Confidence intervals for functional diversity indices considering species abundance

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Functional diversity indexes are based on distance between species evaluated on trait space. Current used indexes are Walker's FAD2, Petchey's FD, FDvar and quadratic entropy (HD); mainly using Euclidean, Manhattan or Gower distance measurements. We construct confidence intervals (CI) based on e.p.d. (empirical probability distribution) of the index using parametric (based on normal multivariate distribution), and non parametric (based on fixed probability assignment of possible values for ordinal or nominal variables) random simulations.

The comparison of published data sets, new data sets, and simulated sets with different species numbers, trait numbers and dispersion ranges shows that the CI may be used to asses: a) the effect on the index due to changes in the abundance of each species when it is partially or totally removed from the community; b) the degree of variation on relative abundance of species that do not affect significantly the functional diversity of the original community; c) the significant differences in functional diversity among communities. Only quadratic entropy using a relative expression of the index enables direct comparisons of CI, no matter the number of species or traits considered. However, the expected maximum functional diversity (HDmax) is obtained with very few species, except when an ultrametric distance matrix is used. The species relative abundances and their CI's at HDmax are also interpretable information for the ecologists.

We obtained a FD value of 3.54 (2.91-3.63) in a high grazing community with five traits and 12 spp, and a FD value of 0.0267 (0.0261-0.0272) when the abundance is taken into account. For a similar community but with low grazing (same five traits and 21 spp, 11 in common) the values were 4.54 (3.95-4.87) and 0.0129 (0.0127-0.0134) respectively. When FD is loaded by abundance the order of values is reversed and the high grazing community appears as more diverse. Both, FAD2 and FD are highly correlated with richness. Direct comparisons between communities with different number of species and/or traits are valid only on HD relative values. For the same communities, the HD values were 0.3417(0.3396-0.3472) and 0.3954(0.3942-0.3965) for high and low grazing. If the index is expressed as a fraction of its maximum, the values change to 0.837 (0.832-0.842) and 0.855 (0.852-0.857). The CI's for all the indexes, except for HD, are asymmetric, with a longer upper tail when confidence decreases. The HD intervals are almost symmetric for confidence from 0.99 to 0.70.

From real data sets and simulated data sets we conclude that the estimation of CI may contribute to interpret ecological patterns of change in functional trait space, mainly with functional diversity indexes that considerer the relative abundance of species, or of plant functional groups. Whatever the index applied, and as long as the selected traits are relevant to the ecological functioning of the ecosystem under study, a statistical tool is a must to evaluate the index's degree of confidence. We provide the ecologists with a protocol, including the software, to help analyzing and assessing relationships between ecological complexity and functional diversity.