Local Dispersal Promotes Biodiversity in a Real-Life Game of Rock–Paper–Scissors

MATH40: Introduction to Applied Mathematics

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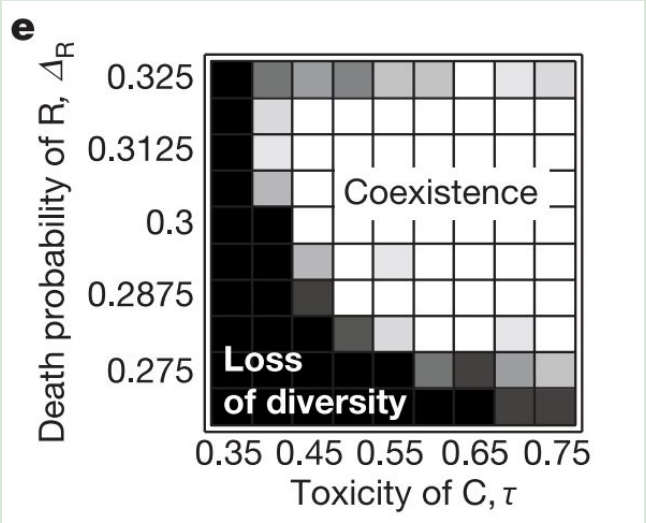
1 Introduction

Overview of the Study



Study's Focus: how local dispersal mechanisms maintain biodiversity

Methodology: using mathematical models to stimulate species interactions
Explores varying dispersal strategies and their impact on biodiversity

Goals: highlight the relationship between dispersal rate and species coexistence
Connect findingsto game theory and concepts

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Motivations

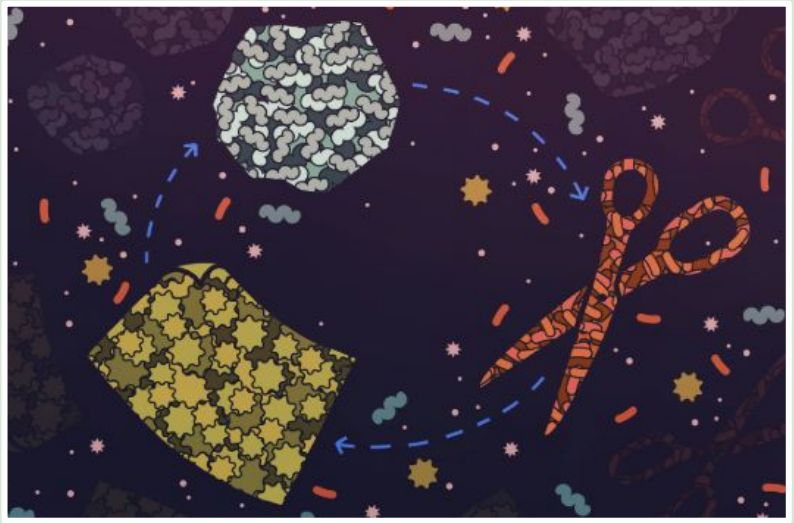
Why do this study?

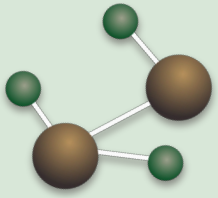
Motivations

Importance of Biodiversity:
Crucial for ecosystem stability and resilience
Often threatened by competitive exclusion and environmental changes

Modeling:
Mathematical modeling allows scientists to study these relationships with larger datasets and develop a new more complex understanding

Relevance:
To provide insights for conservation and ecosystem management efforts



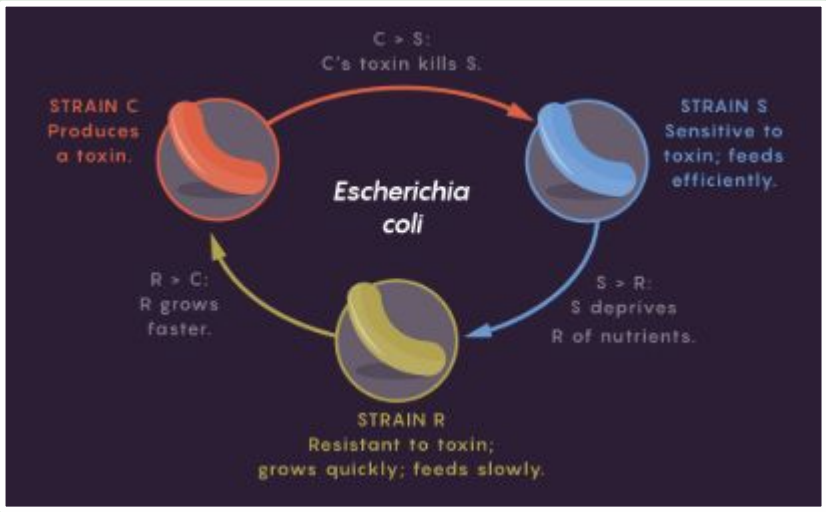


How does local dispersal enable biodiversity in competitive ecosystems?

How can these dynamics be modeled and interpreted through the lens of game theory?

