Function and Structure of a Frequently Immigrated Microbial Community

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Systems Biology of Microbial Communities

Introduction

- Community-level migration is widespread in microbial ecology [1-2].
- Deterministic ecological interactions (such as competition and predation) and random events (such as immigration) combine to shape community dynamics, together with abiotic conditions [3-4].
- Microbial communities in similar environments show convergent function but divergent composition [5].

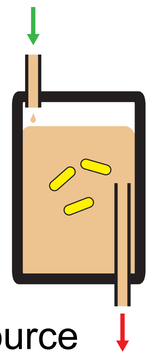
Question

How does migration shape community function and composition?

Model Description

Model Features

- MacArthur's consumer-resource model
- Top-down assembly in chemostat
- Migration from a regional pool
- Community-level migration (100 species)
- Cross-feeding of 10 resources
- Five functional groups with improved ability of using group-specific resource
- Thirty percents of probability of using a resource

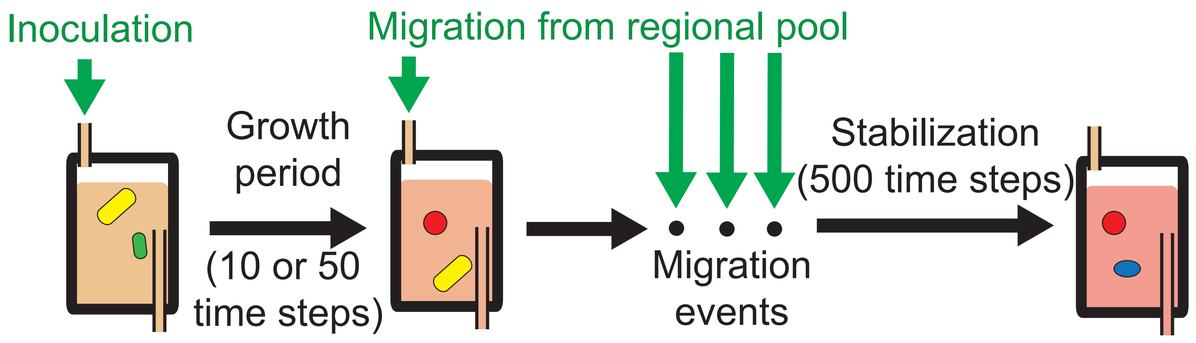


Constant flow and nutrient

Chemostate

Constant washout of microbes and nutrient

Migration diagram



Treatments

Low — Migration Effect — High

	No Migration	Migration #1	Migration #2	Migration #3	Migration #4
Migration Frequency (one per time step)	0	1/50	1/50	1/10	1/10
Number of Migration Event	0	10	20	10	20

- Each treatment has 20 replicates.

Result

Migration drives communities...

