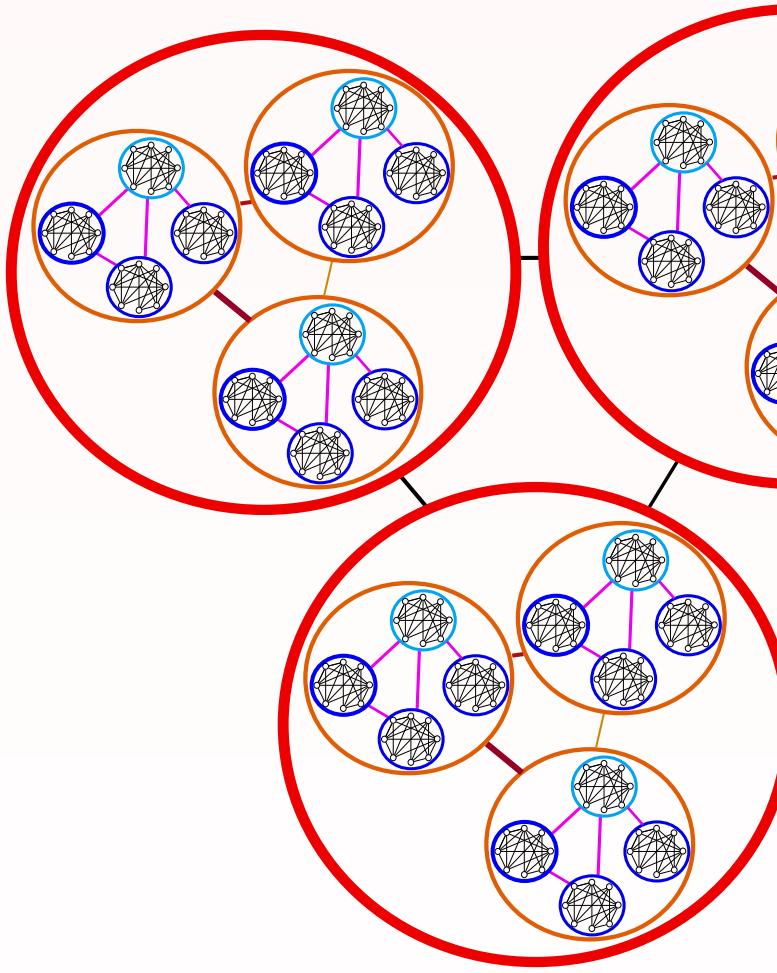
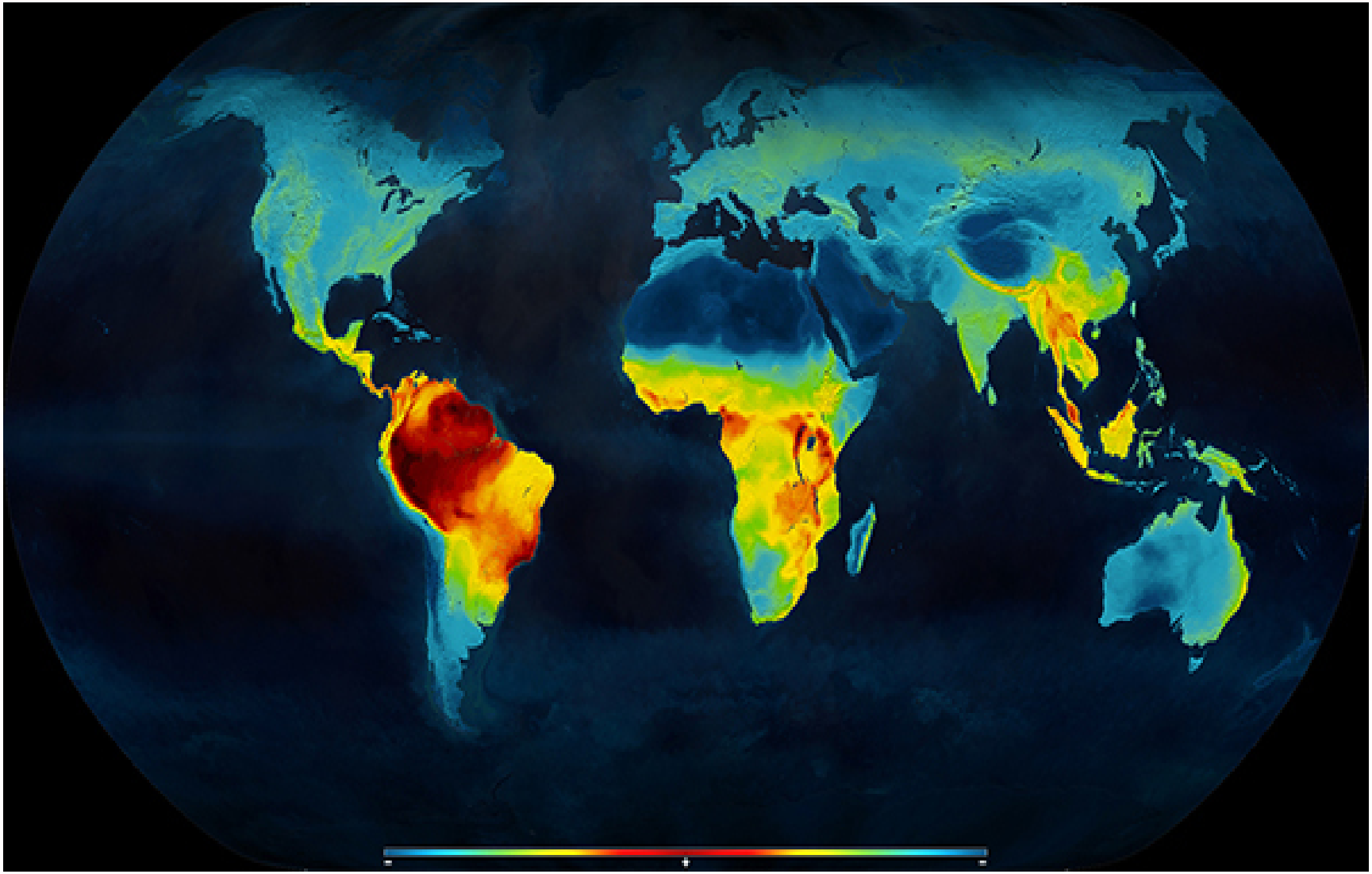
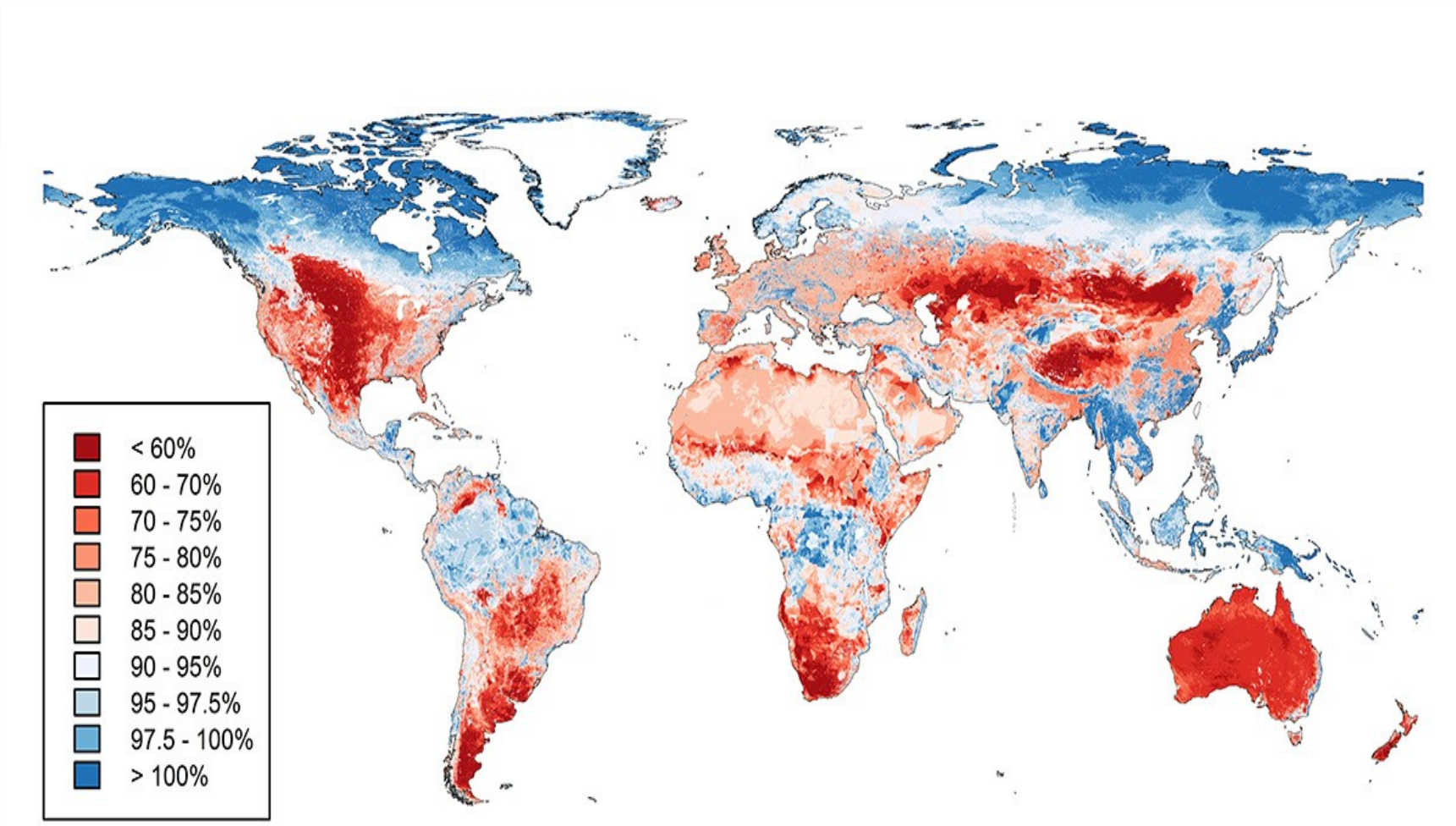
Carlos J. Melián
ETH-EAWAG
https://github.com/melian009

