THE BIOLOGICAL DARKENING OF THE GREENLAND ICE SHEET:

IMPACTS OF VISIBLE AND UV LIGHT ON THE PHOTOSYNTHETIC PERFORMANCE, METABOLOME AND TRANSCRIPTOME OF GLACIER ALGAE

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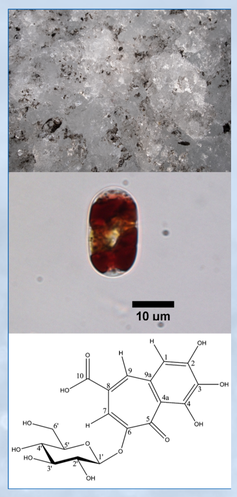
Why are ice algae important?

Background

The Greenland Ice Sheet (GrIS) is melting. Ice algae living on the ice surface contribute significantly towards the darkening of the ice surface and thereby accelerate its melting[1,2]. ***Mesotaenium berggrenii*** is one of the most abundant ice algae. These tiny creatures are perfectly adapted to survive under the harsh conditions of the GrIS at freezing temperatures, long periods of darkness and high irradiances. To protect themselves from too much sunlight they pack their cells with high amounts of **a deep purple pigment**, purpurogallin carboxylic acid-6-O-b-D-glucopyranoside, **short Purpurogallin**, acting as a natural sunscreen[3].



Expected outcome

An improved mechanistic understanding on the factors promoting the algae's growth and pigment production, revealing their role for the darkening of the ice, now and in future.

Implications for downstream marine ecosystems

Supraglacial microbial communities and their associated nutrient and carbon cycling influence nutrient and organic matter export into the adjacent marine system via meltwater runoff.

Where did we go?

Field work on the Eastcoast of Greenland

During July 2019, we went to Sermilik station, located below the Arctic circle (65°N). We collected samples over two weeks on the glaciers Mittivakat (MIT) and on the GrIS.

Watch the drone video of our sampling site (MIT) here!

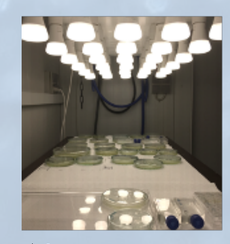
What did we do?

Novel laboratory cultures

To investigate the physiology of *M. berggrenii* in the lab for the first time, we are performing experiments to study the effects of temperature, UV radiation and nutrient stress on their growth and pigmentation.

The "return home experiment"

How does light in the VIS- and UV-range influence pigment production and photosynthetic performance of *M. berggrenii*?



Algae grown for five months in the lab lost their original pigmentation

We brought them **home to Greenland** to incubate them with their relatives from the field

Eight days on the ice with four different light treatments

Pulse-Amplitude-Modulated fluorometry (PAM)
Measures the quantum yield of charge separation in Photosystem II (proxy of in vivo variable chlorophyll a fluorescence yield, i.e. rate of photosynthesis) by applying short light flashes (µs) at defined wavelengths

What did we find out so far?

The presence of purpurogallin leads to a higher photosynthetic performance at a given irradiance

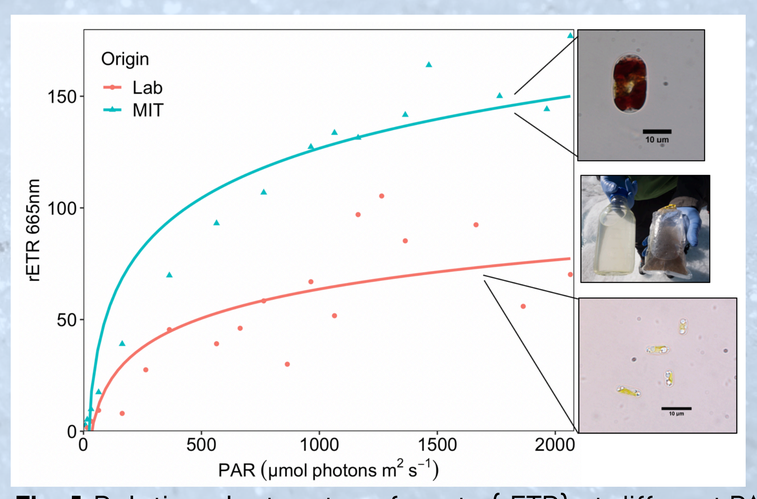


Fig. 1 Relative electron transfer rate (rETR) at different PAR intensities of M. berggrenii from the field (MIT) and from the lab.

Intracellular shading effect of Purpurogallin leads to a higher photosynthetic capacity

UV radiation itself does not seem to inhibit photosynthesis at low light intensities

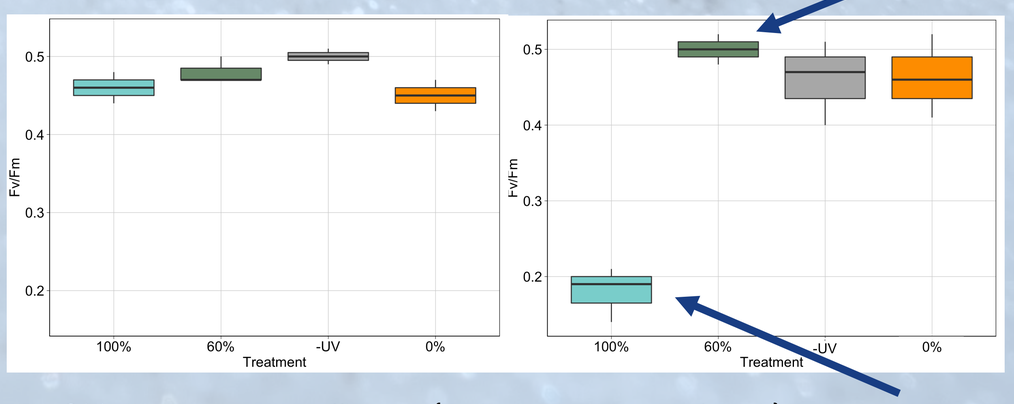


Fig. 2 Maximum quantum efficiency (Fv/Fm, inverse proxy of stress) at different treatments of **a community with phenolic pigmentation** (left image) and **M. *berggrenii* without phenolic pigmentation** (right image).

Photodamage/ stress through high irradiances

What's next?

- Pigment quantifications (incl. phenolics) using HPLC and LC-high resolution mass spectrometry
- Non-targeted metabolomics using ion/liquid chromatography-mass spectrometry
- *In* and *ex-situ* nutrient fertilisation experiments

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References

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2 Stibal, M., Box, J. E., Cameron, K. A., Langen, P. L., Yallop, M. L., Mottram, R. H., et al. (2017). Algae Drive Enhanced Darkening of Bare Ice on the Greenland Ice Sheet. *Geophys. Res. Lett.*

3 Remias, D., Schwaiger, S., Aigner, S., Leya, T., Stuppner, H., and Lütz, C. (2012). 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 Microbiol. Ecol.*

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See also:
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