Merging mutualistic and antagonistic networks : What consequences for community stability?

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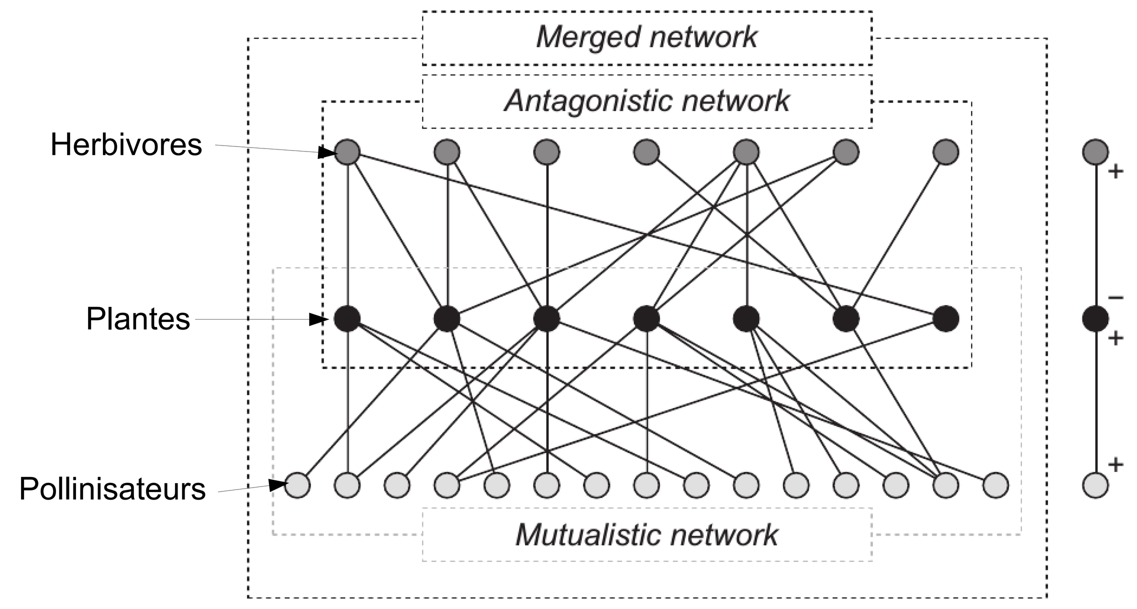
Introduction

In one ecological community, **different types of interactions** occur among species, and define different types of networks that have always been **studied separately**. The structures of these different types of networks affect differently **the response of the communities to disturbance**[1].

Since these interactions occur together in space and time, it may be more relevant to consider them in **one single framework**[2] which is likely to impact the dynamics of ecological communities.

We suggest to study in a theoretical approach **how interconnecting an antagonistic network and a mutualistic network in a super-network**, illustrated here with a herbivory network and a pollination network, **could change our perception of their dynamics**.



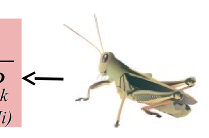
Questions

(i) In a merged network, does the structure of one sub-network affect the persistence of the other?
(ii) What is the relationship between one sub-network's structure and the whole community persistence?

Materials & Methods

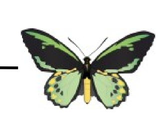
Population dynamics' model : To each guild its dynamic

$$\frac{dH_i}{dt} = r_{Hi}H_i - I_{Hi}H_i^2 + \sum_{j=1}^{Np} \frac{c_{ij}H_iP_j}{\alpha_{ij}^{-1} + \sum_{k \in prey(Hi)} P_k}$$



