Abstract

Microorganisms thriving in low-energy ecosystems have evolved diverse strategies to sustain life, including individual-level energy conservation, optimizing energy utilization through interspecies competition, and mutually beneficial interspecies syntrophy. This study introduces a novel community-level strategy to enhance energy efficiency. We employed an oxidation-reduction (redox) reaction network model to capture the intricate metabolic interactions within microbial communities. Our findings highlight the importance of microbial functional diversity in facilitating metabolic handoffs, leading to an improved energy utilization efficiency. Moreover, the mutualistic division of labor and the resulting complexity of redox pathways actively facilitate material cycling, thereby enhancing energy exploitation. These findings provide new insights into the potential of self-organized ecological interactions to develop efficient energy utilization strategies, with significant implications for the functioning and evolution of microbial ecosystems.

Keywords

community ecology, population dynamics, thermodynamics, bioenergetics, microbial ecology, network model, Gibbs energy, redox reactions

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Author contributions

M.S and M.K conceived of the presented idea. M.S designed the model and the computational framework and analyzed the data. M.S and M.K contributed equally to the interpretation of the results and writing the manuscript.

Conflicts of interest

The authors have declared that no competing interests exist.