Species Roles in a Temporal Multilayer Network of Host-Parasite Interactions

Presented by Klil Shahar
Supervised by Dr. Shai Pilosof

Department of life science, Ben-Gurion University of the Negev, Be'er-Sheva, Israel.

Introduction

Ecological communities can be described as networks in which nodes represent species and edges represent the interactions between them. These networks often have a modular structure, with groups of species that are highly connected to each other and less connected to species outside the group (1). The functional role a species plays in the network can be defined by its connectivity within its own module and across modules. However, the temporal dynamics of species roles have not been studied before.

Objective

To study the temporal variation in species roles in a multilayer host-parasite network.

Methods

The network used here describes the infection of small mammals by arthropod ectoparasites. Data were collected in west Siberia, during six summers in 1982–1987 (2).

- There are six layers, each representing a sampling year.
- **Interlayer edge weights** are the ratio of the species' abundance in year t and its abundance in year t+1.
- **Intralayer edge weights** are the ratio of host and parasite abundance.

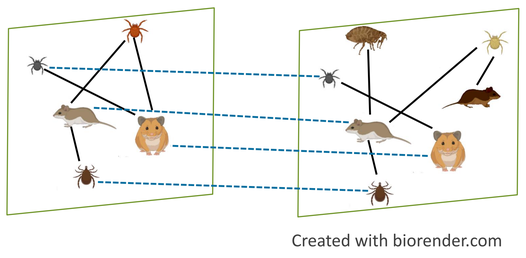

Figure 1. Intralayer edges (full lines) connect each host to parasites infecting it. Interlayer edges (dashed lines) connect each species to itself in the next layer.

The network was partitioned into modules using the tool *Infomap* in the *R* package *infomapecology* (3). The role of each species was determined by its level of connectivity within its module (Z-score) and its connections to other modules (participation coefficient *c*), as defined in (1).

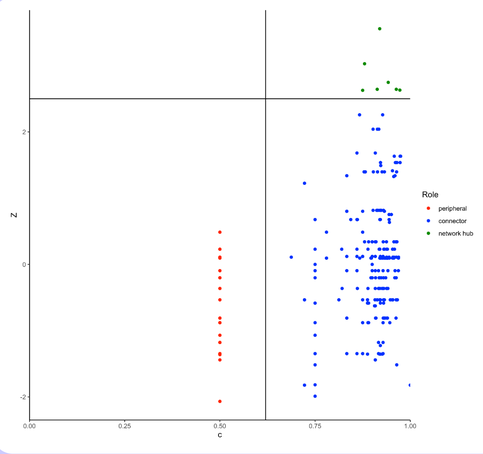

Figure 2. Species roles in the network. Each data point represents a species in a layer. *Peripherals* (red) have few links in general; *connectors* (blue) have few links within their modules but connect them to other modules; and *network hubs* (green) are highly connected both inside and outside their modules. *Module hubs*, highly connected within their modules only, would have appeared in the top left corner, but none were identified in this particular network.

500 randomized networks were created by shuffling the edges within each layer. The degree (number of edges) of each node was preserved. Interlayer edges were kept as in the empirical network. Species roles were assigned to the nodes of each randomized network and compared to the original roles.

Results

- Out of 74 species occurring in multiple years, **48%** changed their roles at least once.
- Seven network hubs were identified. They were all hosts – six rodents (families Muridae and Cricetidae) and one insectivore (family Talpidae). Each had this role in one layer only.
- Only 23% of the species changed modules.
- Shuffled networks had a similar number of modules as the observed (on average 37.01±2.53, compared to 38).
- The proportion of each role was not significantly different from the null models ($X^2_3 = 1.385$, $p = 0.500$).

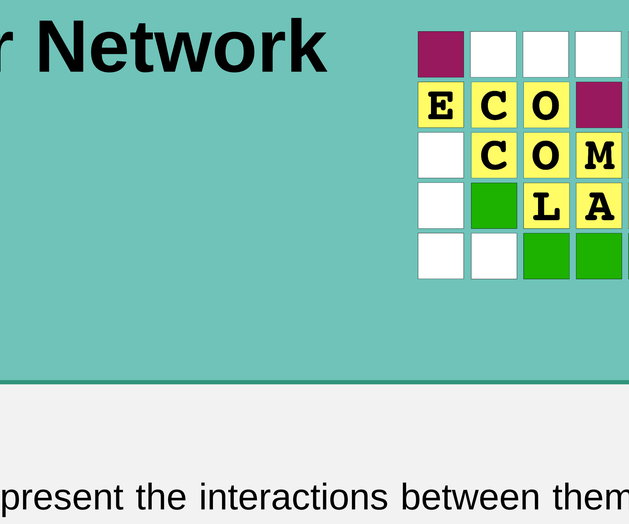

Figure 3. Modular structure over time. Colors represent modules, rectangle size represents the number of species in a module and curved lines represent species moving between layers (years).

