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FONDATION POUR LA RECHERCHE SUR LA BIODIVERSITÉ

CESAB
CENTRE FOR THE SYNTHESIS AND ANALYSIS OF BIODIVERSITY

Project summary

ISLANDS

Community assembly on remote islands: does the equilibrium theory apply?

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Start and finish: 2012-2015

What are the parameters that can influence the biodiversity of islands? What are the different stages of species diversification in an island environment, and what are the evolutionary processes involved? Here are some examples of questions that a team of CESAB researchers has tried to answer through the project Islands.

Context and objectives

The Equilibrium Theory of Island Biogeography (ETIB) has long served as a reference for understanding the formation of communities on islands. Based on the assumption that the number of species on an island depends on a balance between colonization and extinction processes, it predicts, in particular, that large islands or those close to continents contain more species than small or distant islands. However, although the predictions of this theory have often been verified, the size and degree of isolation are not the only factors that can influence the biodiversity of islands. Indeed, evolutionary divergence (when two groups of the same species develop different traits within these groups in order to adapt to different environmental and social pressures) and the formation of new species on the islands is a parameter that has not yet been taken into account. Recent studies have suggested that speciation - the evolutionary process by which new species emerge - can play a role similar to colonization, adding species to communities on remote islands. Two island populations resulting from the same colonization event

(the same mother population) can thus differentiate themselves within an island or archipelago and become reproductively isolated from each other; this phenomenon is called cladogenesis. But the consequent differences between speciation and colonization processes do not allow us to determine how and to what extent the analogy can be extended to the ETIB or other relevant theories that seek to explain community assembly. The initial objective of this working group was therefore to take advantage of the excellent experimental conditions of island systems to systematically examine and compare the influence of geographical and geological factors on the evolution of ecological assemblages, and then to provide a new and better understanding of the communities of species assembled over time on the islands.

Methods and approaches used for the project

Initially, the general approach was to test the assembled datasets against forecasts from biogeographic models. Those datasets, newly developed, can account for both ecological and geographical factors and historical events in the evolution of living organisms on the islands. CESAB has brought together through Islands working group an important network of the most active researchers in this field, and has also launched a major effort towards more conceptual and synthetic research.

Principal conclusions

Some of the major results that were not initially predicted are from a review article celebrating the 50th anniversary of the MacArthur and Wilson's ETIB. In this article initially published in 1963 in the journal Ecology Letters, participants combined their expertise to discuss the importance and relevance of the major principles that have emerged from theory in recent decades, and to propose a series of perspectives for future research.

This document contains a compilation of under-explored or potentially outdated ideas and hypotheses on the use of islands as a tool for understanding ecology and evolution in general.

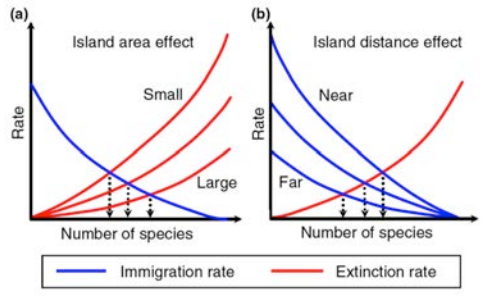

Figure 1 : The Island Biogeography Theory model, illustrating MacArthur & Wilson's original assumptions regarding the following: (a) the effect of island area on extinction rate, and (b) the effect of distance from the mainland on immigration rate.
Predicted species numbers appear on the x-axis, with dotted arrows marking equilibria between immigration and extinction rates. From Warren *et al.*, 2015.

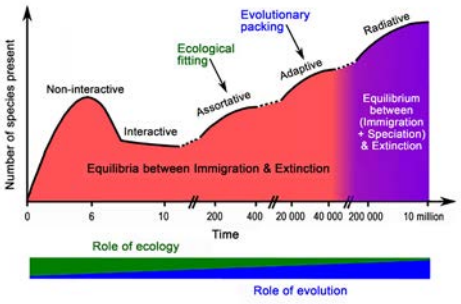

Figure 2 : Schematic hypothesis for the time-progressive continuum of equilibria involved in community assembly, modified from E. O. Wilson's (1969) Brookhaven paper.
A hypothetical relative time scale is used. Equilibria between immigration and local extinction are shaded red, while the equilibrium among immigration, speciation and local extinction is shaded purple. Once populations have differentiated *in situ* to the species level, local extinction events will also be total extinction events. From Warren *et al.*, 2015.

Anticipated (or actual) impact of these results for science, society, and public and private decision making

More than fifty years after the reference article by MacArthur & Wilson (1963) on the theory of island biogeography, it is appropriate to take into account new approaches to understanding ecology and evolution. Until recently, there was a real gap between spatial ecological studies, based on short time scales, and evolutionary studies based on longer periods and for which the spatial dimension is difficult to define. For ecologists and evolutionary biologists, all the assets offered by islands as model systems help to reduce this gap.

The increasing acquisition of DNA sequencing at the genomic level of non-model organisms, i.e. organisms with little or no genome modification, is of paramount importance in this endeavour. It provides ecologists and evolutionary biologists with unprecedented opportunities to discover the history of lineages at the community level and to decipher the processes underlying community formation. Many of the perspectives discussed at length during the project Islands and detailed in a review paper published in Ecology Letters (Warren et al., 2015: Figures 1 and 2) could only be achieved through this technological advance. In addition, islands, as model systems, are currently receiving considerable theoretical input. In accordance with MacArthur and Wilson's intuition, the implications of these island-based analyses are not limited to island environments; they extend to a much more global understanding of ecology and evolution.

Reference :

Warren, B.H., Simberloff, D., Ricklefs, R.E., Aguilée, R., Condamine, F.L., Gravel, D., Morlon, H., Mouquet, N., Rosindell, J., Casquet, J., Conti, E., Cornuault, J., Fernández-Palacios, J.M. Hengl, T., Norder, S.J., Rijsdijk, K.F., Sanmartín, I., Strasberg, D., Triantis, K., Valente, L.M., Whittaker, R.J., Emerson, B.C., Gillespie, R.G., Thébaud, C. (2015) Islands as model systems in ecology and evolution: prospects fifty years after MacArthur-Wilson. *Ecology Letters* 18: 200–216.

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