Plant-Animal Mutualistic Networks: the Architecture of Biodiversity

Jordi Bascompte

http://bascompte.net
Biodiversity
Interactions
ON THE VARIOUS CONTRIVANCES OF WHICH BRITISH AND FOREIGN ORCHIDS ARE FERTILISED BY INSECTS, AND ON THE GOOD EFFECTS OF INTERTRELLING.

By CHARLES DARWIN, M.A., F.R.S., &c.

WITH ILLUSTRATIONS.

LONDON: JOHN MURRAY, ALBEMARLE STREET. 1862.

Ch. Darwin
May 7th 1874.
Mutualistic Networks
Outline

Describe network architecture

Consequences for:
  - species richness
  - network robustness
  - loss of evolutionary history
Network Structure

Bascompte, Jordano, Melián, and Olesen (2003). *PNAS* 100: 9383-9387
Bascompte, Jordano, Melián, and Olesen (2003). PNAS 100: 9383-9387
Number of Species

\[
\frac{dN_i^{(P)}}{dt} = \alpha_i^{(P)} N_i^{(P)} - \sum_{j \in P} \beta_{ij}^{(P)} N_i^{(P)} N_j^{(P)} + \sum_{k \in A} \frac{\gamma_{ik}^{(P)} N_i^{(P)} N_k^{(A)}}{1 + h^{(P)} \gamma_{ik}^{(P)} N_k^{(A)}}
\]

- **Intrinsic growth rate**
- **Direct competition**
- **Mutualistic interaction**
Number of Species

\[ c_{ij}^{(P)} = \delta_{ij} + \frac{1}{S^{(P)}} + R \left( \frac{1}{S^{(A)} + \bar{S}^{(A)}} \right) n_i^{(P)} n_j^{(P)} - n_{ij}^{(P)} \]

\[ \rho^{(P)} = f(\lambda_1) \]

\[ \bar{S}^{(P)} = \frac{1 - \rho^{(P)}}{\rho^{(P)}} \]

The higher nestedness, the lower the effective interspecific competition, and the higher the maximum biodiversity

Nestedness Increases Biodiversity

Biodiversity

Nestedness

Network Robustness

Rohr, Saavedra, and Bascompte (2014). Science, 345: 1253497
Network Robustness

Rohr, Saavedra, and Bascompte (2014). Science, 345: 1253497
Nestedness Increases Robustness

Rohr, Saavedra, and Bascompte (2014). Science, 345: 1253497
Coextinction Cascades

Evolutionary History

Phylogenetic Signal

Non-Random Coextinctions

Alexander Calder, 1943
Mutualistic Networks in Space

Jordi Bascompte
http://bascompte.net
Space: the Final Frontier in Ecology
Space: the Final Frontier in Ecology
Space: is the Devil in the Details?

Spatially implicit

Spatially explicit

Spatially realistic
Spatially implicit
Network Structure and Dynamics

\[
\begin{align*}
\frac{dp}{dt} &= c_{pa} a (1 - d - p) - e_p p \\
\frac{da}{dt} &= c_a a (p - a) - e_a a
\end{align*}
\]
Network Structure and Dynamics

Network Structure and Habitat Loss

Spatially explicit
$c_i = 1 - (1 - c)^2$
Spatial Network Disassembly

Fortuna, Krishna and Bascompte (2013) Oikos
Spatial Network Disassembly

Fortuna, Krishna and Bascompte (2013) Oikos

Number of Interactions

brink of extinction
pristine habitat
Early-warning signals for critical transitions

Marten Scheffer1, Jordi Bascompte2, William A. Brock3, Victor Brovkin5, Stephen R. Carpenter4, Vasilis Dakos1, Hermann Held8, Egbert H. van Nes1, Max Rietkerk7 & George Sugihara6

Complex dynamical systems, ranging from ecosystems to financial markets and the climate, can have tipping points at which a sudden shift to a contrasting dynamical regime may occur. Although predicting such critical points before they are reached is extremely difficult, work in different scientific fields is now suggesting the existence of generic early-warning signals that may indicate for a wide class of systems if a critical threshold is approaching.
Spatially realistic
1. Protecting interactions requires preserving more area.

2. Central nodes harbor more species and interactions

3. Central patches harbor more nested communities

Meanwhile, in the real world ...
Theory 

Field data

Spatial sampling

Number of species and interactions

Theory

Field data

Number of species and interactions

Patch centrality

Theory Field data

Local nestedness vs. Patch centrality

Centrality is a better predictor than area

<table>
<thead>
<tr>
<th></th>
<th>Number of species</th>
<th>Number of interactions</th>
<th>Nestededness</th>
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<tr>
<td>Patch Centrality</td>
<td>0.66</td>
<td>0.67</td>
<td>0.75</td>
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<td>Patch Area</td>
<td>0.37</td>
<td>0.12</td>
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From island biogeography ...
... to protecting interactions

“What escapes the eye, however, is a much more insidious kind of extinction: the extinction of ecological interactions.”

Daniel Janzen
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