3 Methodology

Methodologies



Authors used a spatially explicit model of species interaction where individuals disperse locally and compete for resources

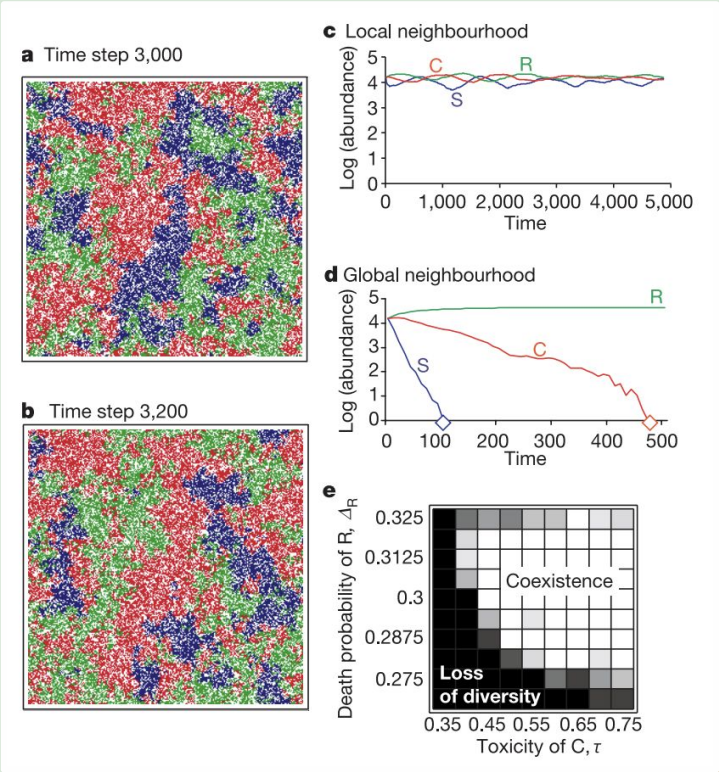
Model includes parameters for dispersal distance, competition intensity, and environmental heterogeneity

4

Analysis

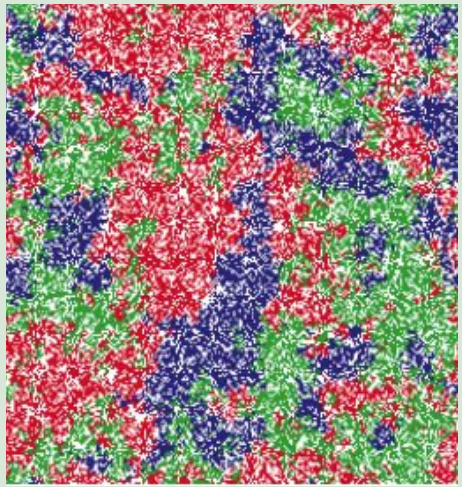
Analysis and Results

- Non-transitive relationships in microbial communities
- Spatial Scale and Biodiversity:
  - Localized Processes
  - Global Processes
- Experimental Environments:
  - Static plate
  - Flask
  - Mixed plate
- Local dispersal and non-hierarchical relationships crucial for biodiversity in microbial, plant, and marine communities.

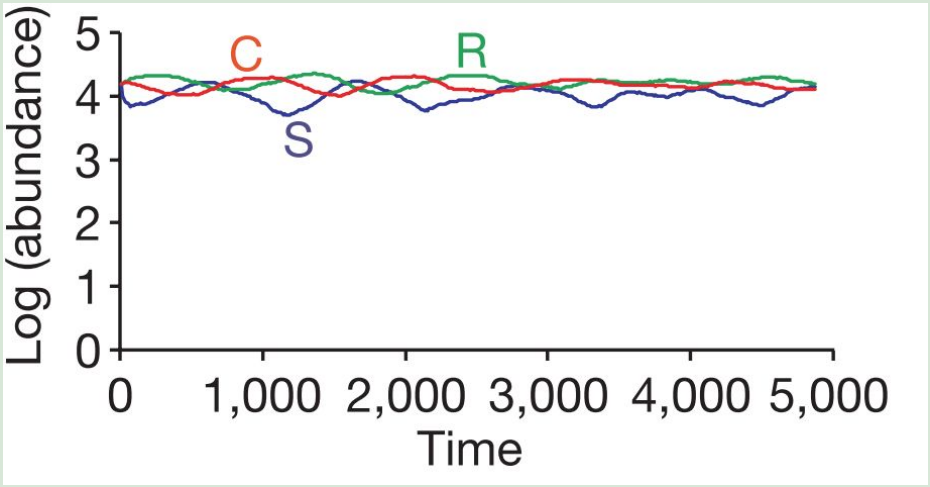


5 Extension of the Model

Given Applications



Snapshot of the lattice in a local neighborhood; 3,000 time step

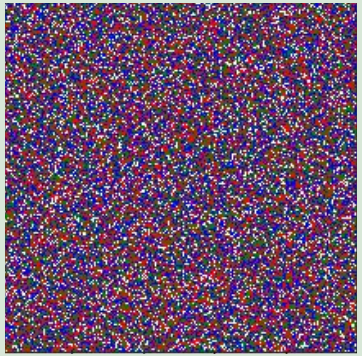


The resulting densities of the populations of each community.

