

Motivation
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Model systems
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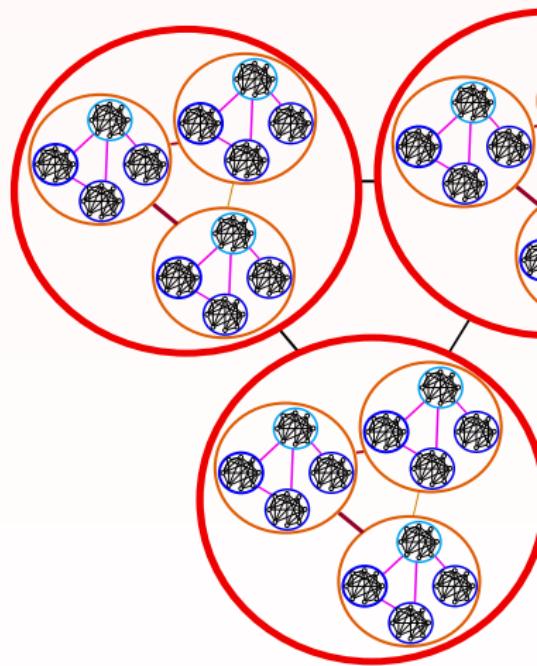
Eco-evolutionary networks
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Carlos J. Melián
ETH-EAWAG
<https://github.com/melian009>

