Simulating the effect of green corridors on the persistence of ecological networks across space

Dolores Ruiz-Lupión[1], Gabriel Barrionuevo Rosales[2], José Román Bilbao-Castro[2], Leocadio G. Casado[2], José María Gómez[1,*] and Jordi Moya-Laraño[1].

[1] Department of Functional and Evolutionary Ecology, Estación Experimental de Zonas Áridas, EEZA-CSIC.
[2] Department of Informatics, University of Almeria.
* Department of Ecology, University of Granada.

INTRODUCTION

Ecological corridors are conceived as geographical spaces connecting fragments of natural habitats (patches or islands) that allow the dispersal of individuals thereby decreasing the degree of isolation. This may buffer extinction rates and enhance the maintenance of multitrophic metacommunities (Haddad *et al*. 2006).

The effectiveness of such corridors when one explicitly considers the fact that there is widespread genetically-based multidimensional functional individual variation within the populations embedded in ecological networks (e.g., food webs) is unknown. However, this complexity can be grasped by taking advantage of the current computational power which facilitates "virtual" experimentation in simulated systems.

AIM

The aim of this study is to use a recently implemented individual-based simulation framework (*Weaver*, Moya-Laraño *et al*. 2012, 2014) to explore how the presence or absence of micro-ecological corridors (central soil moisture pockets) affects the persistence of ecological networks when fertility islands (soil moisture pockets) are located at different distances.

METHODOLOGY

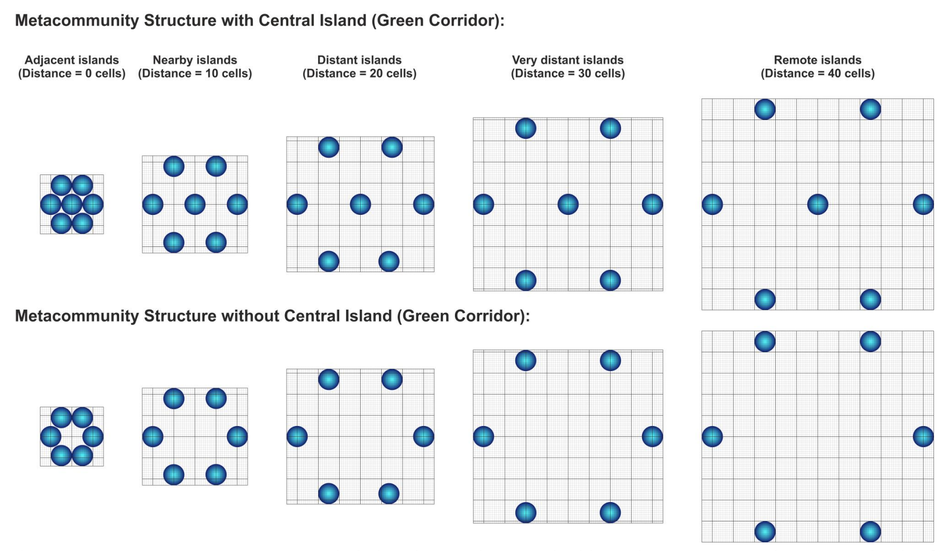

Figure 1. Metacommunity structures included in the simulations. The blue spheres correspond to micro-islands of moisture (moisture pockets) in the forest floor.

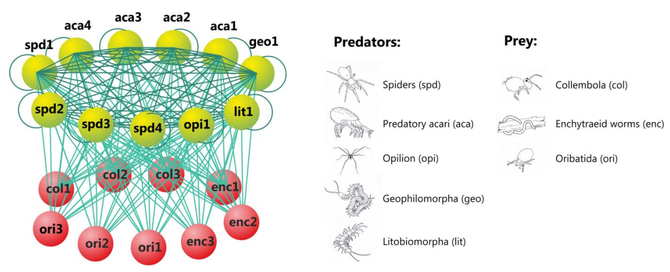

Figure 2. The simulated web: a simplified hypergeneralist beech forest floor food web (connectance = 0.55).