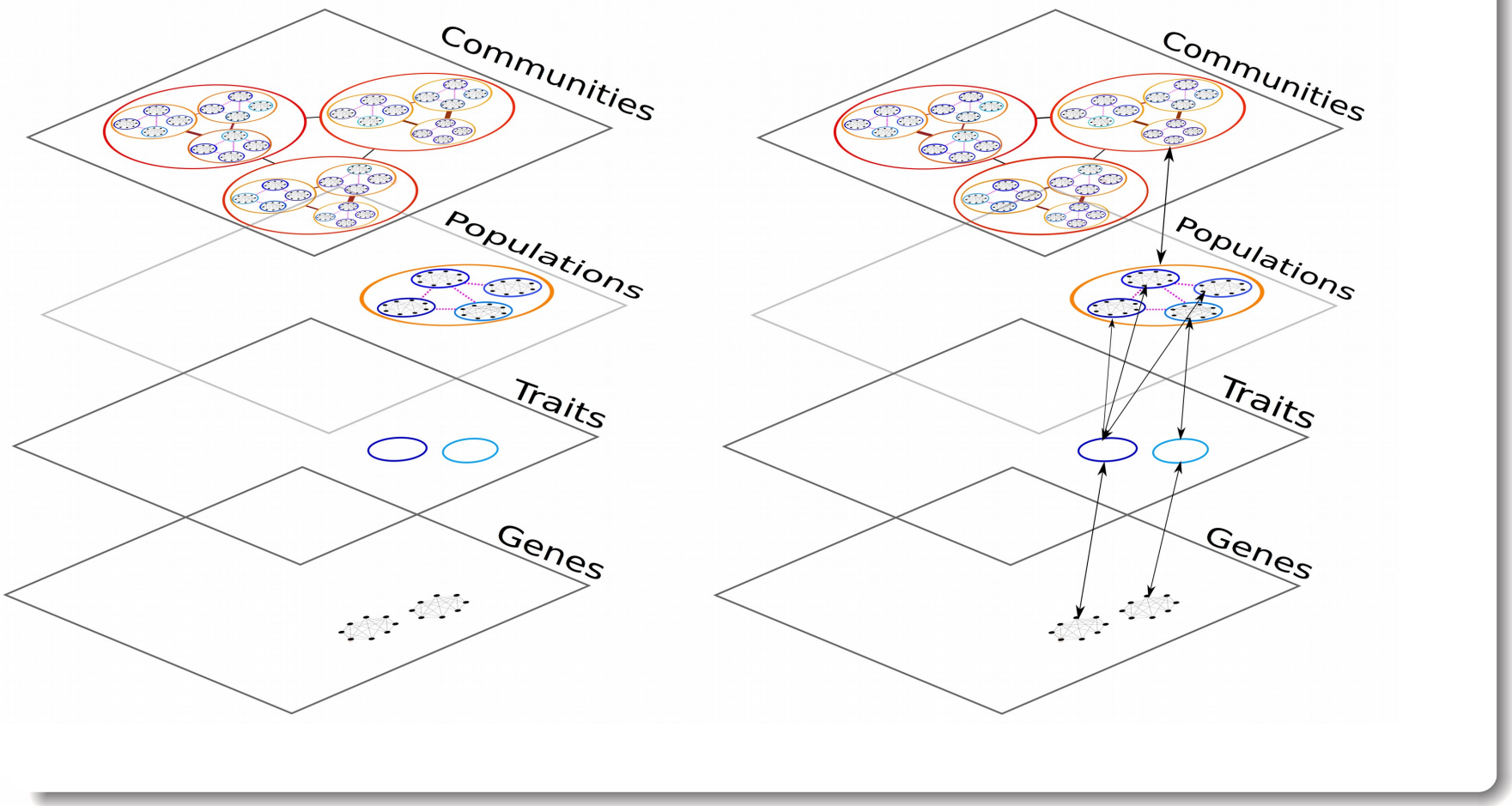
# Eco-Evolutionary Networks

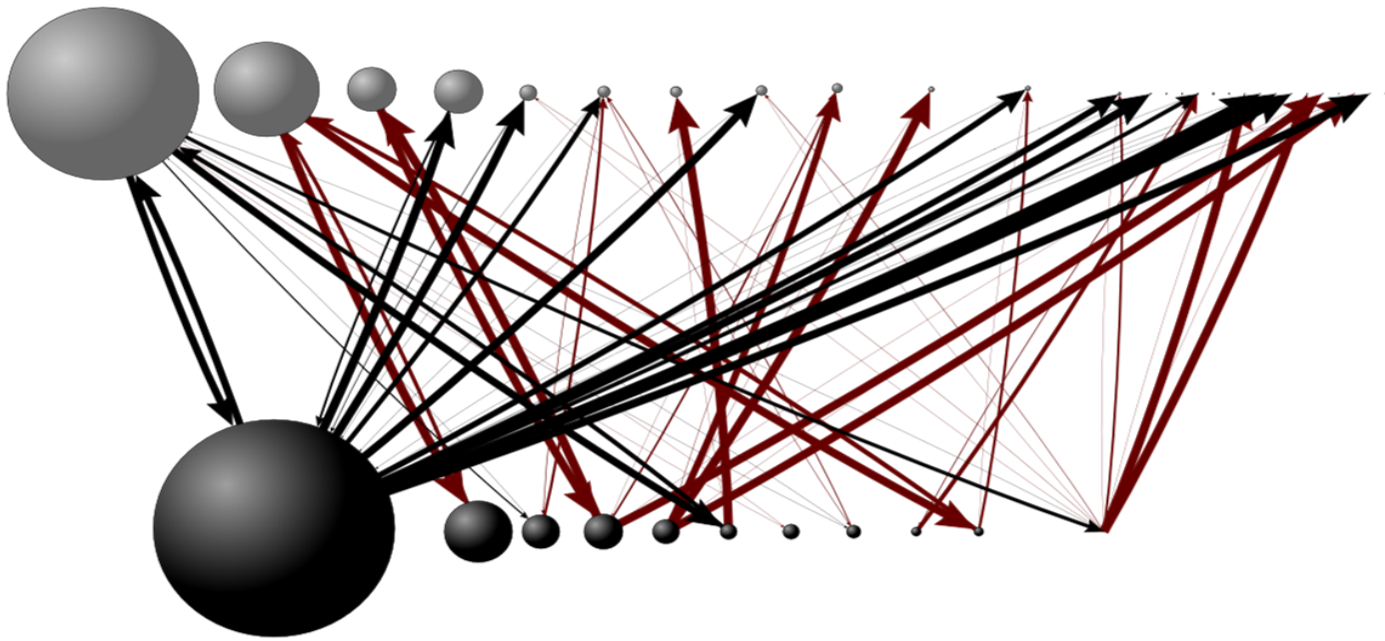
U. Zürich, 28 March 2019 – Ecological Networks BIO365

