FRB
FONDATION POUR LA RECHERCHE SUR LA BIODIVERSITÉ

CESAB
CENTRE FOR THE SYNTHESIS AND ANALYSIS OF BIODIVERSITY

Project summary

BIODIS

Disentangling the linkage between biodiversity and emerging infectious diseases

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The vast majority of human infectious diseases are of animal origin. How are pathogens transmitted? Is biodiversity the main cause of these diseases? Within the framework of the BIODIS project, CESAB has brought together experts from different backgrounds to provide answers to these questions.

Context and objectives

60-75% of emerging infectious diseases are of animal origin. Intuitively, these viruses or bacteria should be more important in areas rich in biodiversity. Nevertheless, the emergence of these pathogens is often associated with a loss of biodiversity, mainly due to human activities. Several hypotheses have been proposed to explain this phenomenon, including the dilution effect theory,

which sees the circulation of pathogens being diluted by the contact with great biodiversity. Until today, most of these researches have remained theoretical and the relevant data to test these hypotheses could not be put to good use because of partitioning between disciplines. The best way to understand these relationships between biodiversity and emerging infectious diseases are based on inter-institutional and inter-disciplinary collaboration, highlighting the exchanges of databases and their exploitation.

Methods and approaches used for the project

CESAB brought together ecologists, public health experts, veterinarians, modelers and parasitologists, working in different regions of the world (South and Central America, Africa, Europe). During the various meetings, researchers analyzed the role of biodiversity in the transmission of emerging infectious diseases at different spatial and organizational scales.

From the BIODIS program, various international projects have emerged, such as the Mexican project "Biodiversity and Emerging Infectious Risks". In addition, the project BIODIS responded to two calls for proposals from the ANR. CESAB was one of the very first centers to select a biodiversity/emerging infectious diseases research project, recognizing the excellence of French researchers in this field.

Principal conclusions

- BIODIS has shown that the dilution effect is true in 75 % of situations.
- The amplification effect, when the risk of epidemics increases with the diversity of species present, has been verified in 25 % of situations.
- Dilution and amplification can nevertheless coexist in the same region, depending in particular on spatial heterogeneity, as shown in the work on *Mycobacterium ulcerans*.

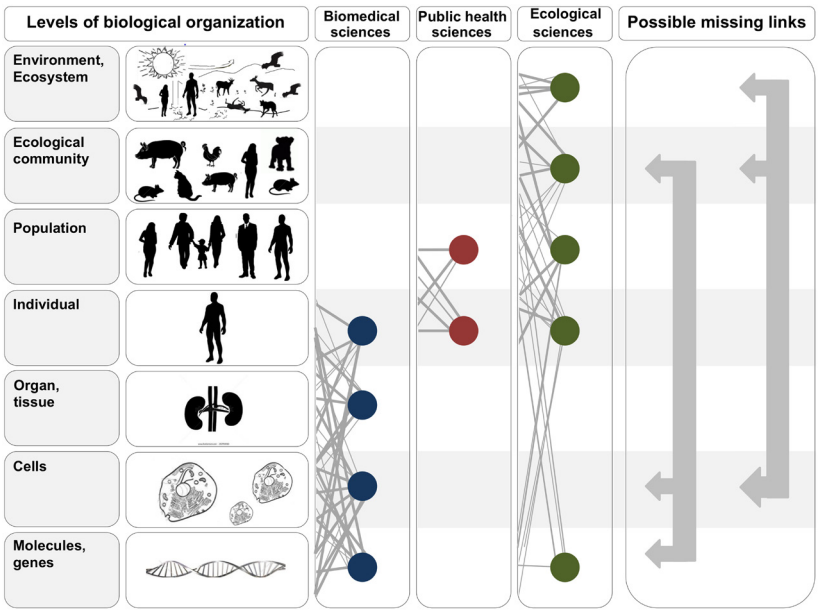

Figure 1: This figure summarizes one of the important findings of our interdisciplinary working group. It illustrates the importance of different levels of biological organization in research on zoonotic pathogens. In the two panels on the left, we describe the biological organization of living systems, from molecules and genes to ecosystems. Each hierarchical level reflects an increase in organizational

complexity, where each level is composed mainly of the units of the previous level. The two central boxes illustrate how research on the interactions between infectious agents and host systems differs between biomedical, public health and ecological sciences. The colored discs and the solid lines connecting these discs give an idea of the research carried out in the different fields of activity and by organizational level. The box far-right gives an indication of on research involving different levels of organization, which is currently missing. In order to improve knowledge on the causes and consequences of infectious diseases of animal or environmental origin, we suggest that future research should focus today on these missing links, all of which should take better account of the highest levels in the hierarchy of the organization of life (Ezenwe *et al.,* 2015).