Eco-Evolutionary Networks

U. Zürich, 28 March 2019 – Ecological Networks BIO365



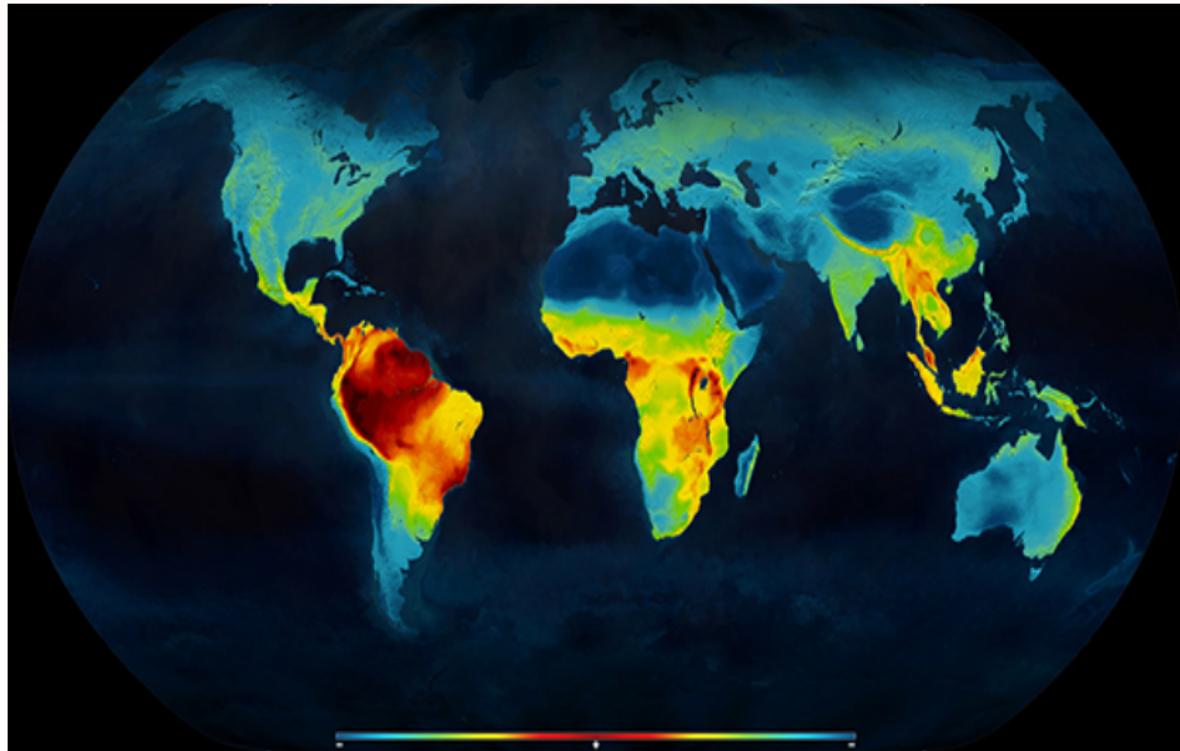
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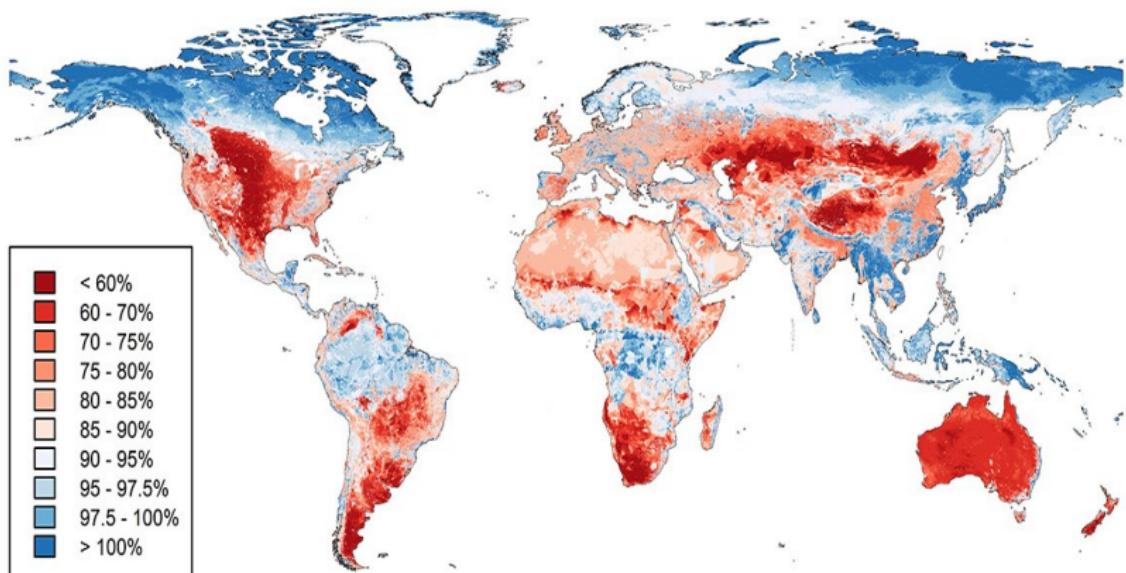
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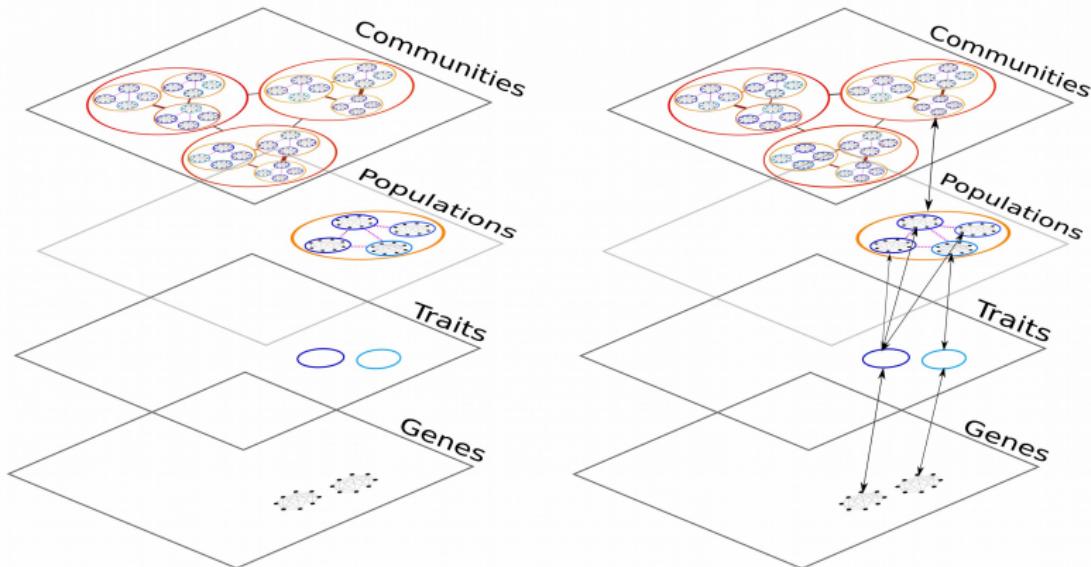
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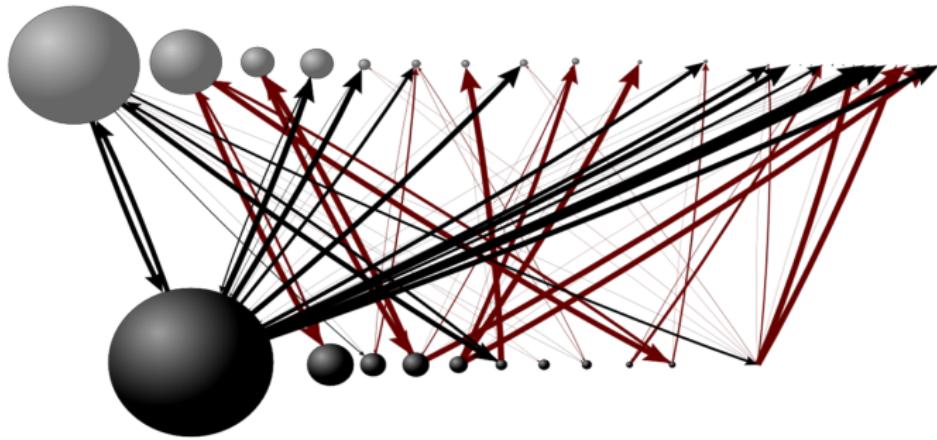
