Structural changes within trophic levels are constrained by within-family assembly rules at lower trophic levels

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08/07/2018, ESA Annual Meeting
Replay the tape of life & Historical contingency

Observed world
- Panda
- Cat
- Owl
- Bird

Observed arrival order

Alternative worlds
- Bird
- Cat
- Bear
- Owl

Alternative arrival order

Stephen J. Gould
Q1: How does the observed arrival order affect community persistence?

Q2: In which alternative worlds can we detect the same effect?
A 2000-year long registry of plant arrivals
Temporal structure of herbivore-plant community
Introduction year of non-native plants over 2000 years

Year 0

Arrival oder

Year 2000BC
Structure of herbivore-plant community at each time

Arrival order
Structure of herbivore-plant community changes with new introduced plant
How does changes in community structure affect community persistence?
What is Structural Stability of Persistence?

- The full range of environmental conditions (parameter values) compatible with the persistence of an ecological community
Larger structural stability = Better chance to persist

May, Stability in ecosystems: some comments (1975)
How to quantify structural stability

Environmental conditions compatible with persistence

Community dynamics

Species abundance interaction strength

\[
\frac{dX_i}{dt} = X_i(r_i + \sum_{j=1}^{S} a_{ij} X_j)
\]

intrinsic growth rate

Community structure

Structural stability := Green area
Blue area

Song et al., *J. of Theoretical Biology* (2018)
Structural stability generally increased as the community assembled over 2000 years.
Would this positive trend be detected in any alternative world?
A universe of alternative worlds with purely random arrival orders

Observed arrival order of plants

- Random reshuffling the order

Group X

Group Y
Structural stability is most likely to decrease if the arrival order is purely random.
In which alternative worlds can we detect the observed positive trend?
Universes of alternative worlds with assembly rules of plant arrivals

- Random reshuffling the order

- Preserving the order of families (Niche Modification)

- Preserving the order within families (Niche Preemption)
Which assembly rule can exhibit the observed trend?

Correlation between structural stability and year

Naive randomization

Across families

Within families

Observed correlation
Arrival order of closely related (but not of distantly related) plant species determines the observed trend.

- Observed arrival order of plants
  
  - Random reshuffling the order
  
  - Preserving the order of families (Niche Modification)
  
  - Preserving the order within families (Niche Preemption)
Take home message

• Q1: How does the observed arrival order affect community persistence?
  • A1: Structural stability generally increased as the community assembled over the time period of 2000 years
• Q2: In which alternative worlds can we detect the same effect?
  • A2: The order of introduction of closely-related (but not of distantly-related) plants is likely to be responsible for the observed increasing trend
Cover Caption: Tussock moth larva (Elkneria pudibunda) feeding on red oak (Quercus rubra), introduced to Europe about 300 years ago.
Photo Credit: Florian Altermatt
Saavedra S, Altermatt F, Pearse I.

Chulian Song, Florian Altermatt, Ian Pearse, Serguei Saavedra. "Structural changes within trophic levels are constrained by within-family assembly rules at lower trophic levels". *Ecology Letters*, 2018