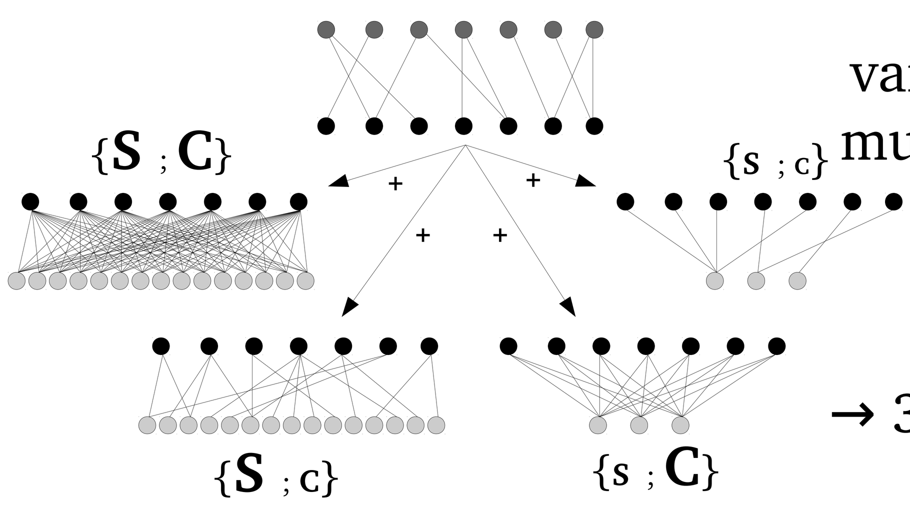
$$\frac{dP_i}{dt} = r_{Pi}P_i - I_{Pi}P_i^2 + \sum_{j=1}^{Nm} \frac{c_{ij}M_jP_i}{\alpha_{ij}^{-1} + \sum_{k \in mut(Pi)} M_k} - \sum_{j=1}^{Na} \frac{c_{ij}H_jP_i}{\alpha_{ij}^{-1} + \sum_{k \in prey(Hj)} P_k}$$

$$\frac{dM_i}{dt} = r_{Mi}M_i - I_{Mi}M_i^2 + \sum_{j=1}^{Np} \frac{c_{ij}M_iP_j}{\alpha_{ij}^{-1} + \sum_{k \in mut(Mi)} P_k}$$



-Intrinsic growth rate: $r_P > 0$ et $r_A < 0$,
-Density-dependant self-limitation,
-Functional response to mutualism, saturating with mutualistic partners' densities,
-Holling type II functional response to predation, saturating with preys' densities.

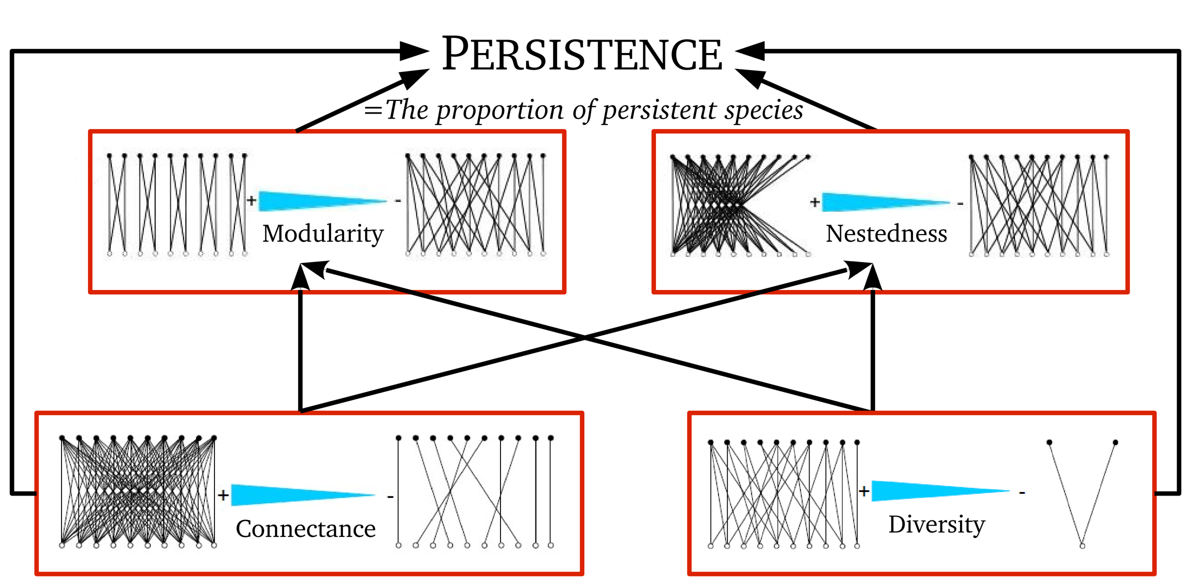
Numerical simulation design



An antagonistic network, with a varying structure is associated with a mutualistic network, initially more or less complex, and vice versa.
→ 4 cases of complexity
K=S (diversity)*C (connectance)
→ 3 cases of interaction strength ratio
$c_{ij}^{(mut)}/c_{ij}^{(ant)} = \{0.5, 1, 2\}$

K{2.8, 4.48, 10, 16} <=> {S,C}=[{40, 0.25}, {16, 0.07}, {16, 0.25}, {40, 0.07}]

Network analysis and relating stability with structure



Correlated measures of network's structure: We perform a *path analysis* according to the model illustrated here.

Results

In a merged network, does the structure of one sub-network affect the persistence of the other?