1. More efficient in converting supplied resources into biomass and evenly distributing resources at equilibrium.

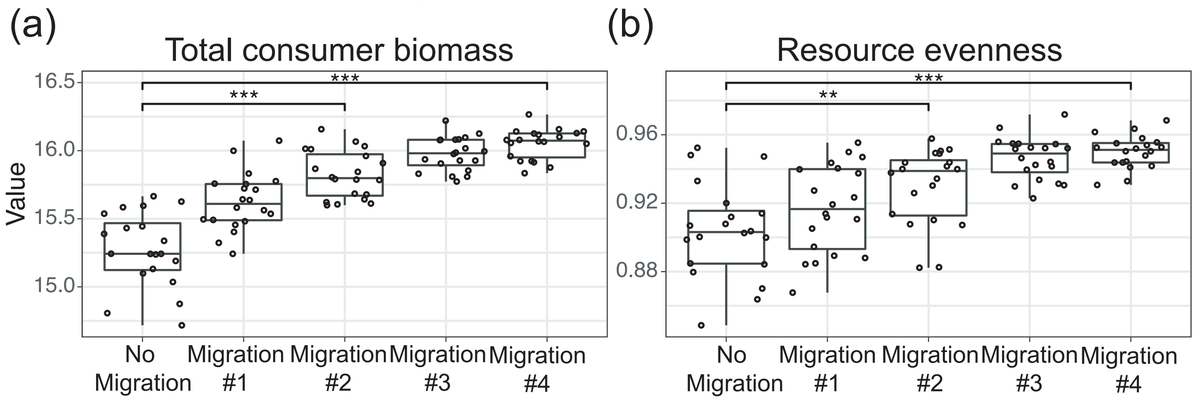


Figure 1. Total consumer biomass and resource composition at equilibrium.
(a) The sum of all consumer biomass at the equilibrium.
(b) Resource evenness at equilibrium. The maximal number of available resources is 10.

Migration drives communities...

2. Increasing species richness and divergent composition, but becoming functionally more convergent at equilibrium.

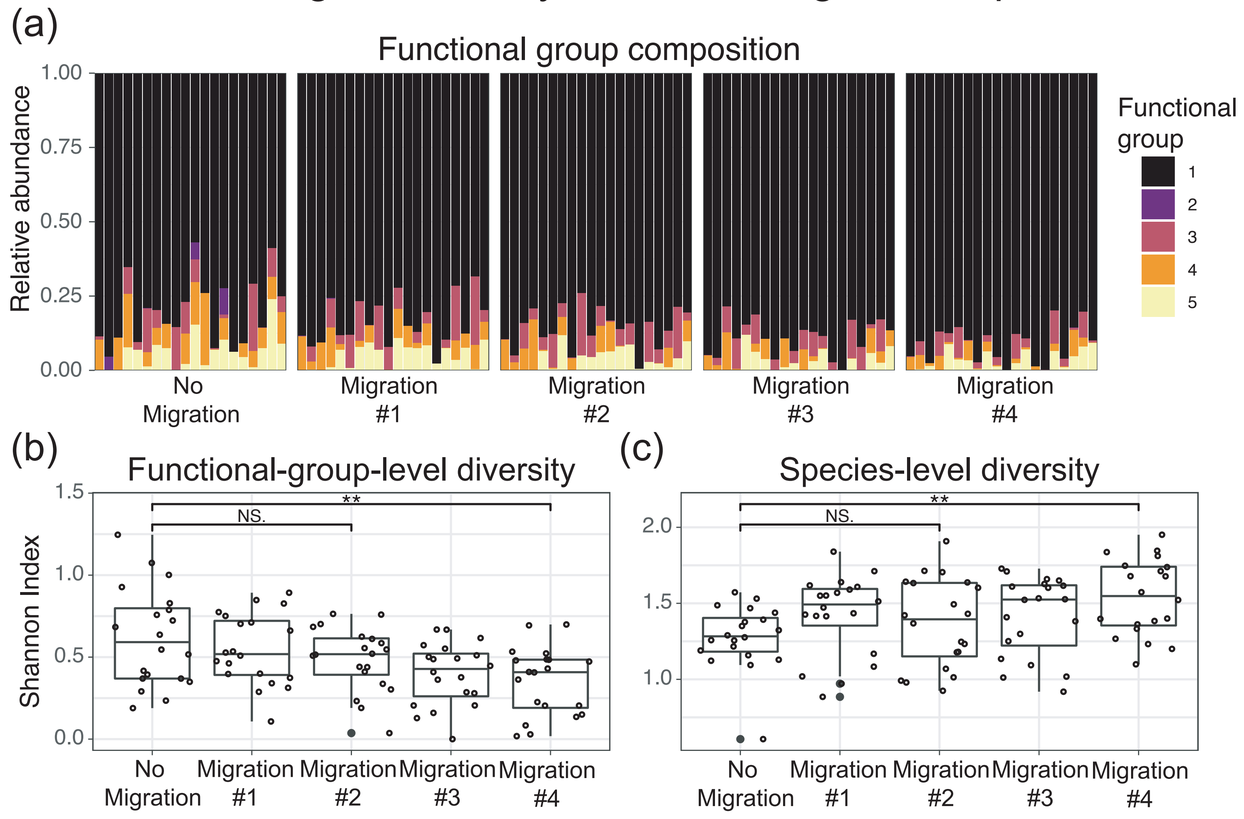


Figure 2. Community composition at equilibrium.
(a) Relative abundance of functional groups at equilibrium. Communities converge to the same functional-group-level composition with improved ability of using the single supplied resource.
(b) Functional-group diversity is represented by Shannon index of functional groups.
(c) Species-level diversity is represented by Shannon index of individual species.