Spatial structure (Fig. 1):

- 6 micro-islands (soil moisture pockets) arranged in a hexagon.
- Basal resources (fungi) grow only in these islands.
- 5 distance x 2 corridor arrangements (with or w/o central corridor).

Food Web (Fig. 2):

- Soil food web composed of 20 species (9 fungivores prey and 11 IGP predators) and a single basal resource (fungus species).

Simulations:

- 5 replicates per distance-corridor combination.
- Each ran for 200 days.
- Output: Proportion of species remaining in each of two trophic levels (fungivores and predators).
- Statistical analysis: GLM with a B-spline fitted over distances (library *splines* - R development core team 2014).

RESULTS

Increasing the distance among islands affected very differently to each trophic level (trophic level*distance, $p < 0.001$), as only predators were (strongly) affected by distance, with an optimum of predator richness at 10 cells (**Fig. 3a and 4**).

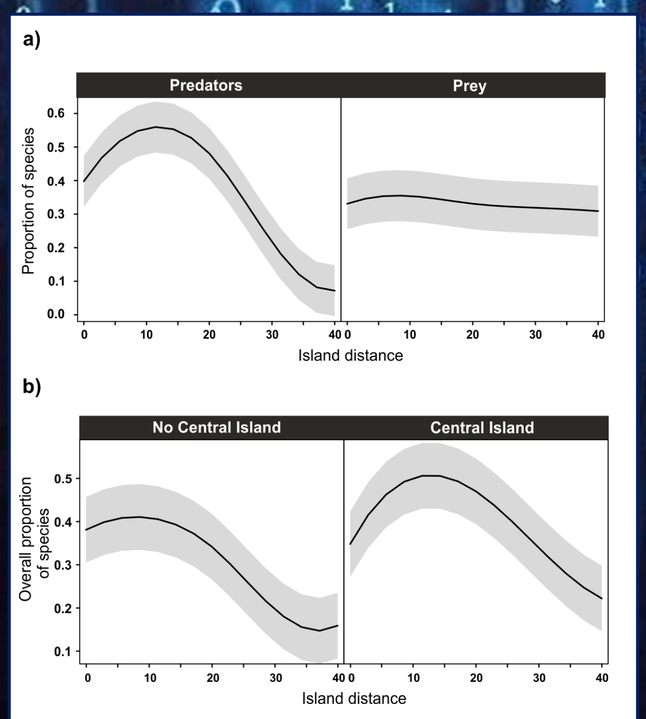

Figure 3. a) Proportion of species of prey (left panel) and proportion of species of predators (right panel) as a function of distance, and b) Proportion of species that remained at the end of the simulation (N=5) as a function of island distance and with the absence (left panel) or presence of a central corridor (right panel).