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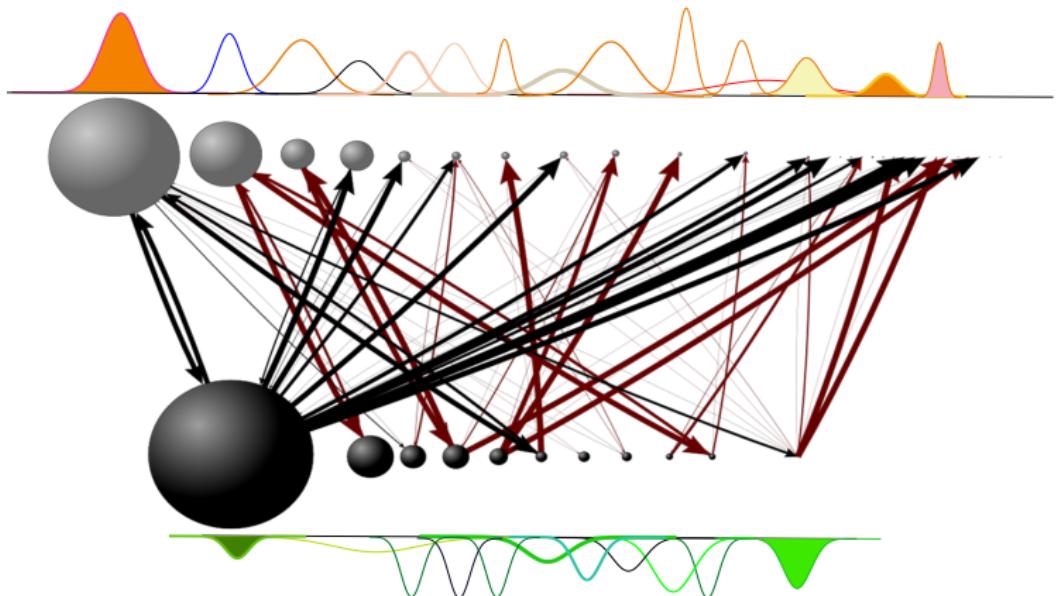
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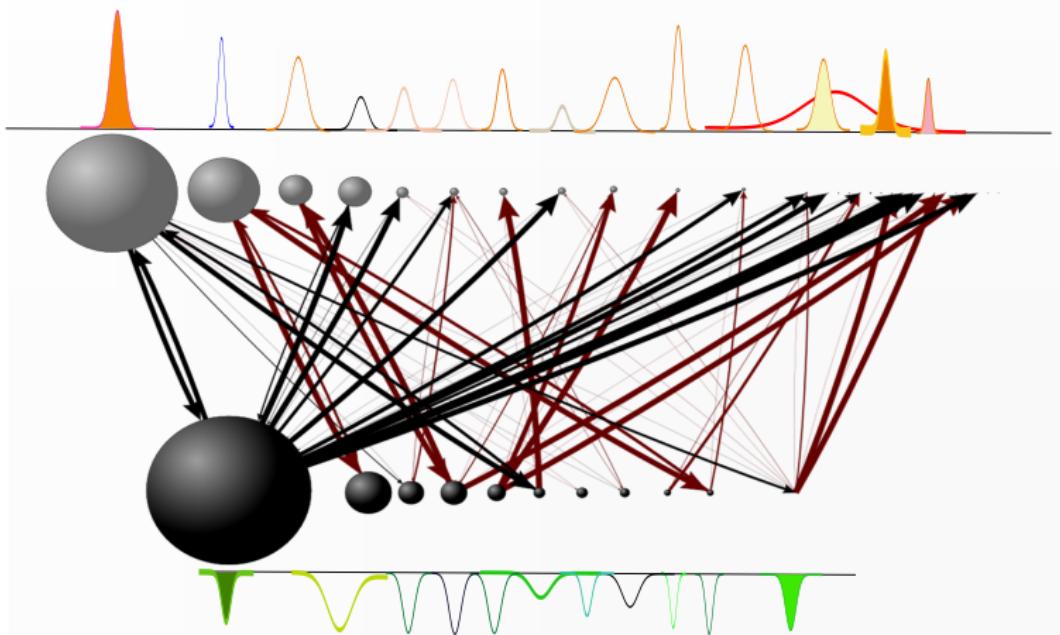
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... and the architecture of traits within species might be rapidly changing

