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CESAB
CENTRE FOR THE SYNTHESIS AND ANALYSIS OF BIODIVERSITY

Project summary

FREE

Causes and consequences of functional rarity from local to global scales

Principal investigator: Cyrille VIOLLE – CEFE-CNRS
Postdoc: Nicolas LOISEAU – CEFE-CNRS
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It has long been thought that rare species contribute little to the functioning of ecosystems. Yet recent studies have discredited that idea: rarity is a matter not only of the abundance or geographical range of a species, but also of the distinctiveness of its ecological functions. Because these functionally distinct species are irreplaceable, it is essential we understand their ecological characteristics, map their distributions, and evaluate how vulnerable they are to current and future threats.

Context and objectives

The majority of species are rare, and this rarity motivates research in conservation, ecology, and evolutionary biology. Researchers have attempted to identify species' characteristics associated with rarity and extinction risk. More recently, ecologists have examined the role of rare species in the regulation of ecosystem processes and the functional consequences of their extinction. **Some results suggest that rare species may over-contribute to the diversity of traits within communities thus supporting irreplaceable functions, while others find that rare species are functionally redundant with common species.** Taxonomic and phylogenetic approaches to diversity include measures that explicitly incorporate rarity and

these have been used to inform conservation and management activities. The rarity of functions, coined as functional rarity, has received far less study. This is in part because functional rarity still lacks a clear definition and a quantitative framework, and the processes underlying the emergence and maintenance of functional rarity within communities are largely unknown. The overall objective of the working group FREE ('Functional Rarity in Ecology and Evolution') is to advance the concept of functional rarity and examine the causes and consequences of functional rarity from local to global scales.

Methods and approaches used for the project

From the beginning of the project, the groupe of researchers benefited from access to regional and global databases containing information on species occurrences and biological characteristics for a large number of taxonomic groups (plants, birds, mammals, fish, reptiles, microorganisms). FREE developed an analytical framework, and associated indices, to identify species that could be considered unique within a species assemblage. It analyzed the spatial distribution of these species and identified factors (e.g., climate, human pressures) that might explain their presence. Finally, through simulation, it assessed the role played by species with unique functions in the functioning of forest ecosystems.

Principal conclusions

Through multi-taxa database analyses, FREE have shown that taxonomic rarity and functional rarity are most often decoupled, which has major implications for conservation policies. **Notably, the researchers found that many species, not yet evaluated by conservation agencies (e.g., IUCN) are in fact at threat from a functional perspective in several taxonomic groups (birds, mammals, reptiles, plants).** They also identified new functional rarity hotspots at global scale (Figure) that should be considered as priority areas in biodiversity conservation. Through modeling and analysis of regional databases, they demonstrated the major role played by functionally rare species in regulating the productivity of alpine forests and herbaceous communities. Strikingly, under stressful environmental conditions, they found that the productivity of a forest ecosystem decreased much faster when functionally rare species were lost first than when species were lost randomly.

They mapped the number of functionally rare species on a 50 by 50 km grid on a global scale to (i) highlight hotspots of functional rarity (ii) examine their spatial congruence with hotspots of species richness and common species. Using two databases that collect information on the world's terrestrial mammals (4,654 species) and birds (9,287 species), they have highlighted considerable geographic disparities between the hotspots of species richness (A and D), functionally common species (C and F) and functionally rare species (B and E). functionally rare (B and E). The distribution of functional rarity is particularly disparate. **2.8% and 8.9% of the world's land area supports at least one functionally rare mammal or bird rare.** The functionally rare mammals are mammals are mainly found in the tropical zone and the southern hemisphere, with a peak for the Indonesian islands, Madagascar and Madagascar and Costa Rica. Functionally rare birds are found mainly in the Andes the Andes, Panama, Costa Rica, and several Indonesian islands (Figure from Loiseau et al. 2020)

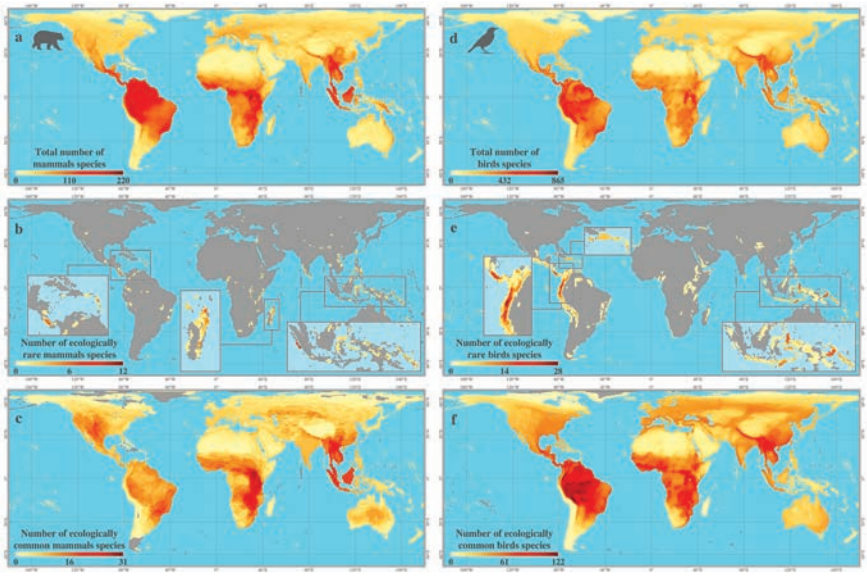

Figure: hotspots of mammals and birds species richness (A and D), hotspots of functionally common mammals and birds species (C and F) and hotspots of functionally rare mammals and birds species (B and E). Loiseau et al., 2020.

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

FREE findings challenge conservation biology from a functional perspective. The project provided new indicators for the monitoring and classification of species and ecosystems on a functional basis. This is a major achievement for both functional ecology and conservation biology. **Indeed, the assessment of the threatened status of all species on earth based on population dynamics criteria is infeasible. Using an additional criterion (based on available trait information) can help prioritize conservation targets.** This also bridge conservation biology and functional ecology, with a quantitative evaluation of the role of biodiversity in driving Nature's Contribution to People (NCP). The evaluation of the role of functionally rare species in ecosystems is a major breakthrough for functional ecology since the focus on common species have been the unique targets of this field for a long time. FREE demonstrated that functionally rare species cannot be ignored anymore in functional ecology studies.

PARTICIPANTS:

A. ALGAR, University of Nottingham (UK) / A. AUBER, Ifremer (FR) / M. CADOTTE, University of Toronto, (CA) / P. DENELLE, CNRS (FR) / B. ENQUIST, University of Arizona (US) / N. FIERER, University of Colorado (US) / M. GRENIE, CNRS (FR) / G.KANDLIKAR, University of California (US) / C. KLAUSMEIER, Michigan State University (US) / N. KRAFT, University of Maryland (US) / S. LAVERGNE, Université de Grenoble (FR) / H. LITCHMAN, Michigan State University (US) / A. MAIRE, EDF (FR) / B. MAITNER, University of Arizona (US) / C. MARTINEZ, Université de Grenoble (FR) / B. MCGILL, University of Maine (US) / M. MCLEAN, IFREMER (FR) / D. MOUILLOT, Université de Montpellier (FR) / N. MOUQUET, CNRS (FR) / F. MUNOZ, Université de Grenoble (FR) / J. MURGIER, Ifremer (FR) / A. OSTLING, University of Michigan (US) / W. THUILLER, CNRS (FR) / S. VILLEGIER,CNRS (FR) / L. ZINGER, Université Paul Sabatier (FR).

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