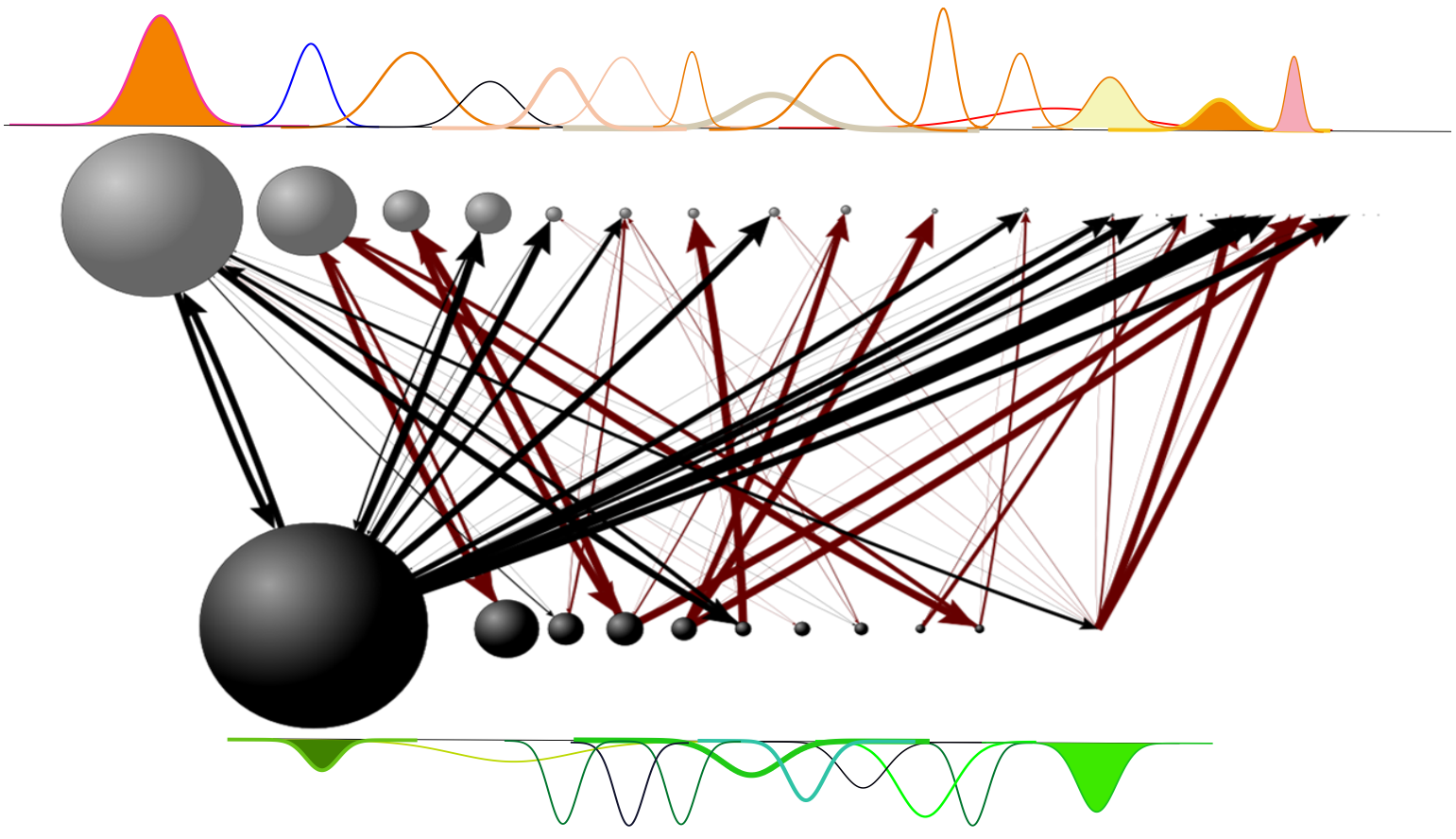


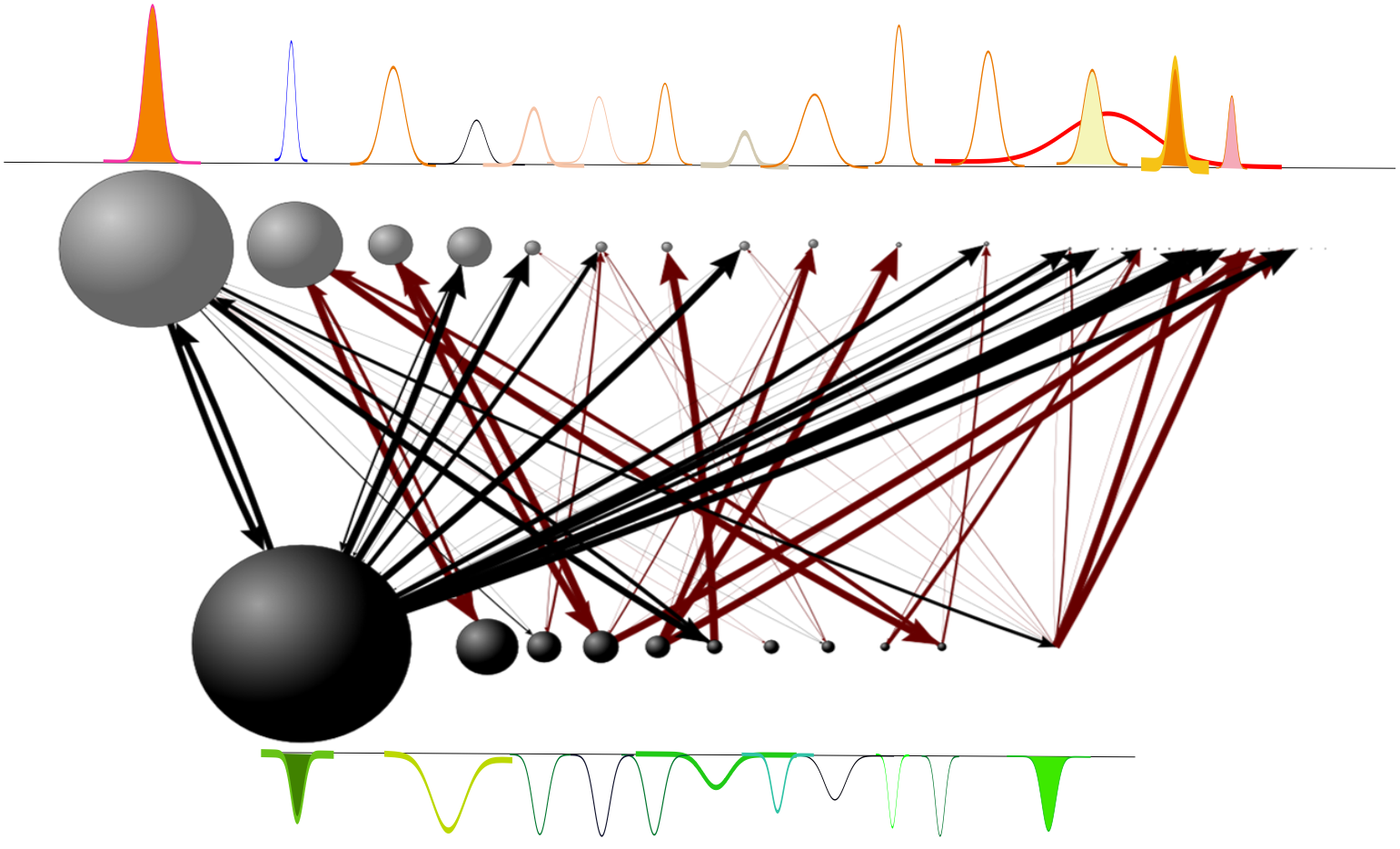



< 60%
60 - 70%
70 - 75%
75 - 80%
80 - 85%
85 - 90%
90 - 95%
95 - 97.5%
97.5 - 100%
> 100%


