mFD: an R package to compute and plot Functional Diversity

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Résumé

Functional diversity (FD), the diversity of organisms attributes that relates to their interactions with the abiotic and biotic environments, is a core biodiversity component. FD has been increasingly assessed for the last two decades in ecology to unravel the response of species assemblages to natural or anthropogenic pressures and their effects on ecosystem functioning. FD is multifaceted and to measure its facets, several frameworks and indices have been proposed. The *mFD* package is an R package which provides a set of "user-friendly" functions covering all the steps of FD-based analyzes to compute 16 functional diversity indices with, in addition, customizable graphical representation of key outputs based on *ggplot2* framework. *mFD* comes with a dedicated website that provides a set of tutorials to help new-comers in the field to compute and analyze FD .

Key words : R Package – Functional Traits - Alpha Diversity – Beta Diversity - Functional Space

Développement

Among all biodiversity components (Pollock et al. 2020), functional diversity (FD), i.e. the diversity of organism characteristics that relate to their interactions with their abiotic and biotic environment, has been increasingly considered for the last two decades in all fields of ecology such as community ecology and biogeography. FD itself is multifaceted, embedding within (alpha-diversity) and between assemblages (beta-diversity) components, which each gathers complementary features to describe the distribution of species attributes (Mouillot et al. 2013 ; Villéger, Grenouillet, et Brosse 2013). To measure those facets of FD, several frameworks (i.e. group-, distance-, dendrogram-, or multidimensional-based) and indices (e.g. richness-, density-, entropy-like), have been proposed and some of them have been increasingly used (e.g. (Villéger, Mason, et Mouillot 2008) and (Laliberté et Legendre 2010) cited > 100 times each year from 2015 to 2020).

Most of these FD indices are already computable using publicly available R functions that are disseminated in several packages, publications' supplementary materials and on personal repositories. For example, the *dbFD* function of the *FD* package (Laliberté 2010) computes seven multidimensional FD indices. However, this package computes the multidimensional space (or dendrogram) and FD indices within the same function while they correspond to independent steps (Mouchet et al. 2008, Maire et al. 2015). The *betapart* package (Baselga et Orme 2012) contains a set of functions to compute functional beta-diversity indices based on overlap of species assemblages in a multidimensional space but it does not allow graphic representation of indices. Other R functions select the best

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multidimensional space in which FD indices are computed (Maire et al. 2015) and also compute group-based indices (Mouillot et al. 2014) or entropy-like indices (Chao et al. 2020) but are not embedded in a single source. This is why we designed the *mFD* package: to provide a set of "user-friendly" functions covering all the steps of FD-based analyzes, from the check of input data, through the identification of functional groups, computation of trait-based distances and the building of the functional space required to compute 16 functional diversity indices, with graphical representation of key outputs. We also provide a set of tutorials to help users to follow correct progression and interpretation of their analyses.

The use of the *mFD* package relies on a dataframe gathering species functional traits for a studied set of species and a matrix of assemblages gathering species biomass or abundance per unit of area, percentage of ground coverage or occurrence for a given set of assemblages. Based on these two main inputs, *mFD* allows measuring FD indices using three different frameworks based on either groups of species, pairwise trait-based distances between species, or species coordinates in a multidimensional space. For this latter framework, *mFD* package computes several functional spaces and returns their quality (the chosen functional space can be plotted and all graphical parameters are personalisable). Then, 16 functional indices can be computed then illustrated with customizable graphical parameters.

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