Snow algal blooms: Melting mountain and polar snow as a challenging habitat

Lenka Procházková, Linda Nedbalová

Department of Ecology, Faculty of Science, Charles University, Prague, Viničná 7,128 00

Keywords: cryoflora, *Chloromonas*, *Sanguina*, snow, microalgae

Snow algae thrive in habitats of melting snow in polar and mountain regions. This taxonomically diverse group of phototrophs is adapted to live under extreme conditions including high light, freeze-thaw cycles and limited nutrients. They synchronized their life cycle with seasonality, entering a cyst stage before final snowmelt takes place.

This contribution is focused on two recent issues: Firstly, red spherical cysts are found worldwide in polar and alpine snow. Only at polar sites, these blooms are occasionally next to orange spots consisting of smaller orange cysts. The aim was to resolve their phylogenetic position, describing morphology, the molecular variability and geographic distribution. Secondly, ten populations of a species causing orange snow in several mountain ranges in Central Europe were explored.

Based on analysis of multiple molecular markers of 42 field samples from Arctic, Antarctic, North and South America and Europe, it was demonstrated that the red and orange spherical cysts formed one independent lineage in Chlamydomonadales (PROCHÁZKOVÁ et al. 2019a). Therefore, a new genus (*Sanguina*) was proposed with *S. nivaloides* as the type species. *S. nivaloides* is a diverse species, containing worldwide at least 18 haplotypes related to ITS2 rDNA. Interestingly, the orange cysts were recognized as very closely related and described as *S. aurantia*. Both species have partly overlapping area of geographical distribution, being commonly found together in Arctic and subarctic regions. Although they share the same habitat of open sites, they significantly differ in their ability of accumulation secondary carotenoids. Consequently, snowfields discolourations differ based on the abundance of astaxanthin.

Contrary, the second story is about a snow alga which is morphologically identifiable as the putative cosmopolitan *Chloromonas nivalis*. The molecular analysis showed that it is a new species, so far found in the Central Europe. It was described as *Chloromonas hindakii* based on combination of morphological characteristics of vegetative flagellates and cysts (PROCHÁZKOVÁ et al. 2019b). While the two *Sanguina* species are restricted to exposed sites, the distribution of *C. hindakii*, at an altitudinal gradient, ranged from montane to subalpine and alpine vegetation zones. Field cysts of the latter from high light conditions got photoinhibited at three times higher irradiances (600 μmol photons m^{-2} s^{-1}) than those from low light conditions, or likewise compared to cultured flagellates.

Since germination of snow algal cyst has not been successful for many species (e.g. *Sanguina*), Sanger sequencing of monospecies field blooms is a good alternative to get long sequence readings of multiple molecular markers needed for a proper molecular identification. Still, it is possible to distinguish the cysts of *C. hindakii* morphologically from cysts of other closely related snow algae based on details of the cell wall flange organisation. The high intraspecific flexibility of *C. hindakii* photosystems to different light conditions allows this species to colonize, resp. survive at changeable conditions in snow.

REFERENCES

PROCHÁZKOVÁ, L., LEYA, T., KŘÍŽKOVÁ, H. and NEDBALOVÁ, L. (2019a): *Sanguina nivaloides* and *Sanguina aurantia* gen. et spp. nov. (Chlorophyta): the taxonomy, phylogeny, biogeography and ecology of two newly recognised algae causing red and orange snow. *FEMS Microbiology Ecology*, 95(6): fiz064.

PROCHÁZKOVÁ, L., REMIAS, D., ŘEZANKA, T. and NEDBALOVÁ, L. (2019b): Ecophysiology of *Chloromonas hindakii*, sp. nov. (Chlorophyceae), causing orange snow blooms at different light conditions. *Microorganisms*, 7(10): 434.