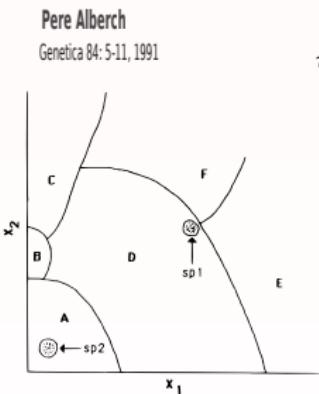
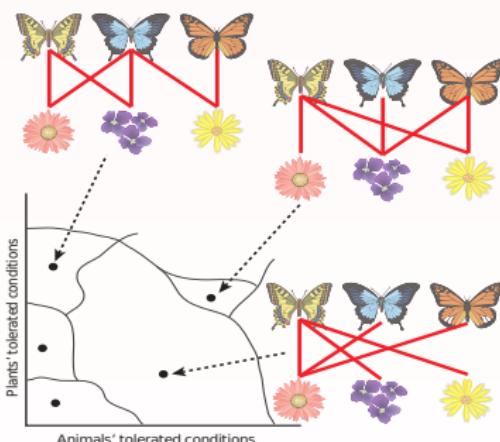


Fig. 3. Parameter Space.

and the phenotype can be mathematically stated as:

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



Rudolf P. Rohr, Serguei Saavedra, Jordi Bascompte
(2014). DOI: 10.1126/science.1253497

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► How does trait evolution affect ecological networks?