3. Having higher survival rate during migration and lower probability of immigrants to invade.

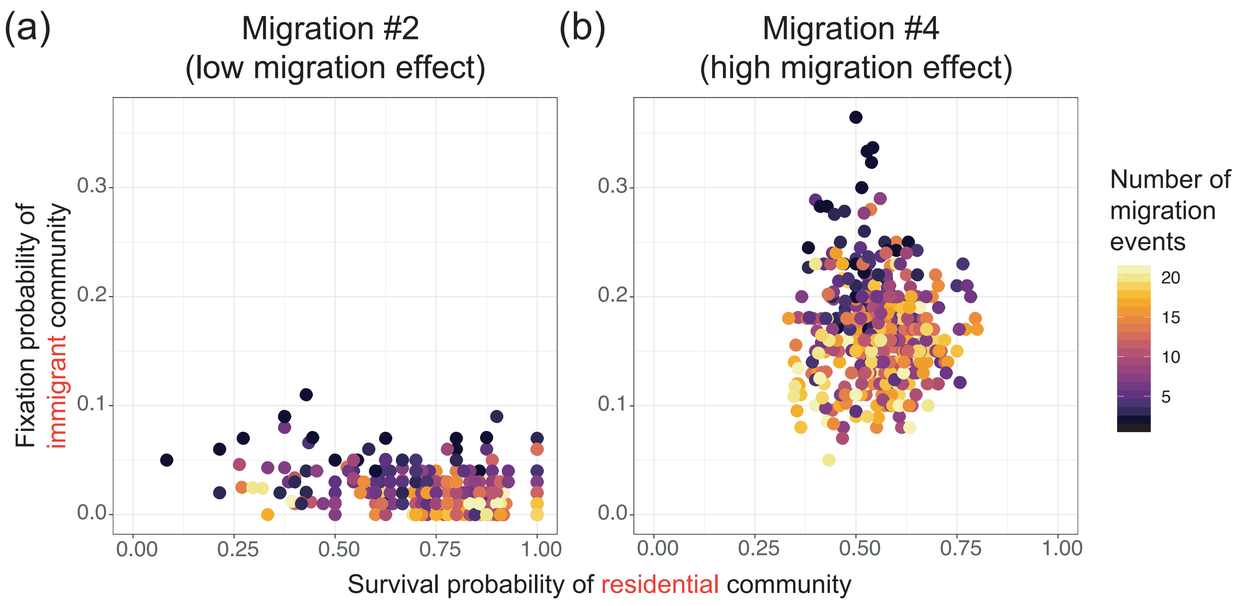


Figure 3. Residential community resistance to invasion versus the fixation of immigrant community. In every migration events, the size of residential community (richness) is measured, and 100 species in immigrant community. The survival (fixation) probability of residential (immigrant) community is measured by counting how many residential (immigrant) species still survive before the next migration events. The color of dots represents the time along migration events when probabilities are measured. Each treatment has 20 migration events.
(a) Migration treatment #2, less disturbed (migration frequency = 1/50) communities.
(b) Migration treatment #4, more disturbed (migration frequency = 1/10) communities.

Conclusion

- We have used consumer-resource models to top-down assemble a community with hundreds of species competing for a single supplied resource, and coexisting by cross-feeding metabolic secretions.
- Overall, our model suggests that high rate of community-level migration enhances community efficiency and species-level diversity, while at the same time reducing functional-group-level diversity and community resistance to invasion.

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Get interested? More details about this project and model are in my website. Scan the QR codes to check my twitter or website!
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