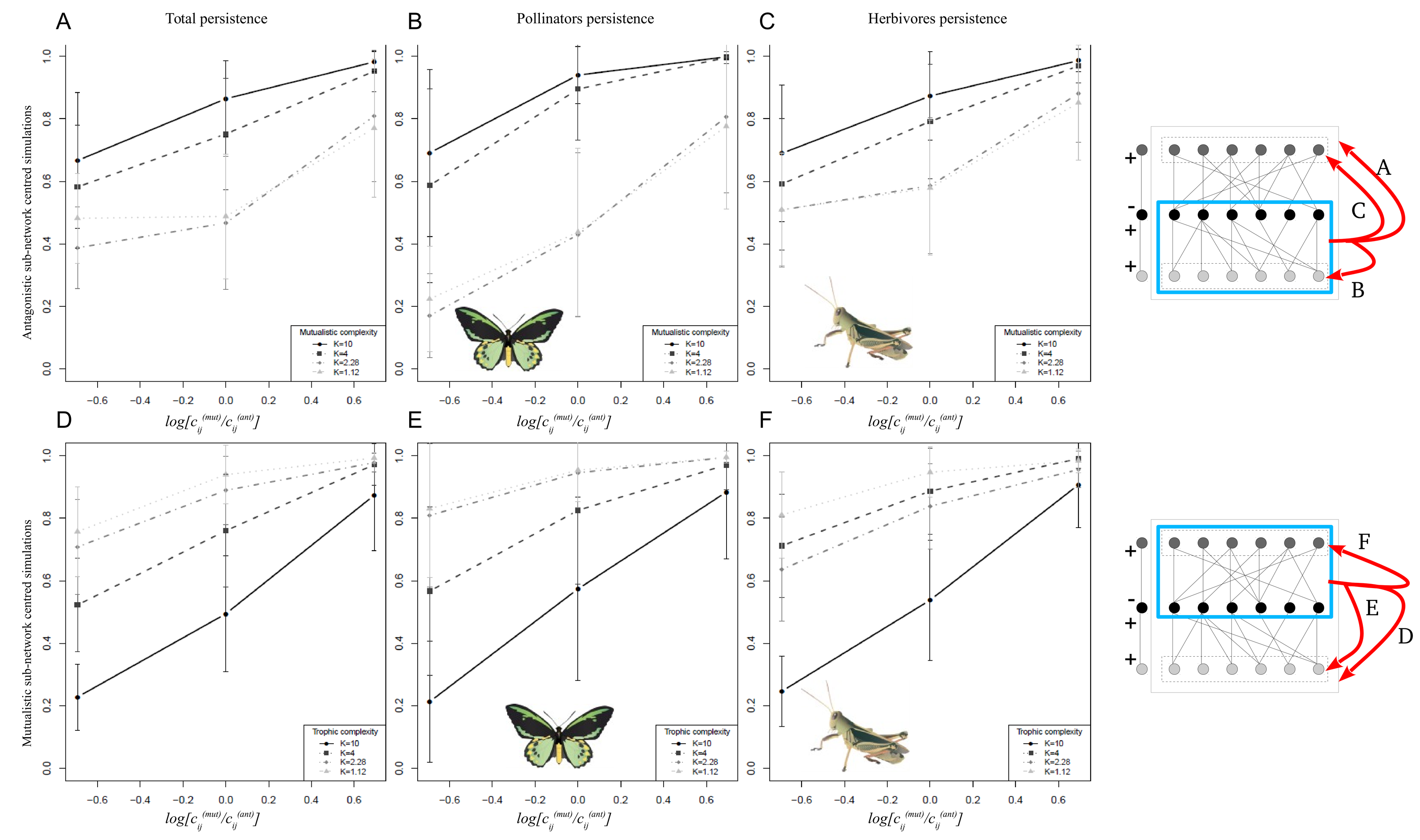


Figure 2: (A-B-C) Persistence against $log[c_{ij}^{(mut)}/c_{ij}^{(ant)}]$, considering different cases of mutualistic complexity; (D-E-F) Persistence against $log[c_{ij}^{(mut)}/c_{ij}^{(ant)}]$, considering different cases of antagonistic complexity.

What is the relationship between one sub-network structure and the whole community persistence?

