Vanadium nitrogenase in boreal cyanolichens: activity and regulation

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Nitrogenases (Nases) are enzymes that catalyze the reduction of inorganic nitrogen (N_2) to ammonia, a readily available N form for living organisms. Besides the canonical molybdenum nitrogenase (Mo-Nase), present in all N_2 fixers, two "alternative" isozymes have been reported- the vanadium dependent (V-Nase) and the iron-only dependent nitrogenase (Fe-Nase). The role of alternative nitrogenases in natural habitats has mostly been overlooked, and Mo-Nase is thought to be the only isozyme with ecological relevance in unmanaged ecosystems.

Here we present the result of a recent project aiming at deciphering the role of alternative nitrogenase fixation in high latitude ecosystems (boreal and subarctic areas), using cyanolichens from the genus *Peltigera* collected in several areas of the northern hemisphere (Eastern and Western Canada, Sweden and Russia).

We find evidence for the presence and use of the alternative V-Nase in cyanobacteria of the genus *Nostoc* in boreal cyanolichens using genetic, metallomics, and isotopic characterisation methods, and report that alternative Nase activity in *Peltigera* may account for as much as half of total N_2 fixation activity. We discuss the factors that might influence the use of V-Nase in cyanolichens, particularly temperature and the availability of Mo.

Overall, our findings challenge the traditional view of Mo Nase hegemony on fixed N input and invite a re-evaluation of the importance of alternative Nases in natural habitats, particularly in low temperature and Mo limited ecosystems.