- ▶ How does trait evolution affect ecological networks?
- ▶ When and how do trait evolution and ecological networks feedback each other?

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- ▶ When and how do trait evolution and ecological networks feedback each other?
- ▶ Which are the consequences of eco-evolutionary feedbacks for species coexistence?

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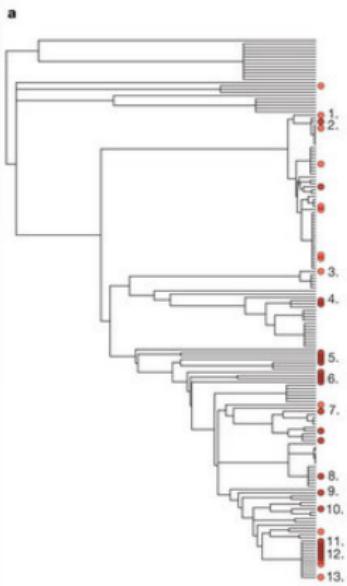
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... radiations can be rapid



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... meaning ecological and evolutionary dynamics might be tangled



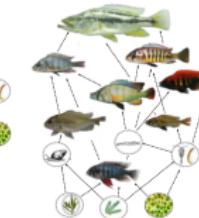
(a)



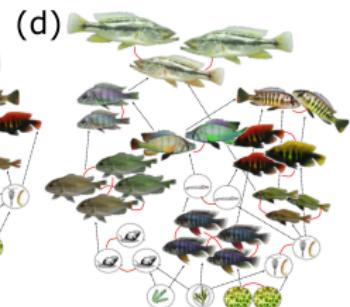
(b)



(c)



(d)



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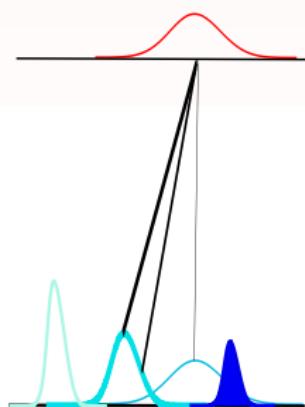
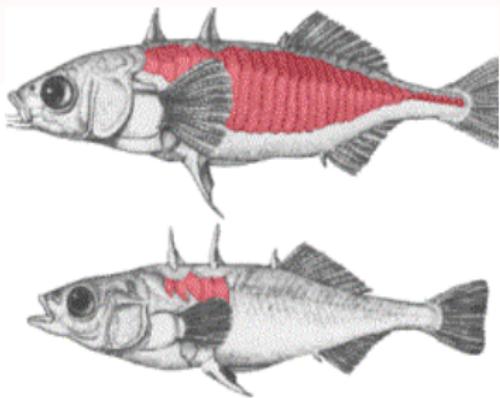
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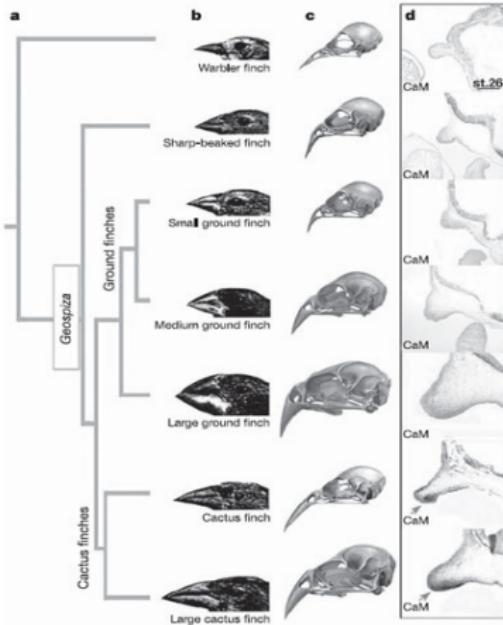
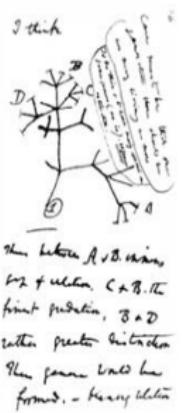
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Sticklebacks

