THE ROLE OF RELATIVE NONLINEARITY IN STABILIZING COEXISTENCE

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08/05/2009
Lottery model

- Study systems: iteroparous populations
  - Coral reef fishes
  - Perennial plant community
- Lottery competition: space as limiting resources
  - Juveniles competing for available space left by dead individuals
Recruitment variation and population dynamics

— example from coral reef fishes

Data from Robertson, 1995
Recruitment variation and population dynamics ——example from coral reef fishes

Environmental response: Reproduction

Competitive Response: Mortality at recruitment because space is limited

Fluctuation Insensitive: Adult Survival

RECRUITED LARVAE

JUVENILES

ADULTS

Environmental Response: larval survival
Coexistence mechanisms arising from recruitment fluctuations
Exogenous fluctuations give rise to two distinct coexistence mechanisms

1. **The storage effect**
   - Temporal niche partitioning
   - *Species-specific environmental response*
   - Covariance between environment and competition
   - Buffered population growth

**Species-specific environmental response**

Data from Robertson, 1995
Exogenous fluctuations give rise to two distinct coexistence mechanisms

2. Relative nonlinearity

- Species have growth rates of different curvature as a function of the magnitude of competition
- Difference in death rate

Total competition in the community from all individuals due to limiting resources
How Relative nonlinearity promotes coexistence
e.g. perennial vs annual

When Species 2 is abundant, it drives large fluctuations in competition
How Relative nonlinearity promotes coexistence 
e.g. perennial vs annual

When **Species 1** is abundant, it reduces the fluctuation in competition
Relative nonlinearity: e.g. perennial vs annual
----- how it promotes coexistence

- Both species drive fluctuations in competition in a direction that favors the other species
Criteria for coexistence

- Stable coexistence: each species can recover from low density
- Recovery rate = Average Fitness difference
  + The storage effect
  + Relative nonlinearity

- Stabilizing effect
  \[ >0 \text{ stabilize coexistence} \]
  \[ <0 \text{ destabilize coexistence} \]
Criteria for coexistence

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- Recovery rate = Average Fitness difference + Stabilizing effect

- Stabilizing effect
  - >0 stabilize coexistence
  - <0 destabilize coexistence
Hypotheses: what makes relative nonlinearity important?

- Factors affecting the relative importance of the two mechanisms
  - Differences between adult death rates
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  - Species differences in sensitivities to the environment (differences between the variances of the environmental responses)
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- Factors affecting the relative importance of the two mechanisms
  - Differences between adult death rates
  - Correlations between environmental responses
  - Species differences in sensitivities to the environment (differences between the variances of the environmental responses)
Results: magnitude of environmental fluctuations

- **Stabilizing effect** increases with magnitude of environmental fluctuation.
Results: magnitude of environmental fluctuations

- But magnitude of environmental fluctuations changes both mechanisms proportionally.
Results: differences in death rate

- The importance of relative nonlinearity increases with differences between adult death rates.
Results: differences in death rate

- The importance of relative nonlinearity increases with differences between adult death rates.
Results: correlation between environmental responses

- The importance of relative nonlinearity increases with the correlation between the environmental responses (synchrony between species).
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Results

- The importance of relative nonlinearity increases with species’ differences in sensitivity to environmental fluctuations
  - Common sensitivity to environment fluctuations
  - Shorter-lived species has higher sensitivity

![Graph showing correlation between environmental responses and relative magnitude.](chart.png)
Results: Species specific sensitivities in environmental fluctuation

- Relative nonlinearity does not always stabilize coexistence
- Stabilizes when shorter-lived species are more sensitive to environmental fluctuations
Results: Species specific sensitivities in environmental fluctuation

- Relative nonlinearity does not always stabilize coexistence
- Destabilizes when shorter-lived species are less sensitive to environmental fluctuations
Conclusions about relative nonlinearity

- ‘Weaker’ mechanisms can be stronger, under narrow restrictions
  - mostly relative nonlinearity is weaker than the storage effect

- The increasing importance of relative nonlinearity is characterized by a weakening of the storage effect

- Relative nonlinearity can also easily be a destabilizing mechanism
  - The Storage effect plays a positive role much more often than relative nonlinearity

- Further research is needed to understand the full complexities of relative nonlinearity
Acknowledgement!

- Jessica Kuang
- Barbara Byrne
- Everyone in the Chesson lab
- Department of Ecology and Evolutionary Biology, University of Arizona
- Science Foundation Arizona
- National Science Foundation