The effect of an enhanced UV AB : PAR ratio on pigmentation and ultrastructure of *Zygnema* from polar regions

Martina Pichrtová[1,2], Daniel Remias[3] & Andreas Holzinger[4]

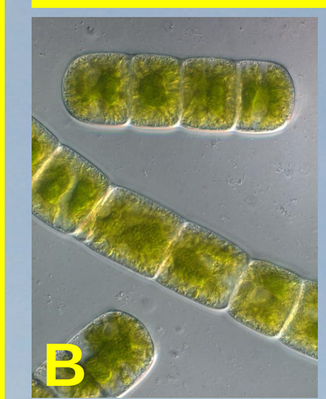
[1]Charles University in Prague, Faculty of Science, Department of Botany, Czech Republic; [2]Academy of Sciences of the Czech Republic, Institute of Botany, Třeboň, Czech Republic; [3]University of Innsbruck, Institute of Pharmacy, Innsbruck, Austria; [4]University of Innsbruck, Institute of Botany, Innsbruck, Austria

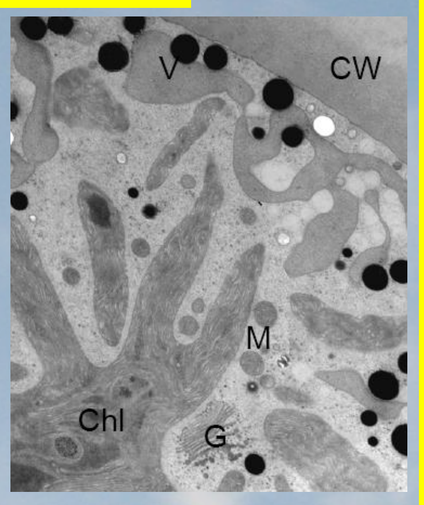
e-mail: pichrtova@butbn.cas.cz

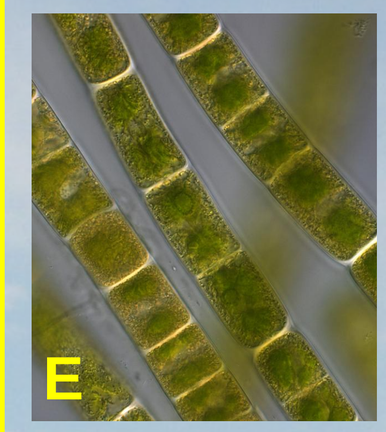
Introduction

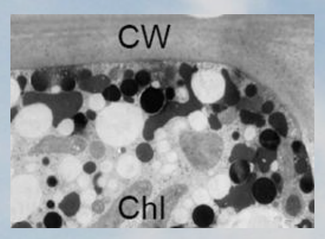
Zygnema is a filamentous green alga belonging to the class Zygnematophyceae (Streptophyta). It has a cosmopolitan distribution including polar regions and grows usually in shallow pools or on the wet soil surface. In such habitats algae are naturally exposed to UV radiation and adaptations to such stress are therefore expected (Holzinger et al. 2009). Moreover, the potentially harmful effects of UV in polar regions have been studied recently in connection with the depletion of the stratospheric ozone layer. Generally, many algae are able to produce special secondary metabolites (e.g. carotenoids or MAAs) as a protection against UV radiation (Cockell & Knowland 1999). Particularly in some Zygnematophyceae, phenolic compounds with an absorption in UV have been revealed (Remias et al. 2011). The aim of our study was to find out, whether Arctic and Antarctic *Zygnema* is also capable of producing phenolic substances and whether their production is dependent on UV exposure. The effect of UV on ultrastructure and photosystem II photochemistry were also studied.

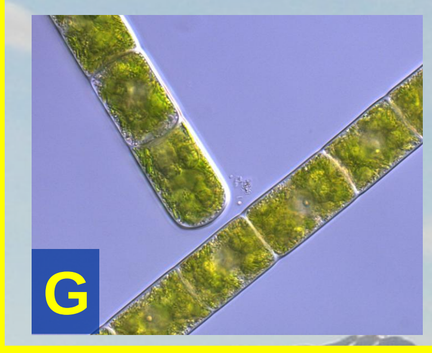
Control samples – PAR:

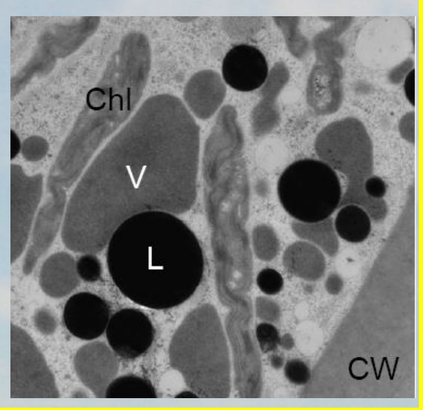






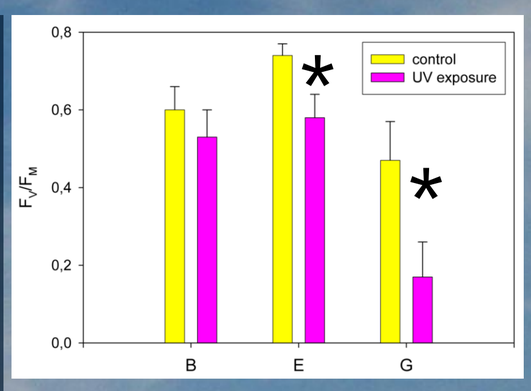


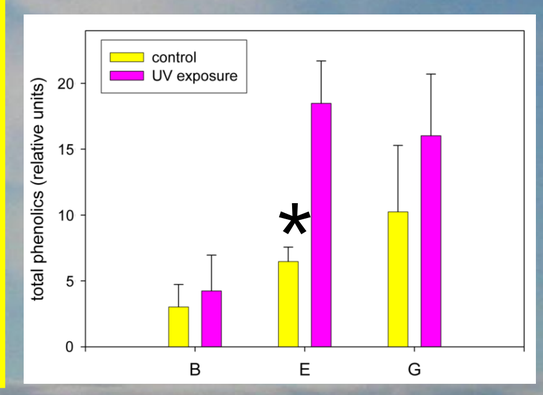




The *Zygnema* cells contained typical star shaped chloroplasts. Moreover, numerous vacuoles and lipid droplets were present, mainly in the cell periphery. After UV exposure alterations in ultrastructure occasionally appeared. Hoever, only in G quite a serious damage was observed, chloroplasts contained swellingss, plastoglobules and electron dense areas, mitochondria were altered as well.

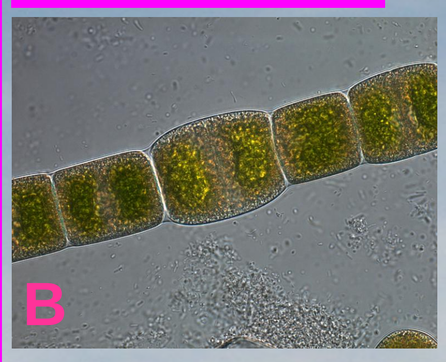
Measured values of F_V/F_M. The difference between control and UV samples was not significant in B. Values measured for G after UV exposure indicate that the cells were practically dead.

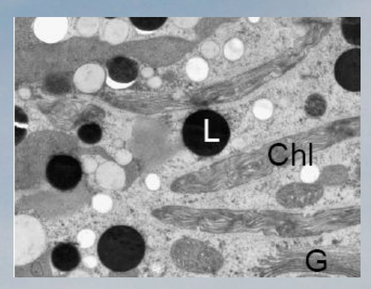


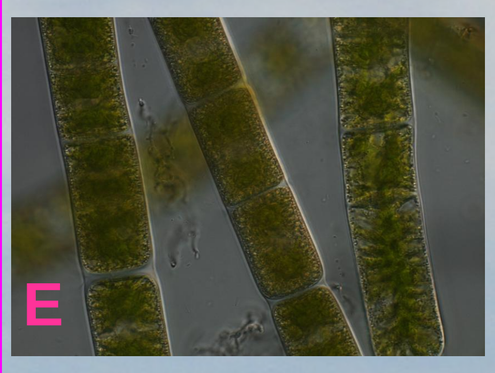


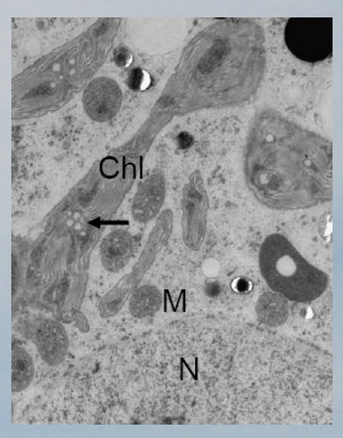
Total content of phenolic substances in semiquantitative units per unit dry weight. The increase in phenolic content afer UV exposure was significant only in E.