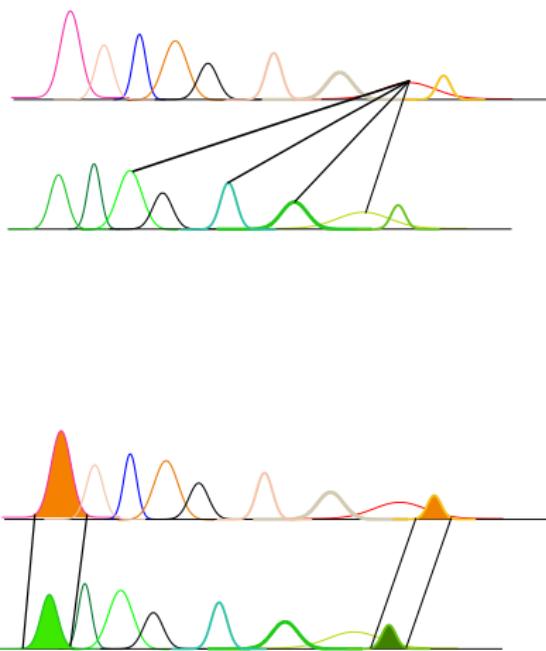
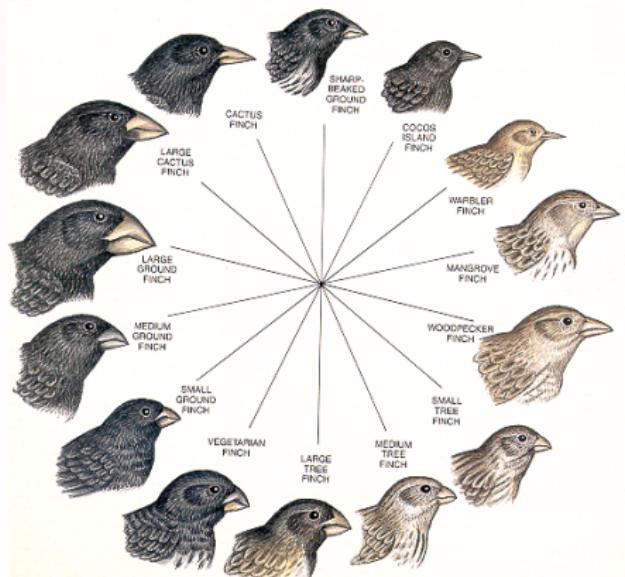


Darwin's finches I



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



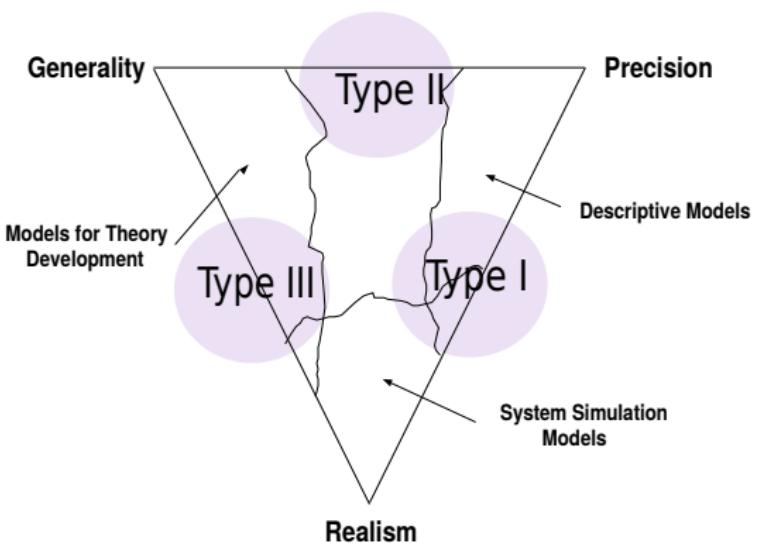
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Modified from Gross, L. J., Use of Computer Systems and Models