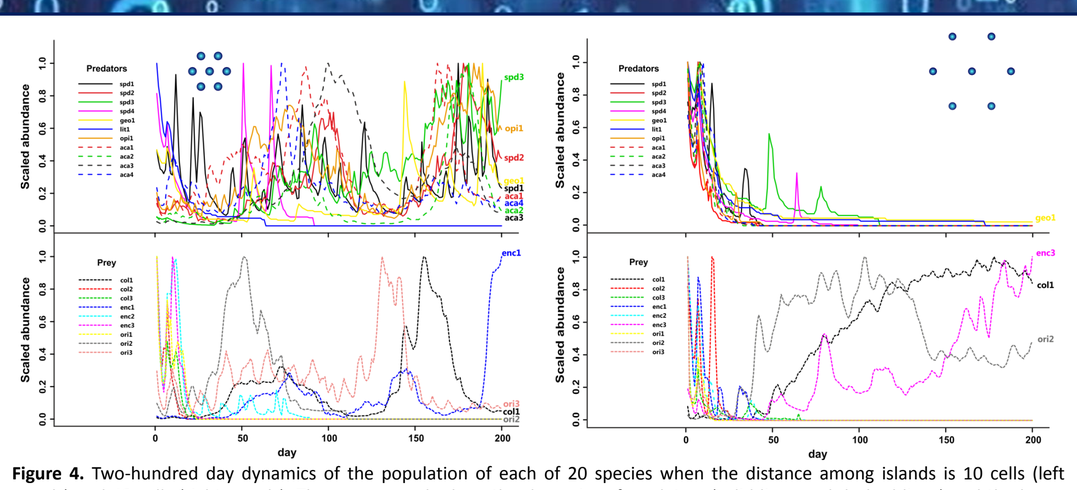

Figure 4. Two-hundred day dynamics of the population of each of 20 species when the distance among islands is 10 cells (left panels) and 40 cells (right panels). The upper panels show the dynamics of predators (solid lines and dashed lines) and the lower panels show the dynamic of prey (dotted lines). Figures depict one out of 5 replicates as an example. Abundance (y-axis) is 0-1 scaled.

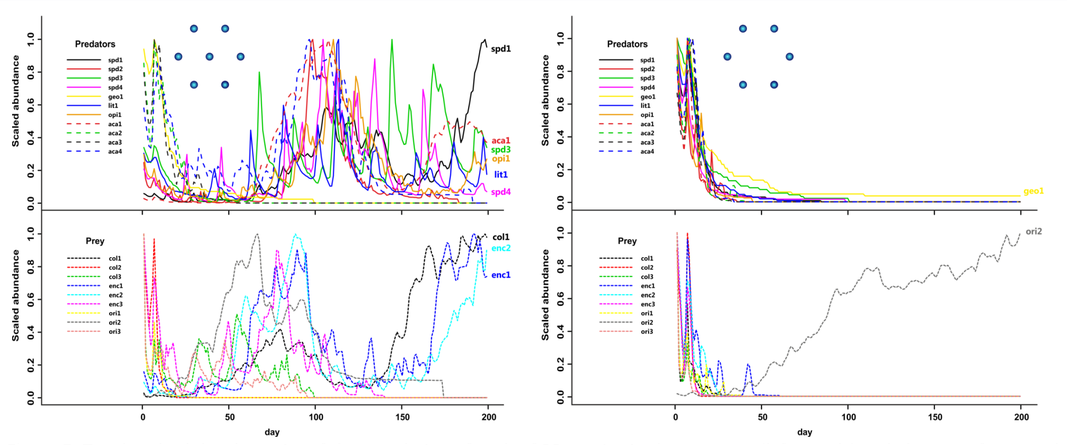

Figure 5. Two-hundred day dynamics of the population of each of 20 species in the presence (left panels) and absence of a central ecological corridor (right panels). The upper panels show the dynamics of predators (solid lines and dashed lines) and the lower panels show the dynamic of prey (dotted lines). Figures depict one out of 5 replicates as an example. Abundance (y-axis) is 0-1 scaled.

Regarding the presence of an ecological corridor, we found that its effect dependent on the distance (distance*corridor, $p = 0.027$), basically because with an ecological corridor there is a higher peak of species remaining at the optimal distance of 10 cells (**Fig. 3b**), and from distances of 30 cells and beyond the absence of a corridor causes the system to collapse (**Fig. 5**).

CONCLUSIONS

The presence of the central island acts as an ecological corridor favoring the persistence of species by dispersal and thus the persistence of the entire network.

The effect of corridors, however, depended on the distant among islands. At an optimal distance of 10 cells competition among predators may be minimized while their mobility allows reaching islands that are not too far apart. At higher distances, predators may have problems finding food and the system collapses unless there is an ecological corridor (central island).

A pattern emerged from this study showing that island distance only affects the persistence of predator richness. The generality of this result should be further investigated.

REFERENCES

Haddad *et al*. 2006. *Impacts of corridors on populations and communities*. Connectivity Conservation eds. University Press. Cambrigde.

Moya-Laraño *et al*. 2012. *Climate change and eco-evolutionary dynamics in food webs*. Adv. Ecol. Res. **47**:1-80.

Moya-Laraño *et al*. 2014. *Eco-evolutionary spatial dynamics: Rapid evolution and isolation explain food web persistence*. Adv. Ecol. Res. **50**:76-143.