Story summary

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# 1. What is the central question?

What are the drivers and the typology of biodiversity changes in freshwater fish communities?

# 2. Why is this question important?

Global change put biodiversity is under underprecedented pressure. This is particularly true for freshwater system that accumulate specific pressure such as flow alteration, overexploitation, accumulate pollution from terrestrial land and is threatened by introduction of exotic species. However, we have little knowledge on how biodiversity change in fish freshwater system and those changes are affected by anthropogenic pressures.

Biodiversity changes can be described in several ways, such as temporal trends in total abundance, species richness and dissimilarity metrics. The question of whether those different ways of describing biodiversity changes covary or not has been overlooked. An answer to this question might give us insight on how many and which biodiversity metrics should be measured to improve our documentation of biodiversity changes.

# 3. What data are needed to answer this question?

1. Time series of freshwater fish community monitoring at large spatial scale

* They should be internally homogeneous to assess temporal trends

1. Characteristics of stream at each site: physiography, hydrology
2. Metric of anthropogenic pressure
3. Metrics of biodiversity
4. Characterisation of species origin: native or exotic

# 4. What methods are used to get those data?

1. RivFishTime database

* Filtering for consistency in protocol, unit of measurement, sampling season and time span

1. Riveratlas extraction of average annual discharge, distance of the sites from the source, site altitude and slope at a spatial resolution of 4km
2. Riveratlas extraction of the Human footprint index (1993;2009):

* Legacy of long-term anthropogenic pressure: Human footprint (1993)
* Recent changes in anthropogenic pressure: Human footprint ratio (2009/1993)

1. Compute metrics of biodiversity, i.e. community composition:

* Dissimilarity based on presence/absence or abundance and their partitioning in Nestedness/Turnover, Appearance/Disappearance
* Total abundance
* Species richness

1. Tedesco et al. database (basin scale) mostly

* Completed by fishbase database (country scale)
* Completed by NAS database for the US (state scale)
* Completed by litterature search
* Metrics: percentage of exotic species, percentage of exotic species abundance

# 5. What analysis must be applied for the data to answer the central question?

* Stream gradient: PCA over stream characteristics and extract site coordinates on the first PCA axis
* Modelling the relationship among biodiversity, time, stream gradient and anthropogenic pressures at global scale
  + Hierarchical model to assess simultaneously the temporal trends at global, basin and site scale
    - One model to characterize the relationship among biodiversity facets, ecological drivers, temporal trends and the effects of ecological drivers on temporal drivers
  + One model without ecological drivers: extraction of biodiversity temporal trends at site scale with the BLUP method
* PCA over the temporal trends of the different biodiversity facets
* Robust clustering method with k-means algorithm over the temporal trends of biodiversity facets

# 6. What data were obtained?

Not applicable

# 7. What were the results of the analyses ?

## Dissimilarity

We found strong evidence that community composition change through time, both due to change in species occurrence (Jaccard) and in species dominance (Simpson based dissimilarity). We further found that this dissimilarity was mainly due to changes in species identity (Turnover) rather than nestedness.

We found strong evidence of positive relationship between dissimilarity rates of change and anthropogenic pressures, both past and recent. We further found strong evidence of a positive relationship between dissimilarity rates of changes and stream gradient.

## Total abundance, species richness and exotic species composition

We found strong evidence of a global positive temporal trends for total abundance, species richness, a weak evidence of a global positive temporal trends of the percentage of exotic species.

We further found strong evidence of a positive effect of legacy of past anthropogenic pressure on the temporal trends of species richness and total abundance but no effect on the temporal trends of exotic species percentage. Conversely, we found moderate and weak evidence that recent increase in anthropogenic pressures had a negative effect on total abundance and species richness temporal trends but we found strong evidence for a positive effect on  
the temporal trends of the percentage of exotic species.

We also found strong evidence that the interaction between past and recent anthropogenic pressure had a positive effect on the temporal trends of the percentage of exotic species but a negative effect on the temporal trends of total abundance and no effect on the temporal trends of species richness and percentage of exotic abundance.

## Typology of biodiversity trends

We found that the PCA isolates four dimensions of biodiversity trends: there were related to dissimilarity in community composition, species richness, nestedness and total abundance. This partition was further confirmed by the cluster analysis.

# 8. How did the analyses answer the central question?

Our analysis suggests that past anthropogenic pressures and recent ones increases the rates of community composition change through time, even synergistic. Past anthropogenic pressures and recent ones have contrasted effects on the temporal trends of biodiversity. While our results suggest that community located in sites of high past anthropogenic pressure are recovering in terms of total abundance and species richness, it is the reverse for community located in site that recently increased in human pressure.

Our result suggests that the temporal trends of different biodiversity facets lies in several dimensions and thus it might be needed to better understand temporal community changes.

# 9. What does this answer tell us about the broader field?

The global positive temporal trends of total abundance and species richness that we found are in accordance with the result of a recent meta-analysis on aquatic insects (Klink et al. 2020). Our results suggest that in fish stream communities, those positive trends are partly attributed to the increase of exotic species percentage. Furthermore, the high rates of community changes that we found were related to changes in species composition, in accordance with previous meta-analysis on marine and terrestrial vertebrates (Dornelas et al. 2014; Blowes et al. 2019). Our results further suggest that site degradation might drive high rates of community changes for three reasons. First, 92% of our site can be considered as in a degraded state (hft > 4, Williams et al. 2020). Two, our results suggest that past and recent anthropogenic pressures lead to faster rates of change in species composition.

Our results on the typology of biodiversity trends are in accordance with previous results showing that species richness temporal changes and temporal changes are unrelated (Dornelas et al. 2014; Blowes et al. 2019). Our results further suggest that total abundance temporal is a third dimension of biodiversity trends.

# Ref

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