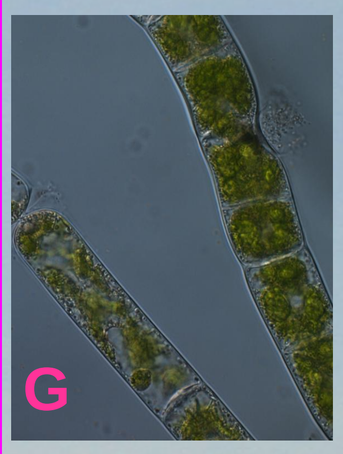
PAR + UV AB:

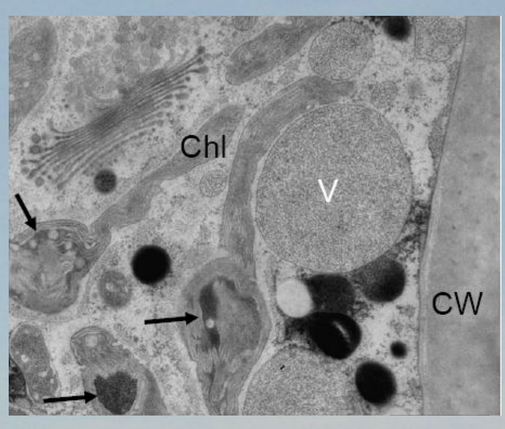






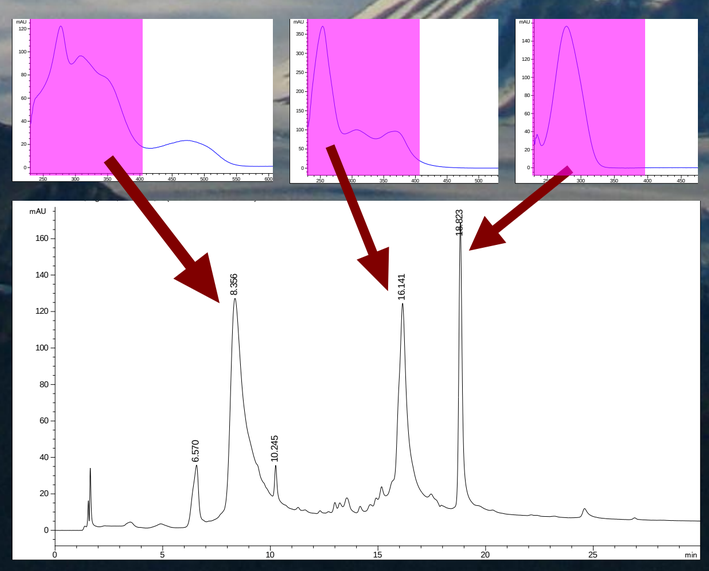






Material and methods

Three strains of *Zygnema* were used for the experiments: B and G isolated from Svalbard (the Arctic) and E isolated from Antarctica. They were cultivated on agar plates in climate chambers with a combination of fluorescence tubes which produced an enhanced UVA/UVB : PAR ratio. Samples grown only with PAR were used as controls and three replicates were used for each treatment. Phenolic substances were extracted in 20% methanol and analysed by HPLC. The ultrastructure was studied by means of transmissiom electron microscopy and the maximum quantum yield of PS II in dark-adapted state (F_V/F_M) was measured using a portable fluorometer.



A typical HPLC chromatogram of a UV-exposed culture (E) revealing several different phenolic substances. The absorption spectra of the three main peaks are also given – note the absorption maxima in UV region. The control samples contained these copounds as well, only in lower concentrations.

Summary

Our experiment revealed that the studied strains of *Zygnema* produce various phenolic substances with absorption in UV region. Generally, the production of these compounds was enanced by UV irradiation. However, only in strain E the increase in production was significant - the controls contained a considerable amount of phenolics as well. They are stored in vacuoles at the cell periphery and therefore they are able to screen UV and protect other organelles effectively. Besides, other mechaisms of protection could also be involved, which would explain why the strain B was not stressed by UV although containing the lowest amount of phenolics. All in all, their presence in our strains can be regarded as an adaptation of life to extreme habitats at polar regions.

References: Holzinger, A., Roleda, M. Y. & Lütz, C. (2009): The vegetative arctic freshwater green alga *Zygnema* is insensitive to experimental UV exposure. – Micron 40: 831-838; **Remias**, D., Schwaiger, S., Aigner, S., Leya, T., Stuppner, H. & Lütz, C. (2011): Characterization of an UV- and VIS-absorbing, purpurogallin-derived secondary pigment new to algae and highly abundant in *Mesotaenium berggrenii* (*Zygnematophyceae*, Chlorophyta), an extremophyte living on glaciers. – FEMS Microbiology Ecology: published online; **Cockell**, C. S. & **Knowland**, J. (1999): Ultraviolet screening compounds. – Biol Rev Camb Philos Soc 74: 311-345.

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