

UQAR – Canada Research Chair in Ecosystem ecology

A quantitative framework for network biogeography

Dominique Gravel, Camille Albouy, Timothée Poisot

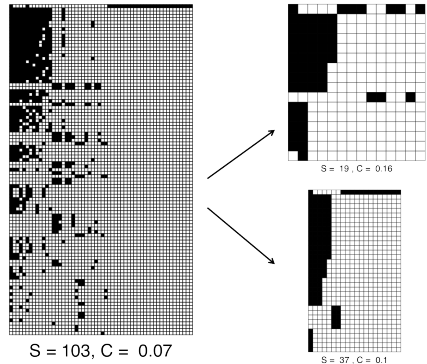
<http://www.chaire-eec.uqar.ca/>

August 13, 2014

Biogeography of ecological interactions

Challenge of getting network data at large spatial scales

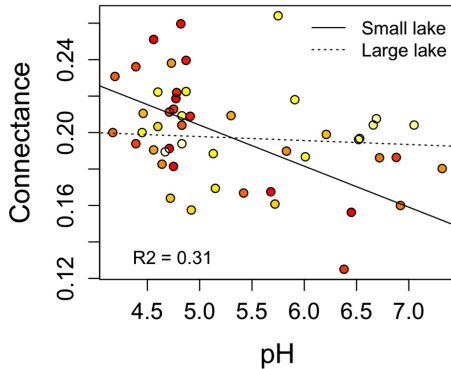
- Hard to document;
- Usually not replicated;
- Applies only to co-occurring species;
- Network structure is deterministic and stationary.



Gravel et al. (2011). *Ecol. Lett.*

Biogeography of ecological interactions

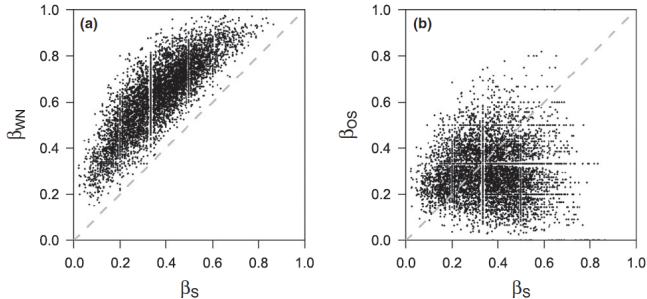
Networks over environmental gradients



Gravel et al. (2011). *Ecol. Lett.*

Spatial variation of interaction networks

Drivers of network variation



Poisot et al. (2012). *Ecol. Lett.*

Networks do vary in space because of:

- Species turnover;
- Link turnover;

Propose a quantitative framework to understand and predict the spatial variation in network structure at the biogeographical scale

Define the stochastic variable X_{iz} representing the occurrence of species i at location z .

And the variable L_{ijz} representing the occurrence of an interaction between species i and j at location z .

We are looking for the probability that an interaction occurs given the environment E_z :

$$P(L_{ijz} = 1, X_{iz} = 1, X_{jz} = 1 | E_z)$$

Obtained from the product rule we get:

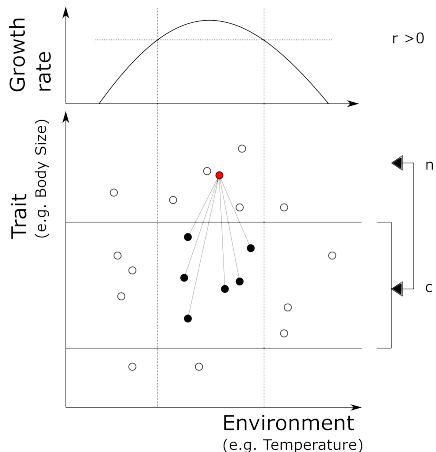
$$P(L_{ijz}, X_{iz}, X_{jz} | E_z) = P(L_{ijx} | X_{ix}, X_{jx}, E_z) P(X_{ix}, X_{jx} | E_z)$$

Where:

$P(L_{ijz} | X_{iz}, X_{jz} | E_z)$ is the metaweb

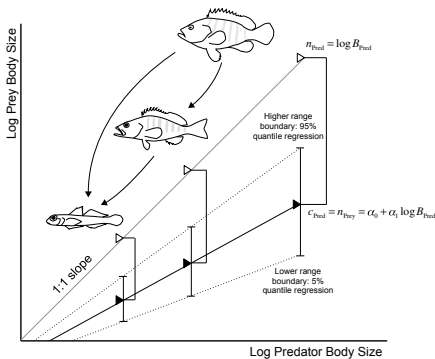
$P(X_{iz}, X_{jz} | E_z)$ is the co-occurrence matrix

$P(L_{ijx} | X_{iz}, X_{jz}, E_z)$ is the
Eltonian niche
 $P(X_{ix}, X_{jz} | E_z)$ is the
Grinnellian niche



The problem: inferring interactions for species that never co-occurred and with incomplete data