Communities
Populations
Traits
Genes
Communities
Populations
Traits
Genes







# ... and the architecture of traits within species might be rapidly changing

**Pere Alberch**

Genetica 84: 5-11, 1991

7

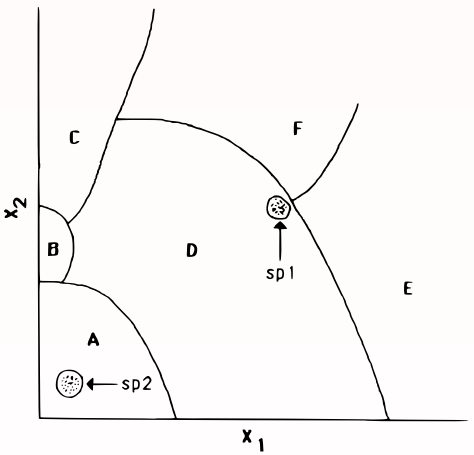
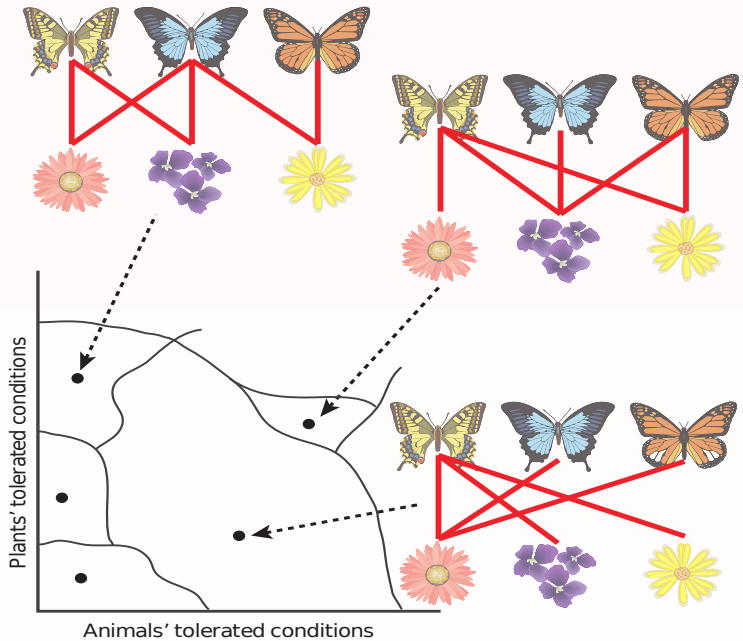



*Fig. 3.* Parameter Space.

and the phenotype can be mathematically stated as:

$$dP/dt = f(P, x_i)$$




**Rudolf P. Rohr, Serguei Saavedra, Jordi Bascompte**

(2014). DOI: 10.1126/science.1253497

- How does trait evolution affect ecological networks?

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- When and how do trait evolution and ecological networks feedback each other?

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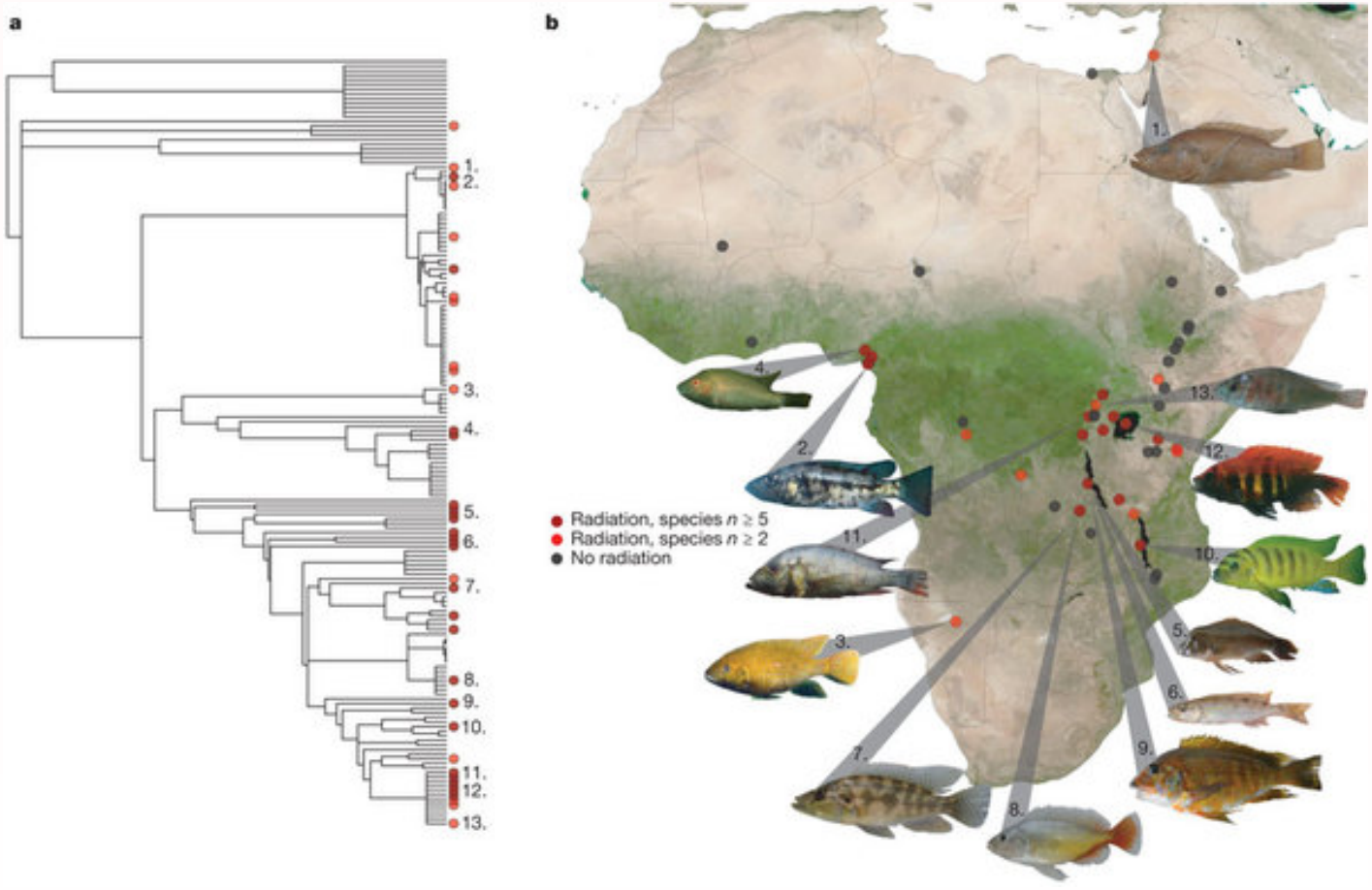
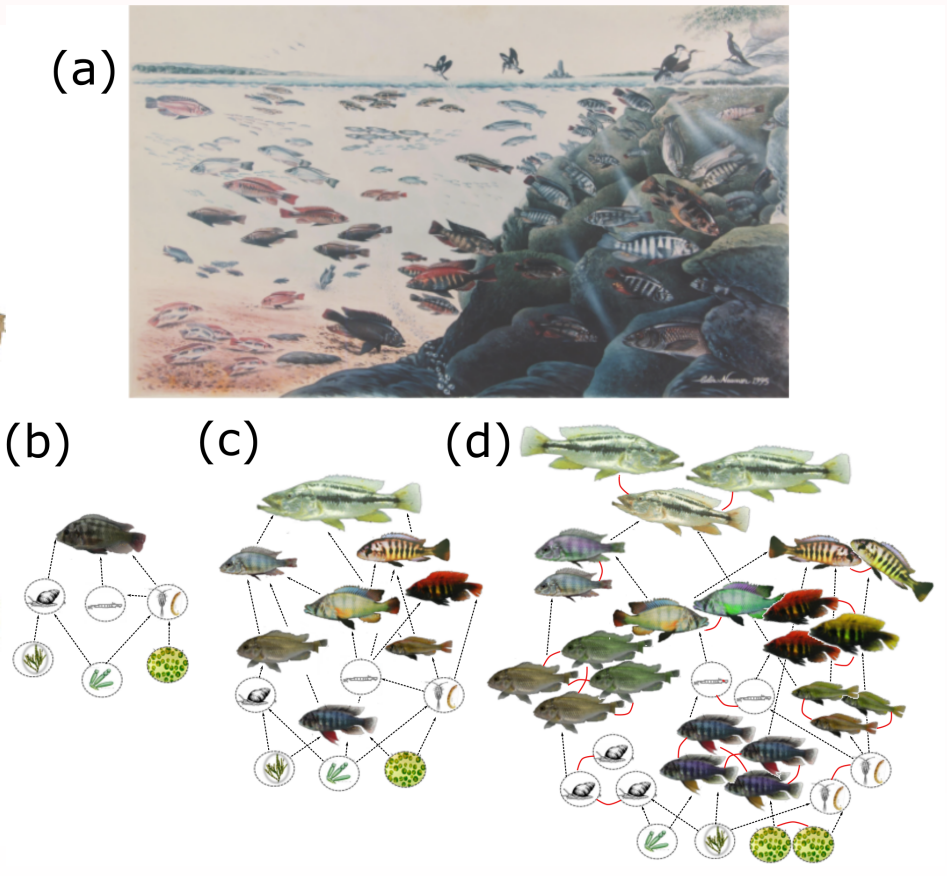
- Which are the consequences of eco-evolutionary feedbacks for species coexistence?