One of the group's major results was to demonstrate the relevance of considering the spatial scale. An analysis on the presence and abundance of a human pathogen, *Mycobacterium ulcerans*, naturally present in the aquatic environment was carried out at 16 sites in the Akonolinga region of Cameroon. This study represents to date one of the most comprehensive studies to understand the dilution phenomenon at a regional level. Two types of ecosystems were identified: rivers (lotic or current ecosystem) and swamps and alluvial zones (lentic or slow ecosystem). It has been shown that these two types of ecosystems work differently with regard to the transmission of mycobacteria; for the same species richness, lentic ecosystems tend to see a decrease in the prevalence of this infectious agent, whereas lotic ecosystems, on the contrary, experience an increase in prevalences. In the same region, two types of aquatic ecosystems, for the same pathogenic agent, work very differently with regard to the relationship between biodiversity and infectious transmission. This work has shown the importance of the spatial dimension and its heterogeneity in understanding the links between biodiversity and the ecology of infectious transmission of emerging pathogens.

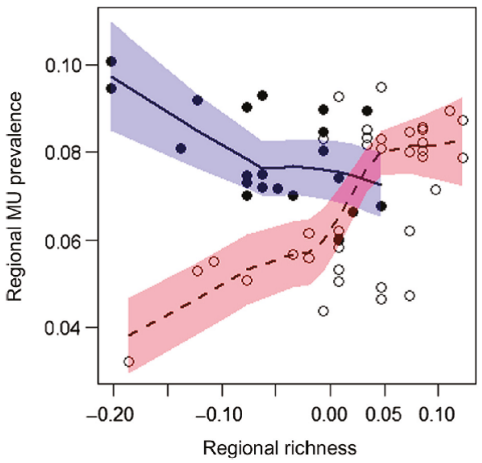

Figure 2: The relationship between regional richness of host taxa and the prevalence of *Mycobacterium ulcerans* is substantially different between the lotic systems (open round, dotted line and red polygon) and lentic (black round, solid line and blue polygon). The prevalence relationship of *M. ulcerans* and regional host taxa richness is positive in aquatic lotic environments and negative in lenticular environments. At a regional level depending on the type of ecosystem and habitat heterogeneity, opposite biodiversity-disease relationships may be encountered. The circles and polygons respectively represent the prevalence of mycobacteria and its standard error, as predicted by the generalized linear model (Garcia-Pena *et al.,* 2016).

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

Several members brought the results and concepts of this working group into the decision-making sphere. Jean-François Guégan participated in the written report on the "Links between Health and Biodiversity", supervised by Patrick Lavarde, Eric Fouquet and Philippe Maler (report N°008095-01) of the French Ministry of Ecology, Sustainable Development and Energy (April 2013), and continues to work on this same theme for this Ministry through the FRB. Benjamin Roche as well as Jean-François Guégan participated in a drafting group for the "National Health and Environment Plan (PNSE) 3" in which a better understanding of the health and environment of the French population was achieved, and in which the linkages between biodiversity and human health is listed as a national public health priority.

The main messages delivered are:

- The more humans affect natural ecosystems and the more opportunities they create exposure to new and emerging infectious threats.
- Ecosystem interface zones represent environments that are opportune for the transmission of new infectious agents. These interface areas are also those frequented or exploited by humans that expose them to these hazards.
- Predominantly, emerging infectious diseases cause few deaths with the exception of the Ebola epidemic in West Africa. However, these emergencies often have dramatic socio-economic consequences for national and global economies. Prevention and population education must be the first priorities in the fight against these new threats.
- At the national level, but also at the global level, the restoration of habitat diversity (hedges, plots of land, etc.) is a multiplied lever to act against soil erosion, promote water retention, curb biological invasions or pathogenic agents, establish greater biological diversity, generate a diversity of territories and environments, participate in the collective imagination, etc., and must be a priority in development policies.

References:

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