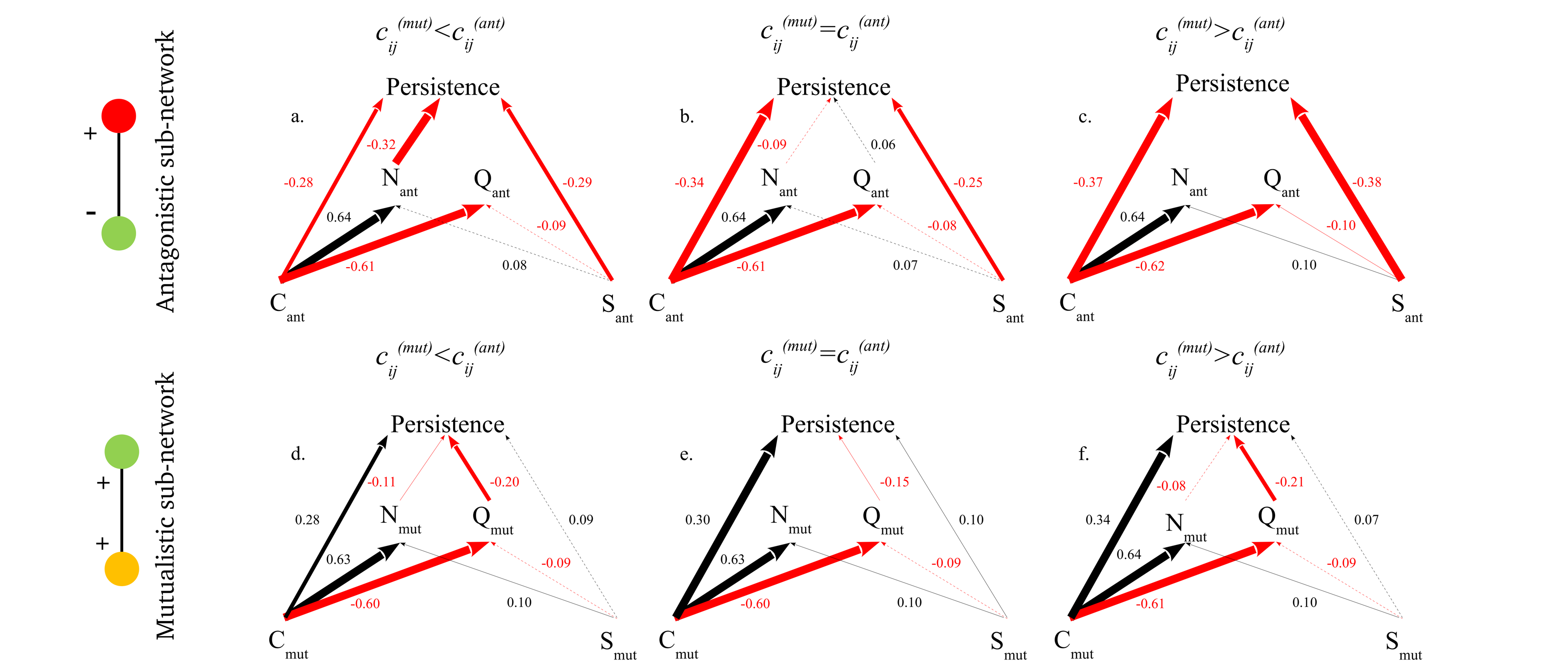


Figure 3: Path diagram of the effects of the initial measures of each sub-network structure on persistence of the merged network, for different ratios of interaction strength.

Conclusion

This theoretical study suggests that:

- ***The structure of one sub-network influences the stability of the other sub-network, and vice versa,***
- ***Current bipartite network metrics are no longer adapted,***
- ***Complexity-stability relationships are robust to the interconnection.***

Two networks that are merged influence each other's persistence as **disturbances can be propagated from one sub-network to the other.** The way the community responds depends on the respective structures, and their interaction types.

Fine architectural patterns have weak effects on stability. We assume the propagation of disturbance depends on **the way the two sub-networks are linked**[2,3], and **the type of interaction** (strength and kind).

Considering the diversity of interaction in a single framework needs to be developed further, as **the interaction types interact.**

[1] Thébault, E., & Fontaine, C. (2010). Stability of ecological communities and the architecture of mutualistic and trophic networks. *Science*, *329*, 853-856.
[2] Fontaine, C., Guimaraes, P. R. J., Kéfi, S., Loeuille, N., Memmott, J., van der Putten, W. H., van Veen, F. J. F., *et al.* (2011). The ecological and evolutionary implications of merging different types of networks. *Ecology Letters*, 1-12.
[3] Melian, C. J., Bascompte, J., Jordano, P., & Krivan, V. (2009). Diversity in a complex ecological network with two interaction types. *Oikos*, *118*(July), 122-130.