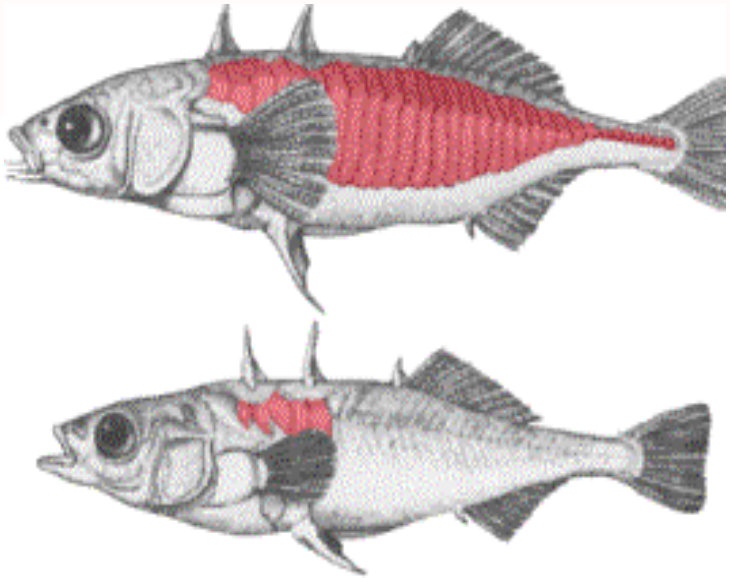
# ... radiations can be rapid

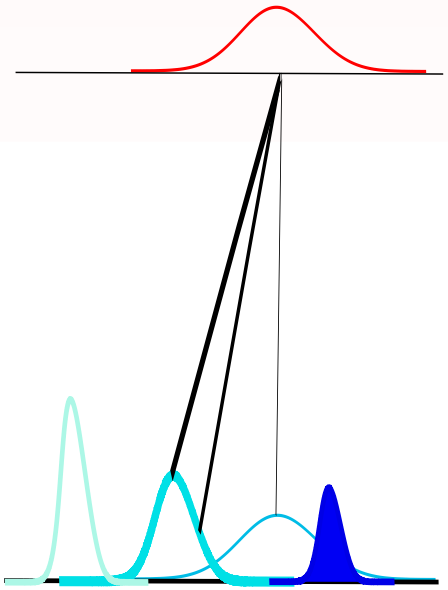


# ... meaning ecological and evolutionary dynamics might be tangled

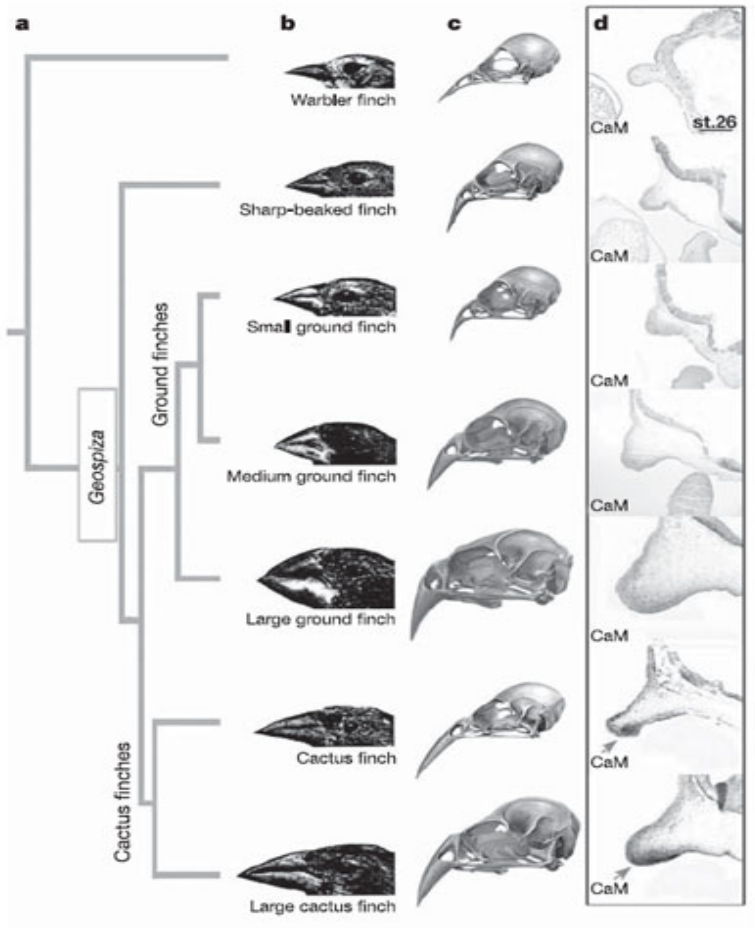



# Sticklebacks



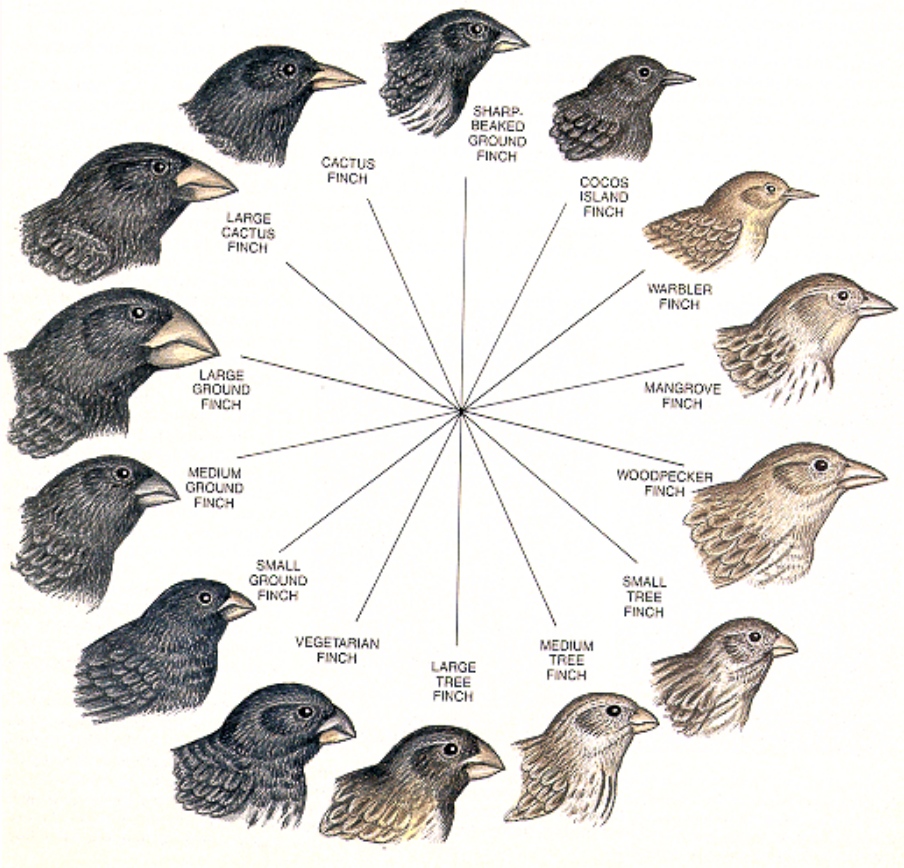