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



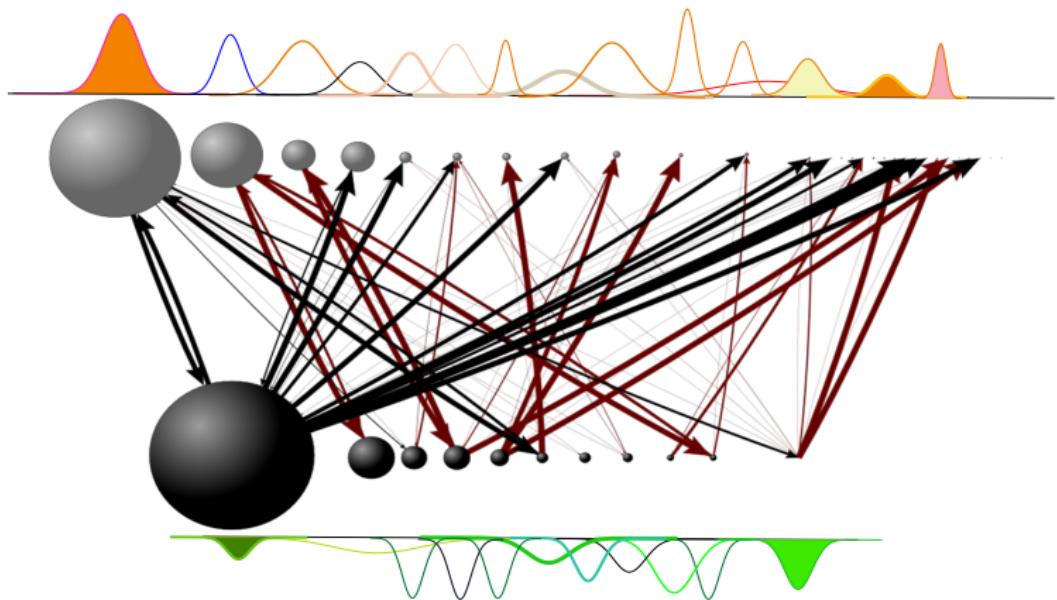
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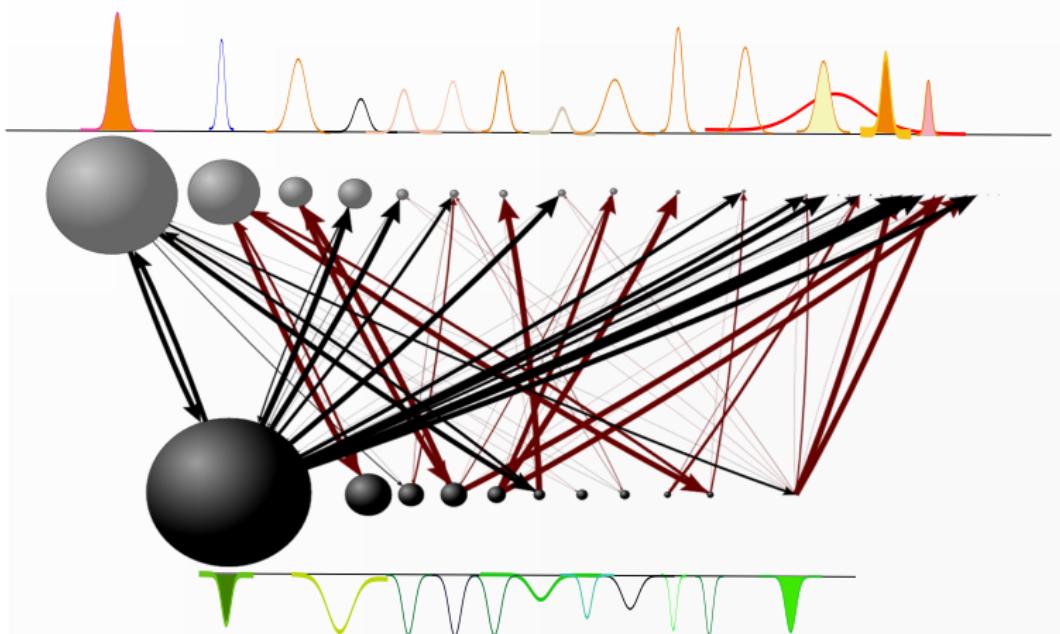
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Modeling eco-evolutionary networks