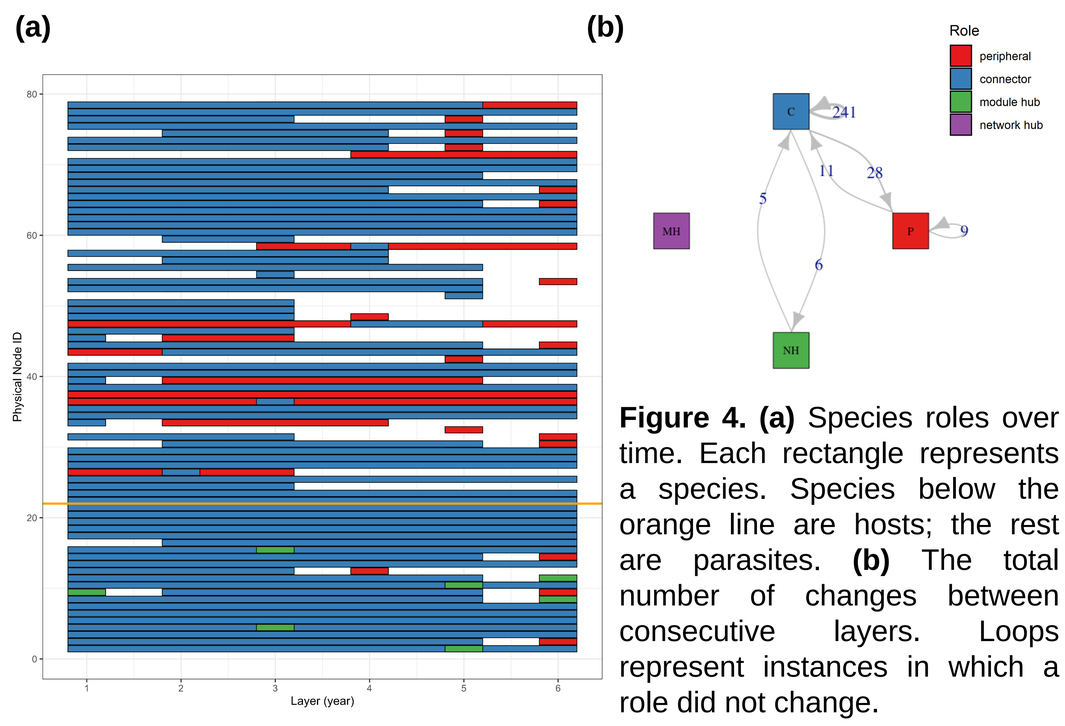

Figure 4. (a) Species roles over time. Each rectangle represents a species. Species below the orange line are hosts; the rest are parasites. **(b)** The total number of changes between consecutive layers. Loops represent instances in which a role did not change.

Discussion:

Species roles changed over the years, but this pattern was not significantly different from random. Network hubs may have a central role in parasite transmission between species, and this function appears to be limited to specific years. Analyzing species roles in other temporal networks may reveal an altogether different picture.

References

(1) Olesen, J. M., Bascompte, J., Dupont, Y. L., & Jordano, P. (2007). The modularity of pollination networks. *Proceedings of the National Academy of Sciences*, *104*(50), 19891-19896.

(2) Krasnov, B. R., Matthee, S., Lareschi, M., Korallo-Vinarskaya, N. P., & Vinarski, M. V. (2010). Co-occurrence of ectoparasites on rodent hosts: null model analyses of data from three continents. *Oikos, 119(1), 120-128.*

(3) Farage, C., Edler, D., Eklöf, A., Rosvall, M., & Pilosof, S. (2021). Identifying flow modules in ecological networks using Infomap. *Methods in Ecology and Evolution*, *12*(5), 778-786.