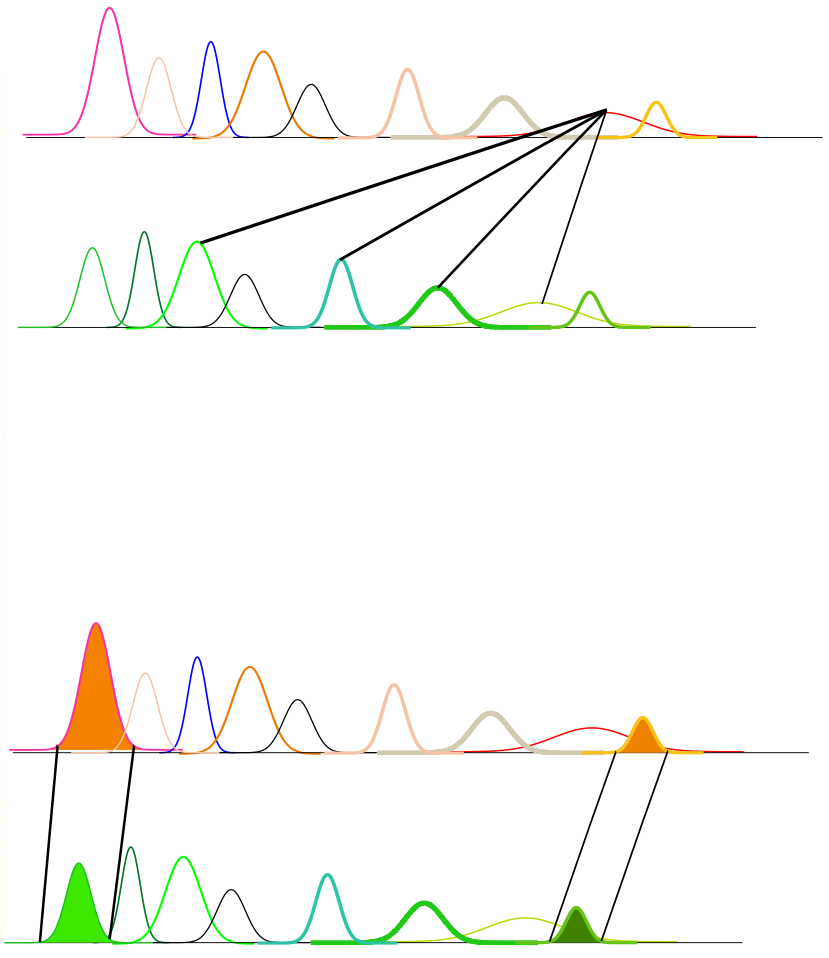
# Darwin's finches I

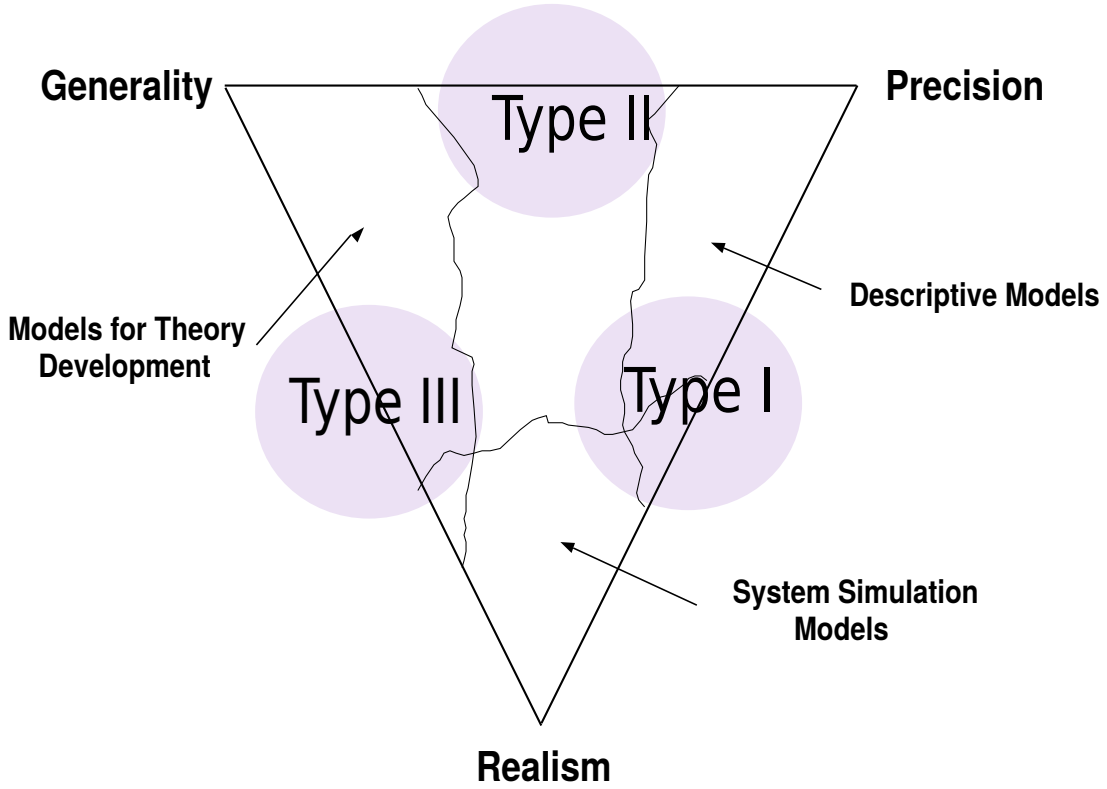



Abzhanov, A., et. al (2006). The calmodulin pathway and evolution of elongated beak morphology in Darwin's finches, Nature, 442:563-567.