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

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

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

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

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

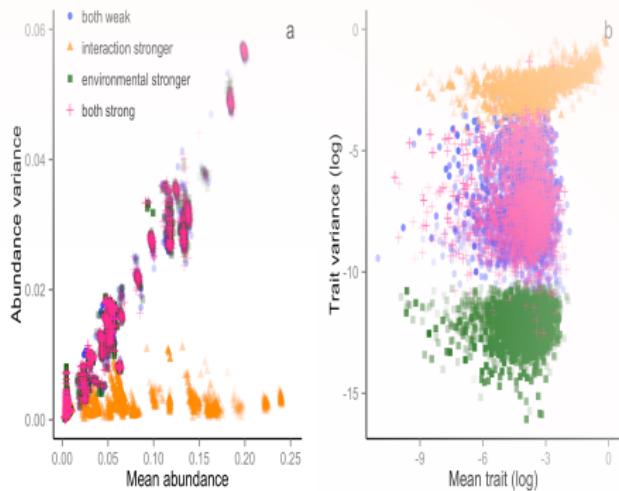
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The temporal fluctuation in the interaction strength among species pairs, s_{ij} , is given by

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

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

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

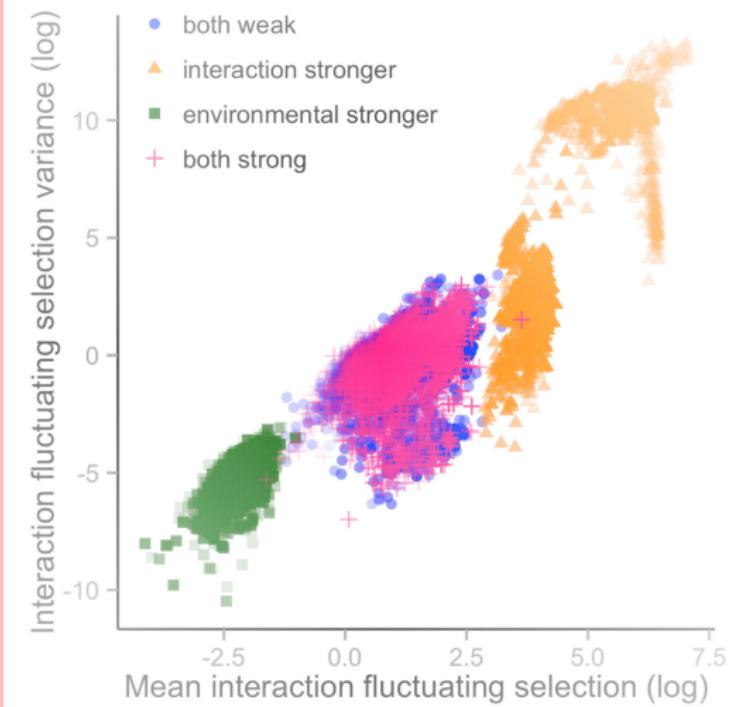
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Outlook

- ▶ 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.

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

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Merci!

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