FRB FONDATION POUR LA RECHERCHE SUR LA BIODIVERSITÉ

CESAB
CENTRE FOR THE SYNTHESIS AND ANALYSIS OF BIODIVERSITY

Project summary

COREIDS

Predicting community resilience to invasions from diversity and network structure

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Co-funding organization: TOTAL-SA

As the 4th cause of biodiversity loss in the world, invasive species raise important environmental issues. The COREIDS project aimed to better understand the behavior of these species in ecosystems, to better determine their impacts and, ultimately, to devise strategies to predict and limit them.

Context and objectives

The earth has entered a new era since man has extended his grip on nature. This new era is called the "Anthropocene". It is a change as important as those that delimit the great periods of the geological and biological past of our planet. One of the most striking actions of man is to move animal and plant species from one place to another, often even from one continent to another, intentionally or not. Some of them adapt well to the environment where they are transplanted, and multiply and spread, often to the detriment of local species and sometimes human economic activities. They are called invasive species. To understand their impact, it is not enough just to understand the links that these species create with the local species present before the arrival of the invaders. Indeed, the local species are interdependent with each other through networks of interactions: for example, one constitutes the food of the other (trophic relation), or one is useful to the other for

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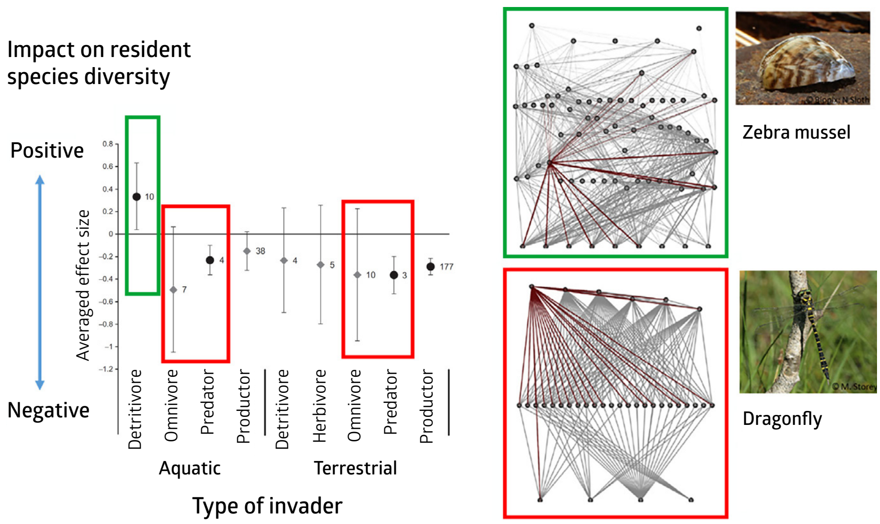
its reproduction, such as insects that pollinate plants. In such networks, the arrival of an invasive species will not only directly affect the species with which it interacts, but also have an effect that will spread in a chain to the entire species community. Understanding how these interaction networks work is essential for predicting the impact of an invasive species within an ecosystem. These networks are complex objects that are difficult to describe and study in nature. The objective of the COREIDS project was to gather the available knowledge on how invasive species interact with these networks to better understand their impacts and ultimately to devise strategies to predict and limit them if possible.

Methods and approaches used for the project

To achieve the project goals, the group has (i) gathered, compiled and analysed a large meta-database of invasion impacts in food webs, (ii) thoroughly reviewed the literature on invasions in food webs and the means to detect and predict invasions, (iii) collectively proposed, discussed and synthesized a list of the pending questions on the topic of invasions in ecological networks, and (iv) developed various theoretical models aimed at understanding the effect of invasions on the structure and dynamics of food webs, at both evolutionary and ecological timescales. The practical implementation of these approaches also involved two successive post-docs and a few masters students.

Principal conclusions

The impact of an invasive species on a resident community is mediated by its integration into a network of interactions. What we see is that the higher the complexity of the networks that structure the community in which it is integrated, the less significant will be its effect. And conversely, the simpler the networks, the greater the impact. The left panel in the graphic below shows the results of a meta-analysis highlighting that impacts of invasive species on biodiversity depend on **trophic types**. The right panels describe two examples, and the networks of trophic interactions they establish with other species in the invaded area. The graphs represent food webs in which each dot is a taxon and links connect predator and prey (interactions with the invasive species are highlighted). The Zebra mussel *Dreissena polymorpha* (classified as an aquatic detritivore) is a typical ecosystem engineer



• Change in species richness depending on the type of habitat that is invaded. Average response ratio and 95% confidence intervals of species richness for each type of habitat that was invaded. The values beside each point represent the number of response included in the analysis. Values that significantly differ from zero according to the 95% confidence intervals are plotted with a black circle.

creating habitat and establishing links with species at various trophic levels; its presence profoundly changes the whole community, and attracts many new species while removing others. In contrast, introduced predators such as the dragonfly *Cordulegaster* sp. in stream communities, usually have negative impacts on native diversity through top-down effects, especially when they are generalists feeding on many different species.

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

The aim of this project was to review an emerging field: the study of how invasive species affect ecological networks, and the potential benefits of a network-oriented view of impacts. This domain is still largely to be explored: most of the ideas still come from theoretical modelling and dispersed data on impacts of a few invasive species on a few potential **interactors**, while comprehensive evaluation of networks (e.g. food webs, pollination networks) before and after invasion are still rare. Our work will hopefully stimulate efforts to develop a form of network-oriented monitoring of ecosystems (not only lists of species but also lists of interactions) in order to get reference points before invasion, evaluate and understand impacts of invasions when they occur, and mitigate or prevent them when appropriate. We highlighted the methodological avenues (based on metagenomics and machine learning) that may represent the most efficient and realistic ways to achieve these goals. Indeed, detailed ecological assessment by classical methods (naturalistic and experimental studies) is likely to be unrealistic economically and scientifically, or must be limited to a few case studies, while impacts of invasive species are ubiquitous.

Even in the absence of such monitoring, our meta-analysis and review papers have already identified general patterns and listed some general principles and recommendations that may guide management, although they do not apply to one invasive species in particular. As an example, one is not to focus systematically on one invasive species and try to extirpate it by all means (often at high cost) in the hope of restoring previous ecosystems, without strong evidence of the efficiency of this action in a particular case. Indeed, invasions are often symptoms of a more general degradation of ecosystems such as habitat destruction or excess of nutrients, making restoration unlikely, and re-invasion likely, except in particular situations. In addition, surrounding species sometimes come to depend heavily on invasive species with which they establish interactions, and rapid suppression of these interactions is not necessarily favorable.

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