# Darwin's finches II

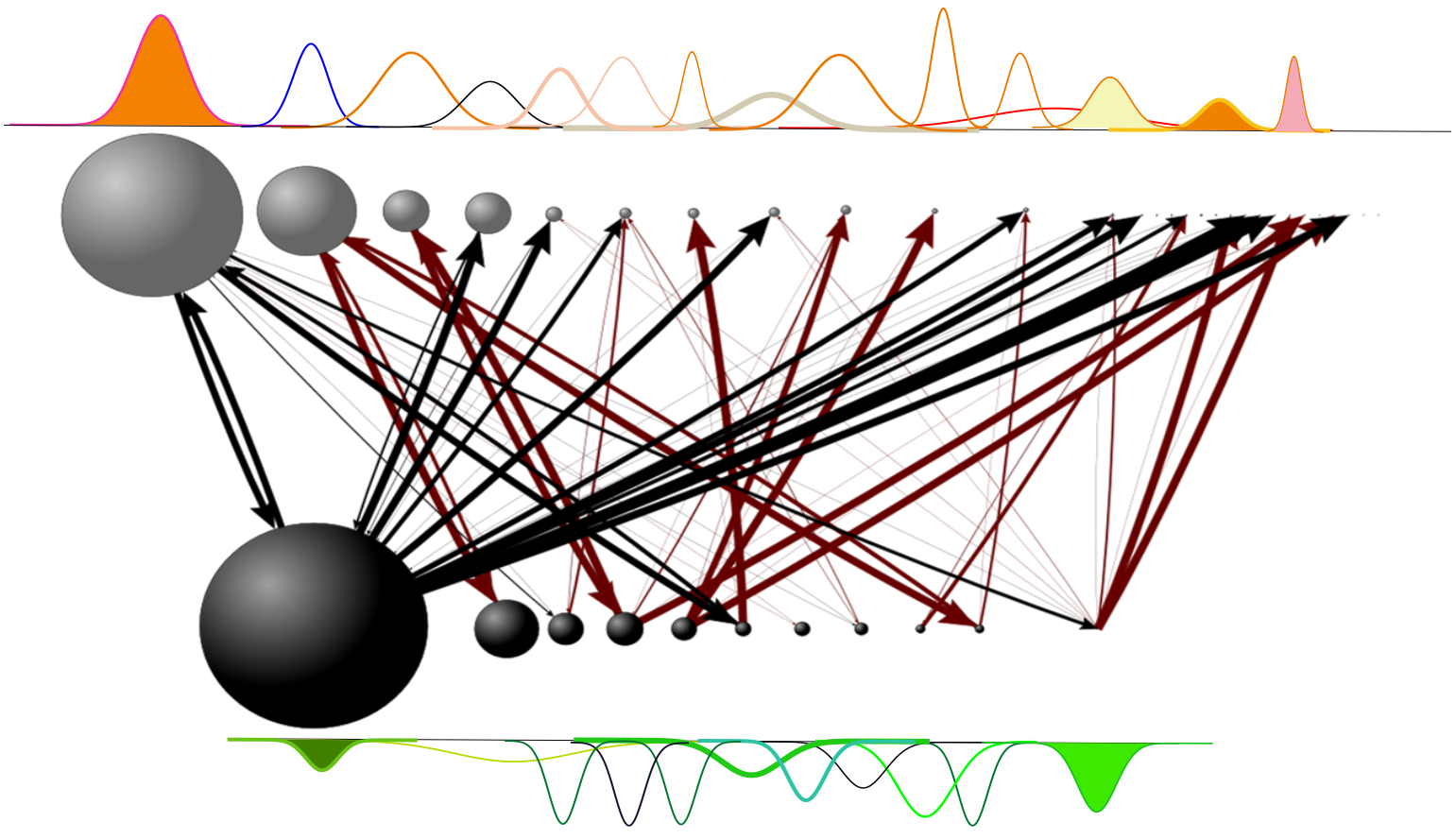


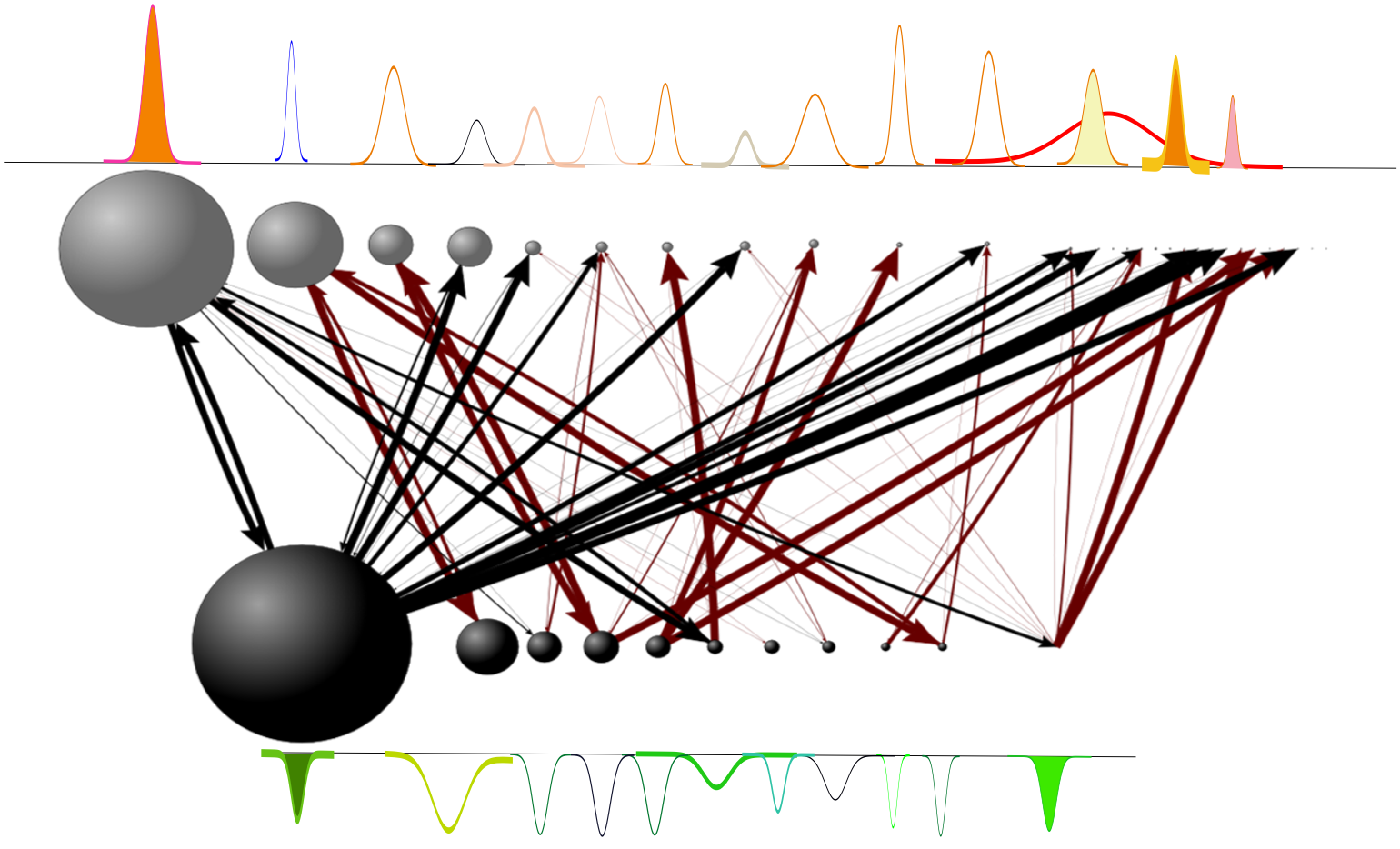






Modified from Gross, L. J., Use of Computer Systems and Models

Levins, R. 1966. The Strategy of Model Building in Population Biology. American Scientist 54: 421-431





# Modeling eco-evolutionary networks

$$\Delta V_i = r_i(t)V_i - c_i(V_i)^2 - \sum_{j=1}^{N_E} X_{ij}\alpha_{ij}(t)E_jV_i \quad (1)$$

$$\Delta E_j = r_j(t)E_j - c_j(E_j)^2 - \sum_{j=1}^{N_V} X_{ji}\alpha_{ji}(t)E_jV_i, \quad (2)$$

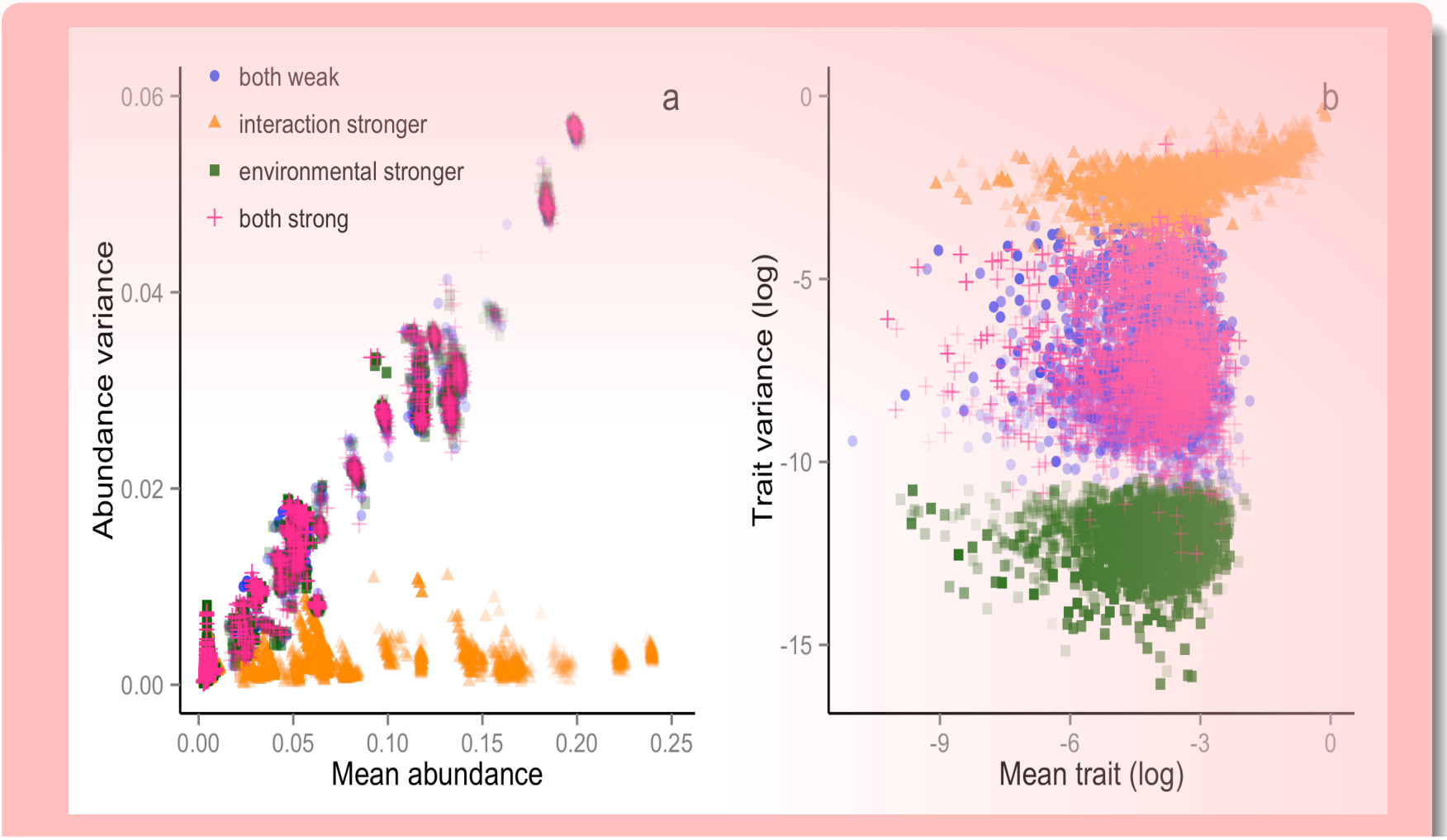
where $\alpha_{ij}(t)$ and $r_i(t)$ are given by