Inferring the metaweb from traits

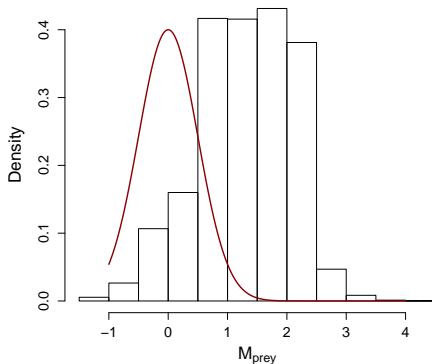


Gravel et al. (2013). *Meth. Ecol. Evol.*

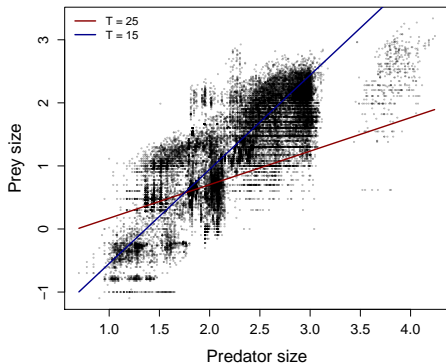
Bayesian formulation of the interaction probability

The likelihood function:

$$P(M_{prey} | L, E_z) = \frac{P(L_{ijz} | M_{prey}, M_{pred}, E_z) P(M_{prey})}{P(L | M_{pred})}$$

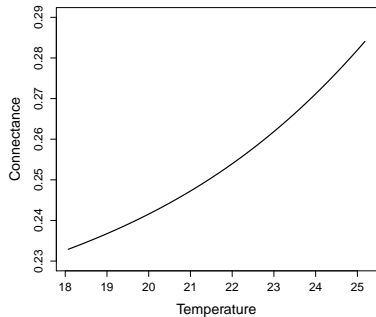
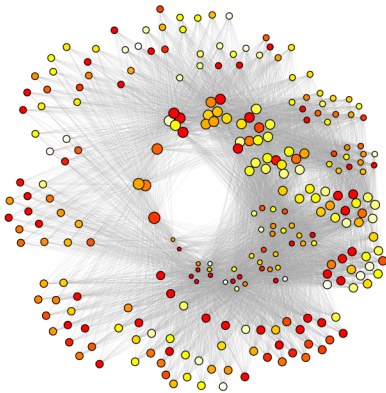


- Data from Barnes et al. (2008), Predator and prey body sizes in marine food webs, *Ecology* 86: 881;
- 34 931 recorded interactions;
- 25 sites.



Gibert and Delong (in press) *Bio. Lett.*

Effect of temperature on the metaweb

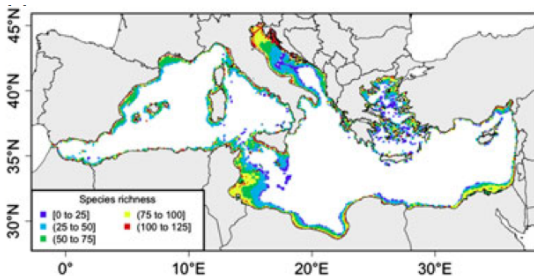


How to add the effect of species distribution on the network properties?

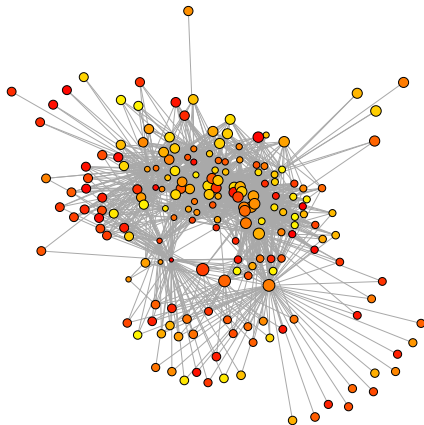
Distribution of Mediterranean fish networks

Neutral species
distribution:

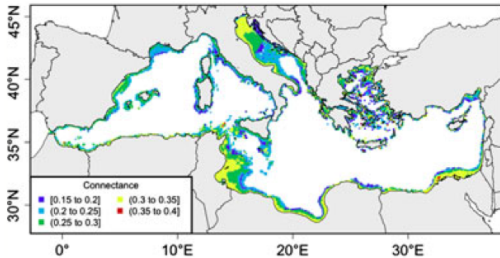
$$P(X_{iz}, X_{jz} | E_z) = \\ P(X_{iz} | E_z) P(X_{jz} | E_z)$$



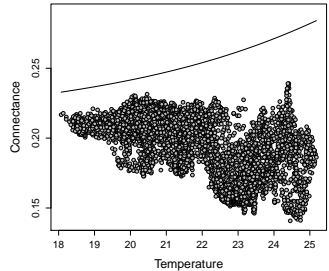
Albouy et al. (2014). *Glob. Change Biol.*



Mapping connectance



Albouy et al. (2014). *Glob. Change Biol.*

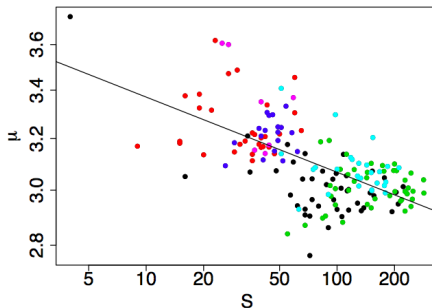


The multiple roles of the environment on network structure:

- Predator-prey body size relationship
- Regional species pool
- Species distribution

Additional sources of information:

- Phylogeny
- Feedback between interactions and co-occurrence
- Habitat area and isolation



Co-authors: SFI Working group on gradient-based network research; CIEE Working group on spatial variation in network structure

Funding: NSERC, FRQNT, Canada Research Chair program, Quebec Center for Biodiversity Sciences, Santa Fe Institute, UQAR, CIEE.