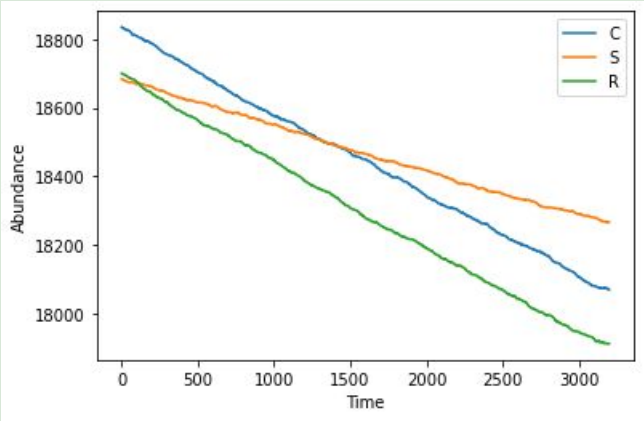
Computational Applications

```
def create_lattice(sz, prob):
    lattice = np.random.choice(["C", "S", "R", "E"], size = sz, p = prob)
    return lattice
```

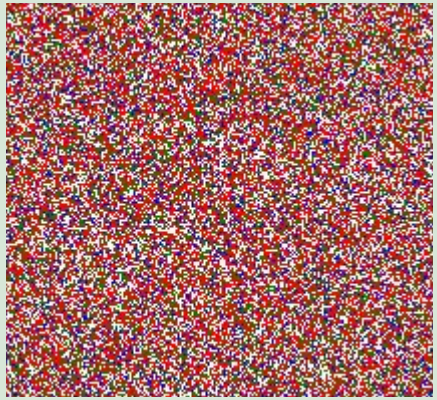
```
size = (250,250)
probs = [0.30, 0.30, 0.30, 0.10]
death_rates = {"C": .05, "S": 0.05, "R": 0.05}
effect = .3
steps = 3200
```



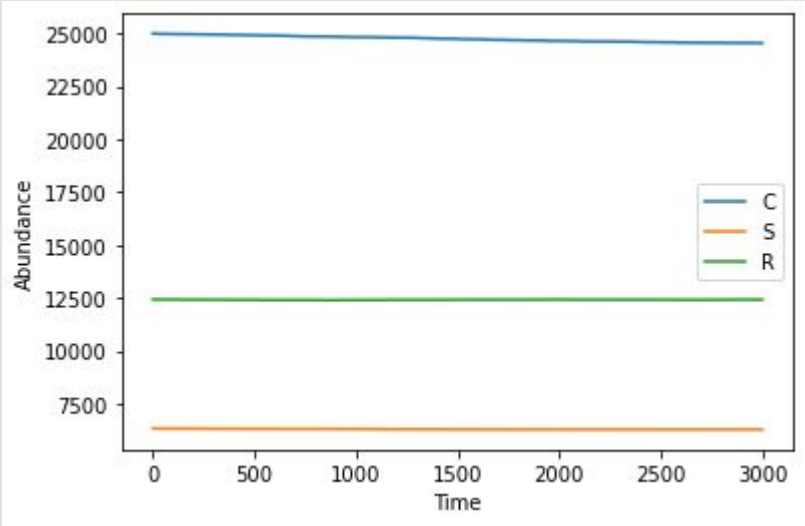
Randomized initial lattice with fixed death rates results in a very random lattice which does not replicate the trend from the paper. The graph shows a decline in all three populations.



Changes in Computations



```
size = (250,250)
probs = [0.40, 0.10, 0.20, 0.30]
death_rates = {"C": .01, "S": 0.05, "R": 0.08}
effect = .3
steps = 3000
```

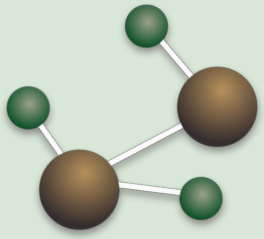


Larger differences in the random probabilities and death rates; in this case, C was assigned the larger probability and has the lowest death rate.

6 Conclusion

Conclusion

- Local dispersal promotes biodiversity by creating spatial refuges and mitigating direct competition.
- The findings highlight the importance of spatial structure in ecological systems.
- When modifying these results to fit more real world scenarios, we get different results from the methods in the paper due to the randomness of the populations and community interactions
- Game Theory:
  - Dispersal strategies can be viewed as players trying to optimize their fitness in a competitive game
  - Helps to explain the stability of coexistence at intermediate dispersal rates



Citations

Arnold, Carrie, et al. “Biodiversity May Thrive through Games of Rock-Paper-Scissors.” *Quanta Magazine*, Quanta Magazine, 13 July 2021, www.quantamagazine.org/biodiversity-may-thrive-through-games-of-rock-paper-scissors-20200305/.

Kerr, Benjamin, et al. *Local Dispersal Promotes Biodiversity in a Real-Life Game of Rock–Paper–Scissors*, vol. 418, no. 6894, July 2002, pp. 171–174, https://doi.org/10.1038/nature00823.