New insights into moss nitrogen fixation and associated N2 fixer communities from a 1000 Km latitudinal transect in Eastern Canada.

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Moss-associated cyanobacteria nitrogen (N2-) fixation can support moss growth and constitutes a major source of new N in boreal forest ecosystems. Moss-colonizing cyanobacterial biomass and their N2-fixation are usually considered linearly correlated. However, recent evidence showed that cyanobacterial biomass and N2-fixation can be disconnected, hinting that they might be affected by the different environmental and ecological drivers. These drivers are often studied using manipulative experiments (e.g. fertilization, incubation) and remain to be validated with complementary work in observational studies. Cyanobacteria are considered the major actors of N fixation. However, the nature and diversity of active microbial communities associated with feather mosses are still unclear and the effects of the environment on these community are vague.

Using random forest, spearman correlations and linear mixed-effects models, we studied the main drivers of cyanobacterial biomass and N2-fixation of two dominant feather moss species collected over three years on a 1000-km latitudinal transect in the eastern Canadian boreal forest. Using RNA-based amplicon sequencing of the 16S rRNA and nifH genes we explored the active bacterial communities along this transect and along the moss shoot.

We report that temperature, precipitation, and phosphorus were the main drivers of moss cyanobacterial biomass and that temperature, molybdenum and vanadium were the main drivers of N2-fixation. Cyanobacteria accounted for 33% of global bacterial communities and 65% of diazotrophic communities, respectively. Several cyanobacterial and proteobacterial methanotrophic genera, including poorly known taxa found for the first time on boreal feather mosses, were actively contributing to N2-fixation. We showed that bacteria were heterogeneously distributed along the moss shoot, with phototrophs being dominant in the apical part and methanotrophs being dominant in the basal part. Finally data showed that climate (temperature, precipitation), environmental variables (moss species, month, tree density) and nutrients (nitrogen, phosphorus, molybdenum, vanadium, iron) strongly shape the global and diazotrophic bacterial communities and create ecological niches on the moss shoot.

This work provides new insights into the feather moss microbiome and its ecological and
biogeochemical functions. Our data provides evidence that the feather moss microbiome plays crucial roles in supporting moss growth, health, and decomposition, as well as in the boreal forest carbon and nitrogen cycles. Finally, this study highlights the strong effects of climate and nutrients in shaping feather moss microbiome and its activity (i.e., $N_2$ fixation). This work will help better predict the impacts of global change on this symbiosis and on nitrogen input in boreal forest ecosystems.