$$\alpha_{ij}(t) = \alpha_{ji}(t) = e^{-\gamma(z_i(t)-y_j(t))^2}; r_i(t) = b_i - (1 - e^{-\beta(\theta_i(t)-z_i(t))^2})$$

and mean trait values are calculated as

$$z_{i(t)} = z_{i(t-1)} + \phi_i(Z_i(t-1) - z_i(t-1))$$

$$y_{j(t)} = y_{j(t-1)} + \phi_j(Y_j(t-1) - y_j(t-1))$$


both weak
interaction stronger
environmental stronger
both strong
a
b
Abundance variance
Mean abundance
Trait variance (log)
Mean trait (log)
0.06
0.04
0.02
0.00
0.00
0.05
0.10
0.15
0.20
0.25
0
-5
-10
-15
-9
-6
-3
0

The temporal fluctuation in the interaction strength among species pairs, $s_{ij}$, is given by

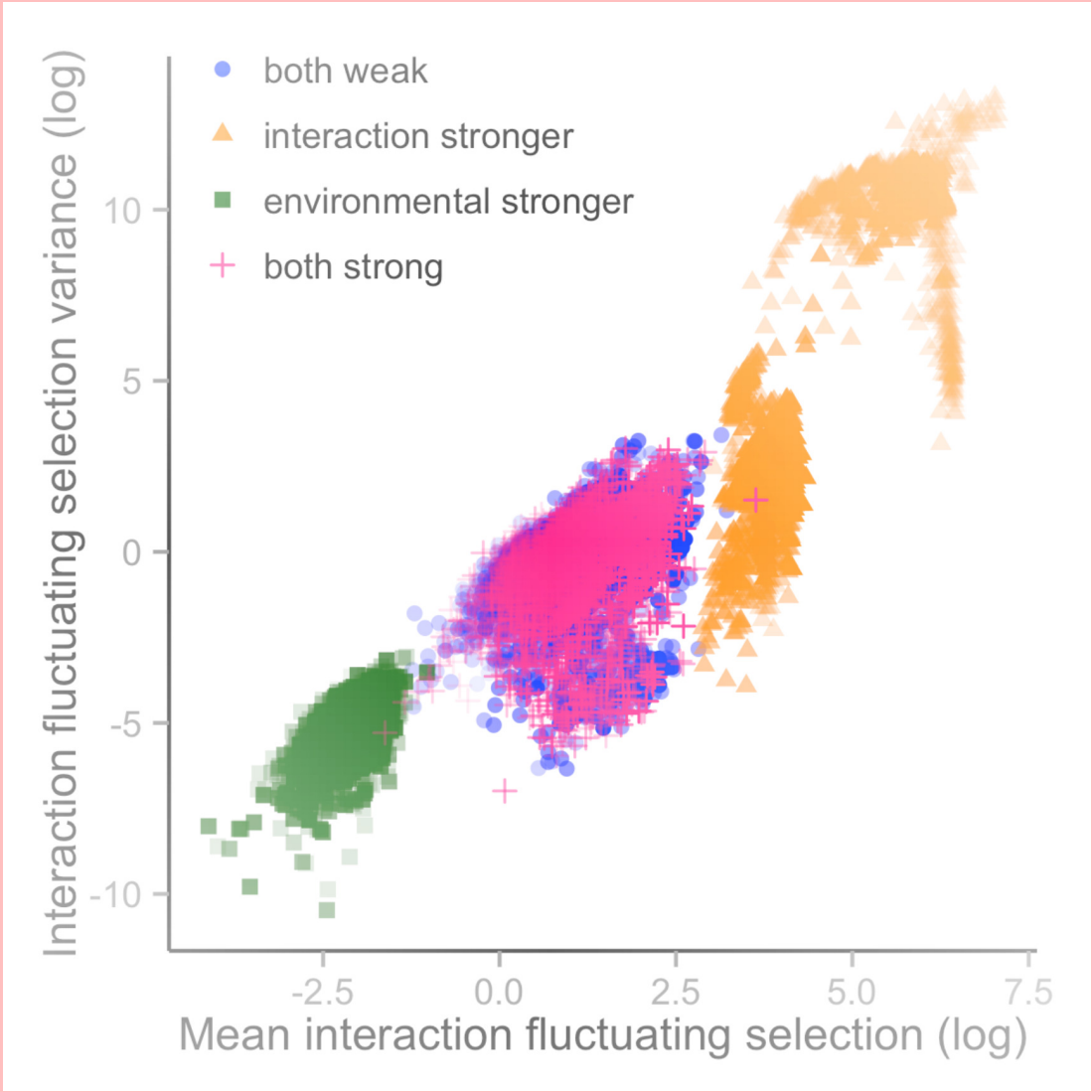
$$s_{ij}(t) = X_{ij} \sum_{t=1}^{t=N} |(z_{i(t)} - y_{j(t)}) - (z_{i(t-1)} - y_{j(t-1)}|,$$

The cumulative change in pairwise matching for each victim (exploiter) is

$$s_i = \sum_{j=1}^{N_E} s_{ij},$$

and the mean and variance in cumulative change in pairwise matching in the network is

$$s = \sum_{i=1}^{N_V} \sum_{j=1}^{N_E} s_{ij}/(N_V N_E); \sigma_s^2 = (\sum_{i=1}^{N_V} (s_i - s)^2 + \sum_{j=1}^{N_E} (s_j - s)^2)/(N_V N_E)$$


both weak
interaction stronger
environmental stronger
both strong
Interaction fluctuating selection variance (log)
10
5
0
-5
-10
-2.5
0.0
2.5
5.0
7.5
Mean interaction fluctuating selection (log)

# Outlook

- Eco-evolutionary networks running on interaction trait distributions show many selection regimes, from fluctuating to directional and stabilizing selection.

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- Rapid trait co-evolution when biotic interactions are stronger than environmental stressors drive higher and less variable abundances.
- Eco-evolutionary networks can be highly persistent despite strong interactions yet environmental stressors and reduction of functional trait variance might rapidly alter population fluctuations and the persistence of these networks.

# Merci!


- Swiss National Science Foundation
- Cecilia S. de Andreazzi, Jordi Bascompte, Miguel A. Fortuna, Paulo Guimaraes, Jan Klecka, Ayana Martins, Gian Marco Palamara, Alex Rozenfeld, Charles N. de Santana, and Ole Seehausen