

Taxonomic, functional, and phylogenetic diversity of fungi in a forest-tundra ecotone in Quebec

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The taxonomic, functional, and phylogenetic diversity of fungi associated with dead moss tissues (*Racomitrium lanuginosum*) and conifer needles (*Picea glauca*) were quantified in a forest-tundra ecotone in sub-arctic region, at Kuujjuarapik-Whapmagoostui (55.31°N, 77.75°W), Quebec, Canada in order to demonstrate the effects of host plant species and local environmental heterogeneity on fungal diversity in the cold region. The moss and conifer are dominant plants in the study site. A total of 615 operational taxonomic units (OTUs) of fungi in 84 families were detected using MiSeq sequencing with 97% sequence similarity by metabarcoding the internal transcribed spacer (ITS) region of nuclear ribosomal DNA, of which saprotrophs were the dominant functional guild based on the FUNGuild database. The methods of data analyses follow Matsuoka et al. (2019). Taxonomic diversity indices included OTU richness, the number of family, and the number of OTUs that were identified to family (denoted as OTUf richness). We constructed a data matrix of functional traits for 84 fungal families with reference to Cannon and Kirk (2007) by extracting ecological information of five traits relating to geographical distribution (cosmopolitan, widespread, subtropical, tropical, temperate) and 12 traits relating to functional group to calculate FRd, an index of functional diversity, and the standardized effect size (SES) of FRd to show the functional diversities without dependence on richness gradient among samples. The 84 fungal families identified were placed on a tree based on the phylogenetic relationships known between the fungal families to calculate three common metrics for the phylogenetic α diversity: Faith's index of phylogenetic diversity (Faith's PD), the mean pairwise distance (MPD) and its SES, and the mean nearest taxon distance (MNTD) and its SES. Taxonomic and phylogenetic diversity indices of fungal communities were significantly greater in moss than in conifer (Table 1). The greater phylogenetic diversity in moss was mainly attributed to the occurrence of families in Mucoromycota, compared to those in conifer with relatively closely related families of Dikarya. The taxonomic diversity was also related to local variations in vegetation and soil properties, suggesting that the local colonization and establishment of vegetation and the concomitant development of soil contributed to the taxonomic diversity of fungi in the forest-tundra ecotone. In contrast, functional diversity was not significantly affected by host, vegetation, or soil properties (Table 1), indicating that the fungal communities were relatively redundant in terms of the functional traits summarised in the present study.

Table 1. Taxonomic (OTU richness, number of family, and OTUf richness), functional [FRd and FRd(SES)], and phylogenetic diversity [Faith's phylogenetic diversity (Faith's PD), the mean pairwise distance (MPD), and the mean nearest taxon distance (MNTD)] of fungi. OTUf denotes OTU that was assigned to family with Cladent. Standard effect size (SES) was calculated for FRd, MPD, and MNTD. Values indicate means with standard errors in parentheses. Results of generalized linear models are shown; *** P<0.001, ** P<0.01, * P<0.05, ns not significant.

| | Moss | Conifer | <i>t</i> value | Probability |
|------------------|--------------|--------------|----------------|-------------|
| OTU richness | 29.8 (2.6) | 22.7 (2.0) | 4.77 | 0.000 *** |
| Number of family | 9.3 (0.7) | 6.7 (0.6) | 3.13 | 0.002 ** |
| OTUf richness | 14.1 (1.3) | 10.1 (1.0) | 3.86 | 0.000 *** |
| FRd | 1.41 (1.13) | 0.09 (0.09) | 1.86 | 0.068 ns |
| FRd (SES) | -0.37 (0.20) | -0.28 (0.32) | -0.27 | 0.786 ns |
| Faith's PD | 40.1 (2.3) | 30.1 (1.8) | 2.84 | 0.006 ** |
| MPD (SES) | 0.56 (0.20) | -0.30 (0.28) | 2.43 | 0.019 * |
| MNTD (SES) | 0.58 (0.18) | 0.00 (0.24) | 1.87 | 0.067 ns |

References

- Cannon, P.F., Kirk, P.M., 2007. Fungal families of the world. CABI, Wallingford.
- Matsuoka, S., Ogisu, Y., Sakoh, S., Hobara, S., Osono, T., 2019. Taxonomic, functional, and phylogenetic diversity of fungi along primary successional and elevational gradients near Mount Robson, British Columbia. *Polar Sci.* 20, in press.