Effects of ultraviolet radiation and temperature on the antioxidative status of two *Enteromorpha* (Chlorophyta) species from Antarctic and Subantarctic regions

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Introduction

The seasonal degradation of the ozone-layer over the Antarctic continent is leading to an increase in ultraviolet radiation (especially UV-B) on the earth's surface, also affecting marine organisms, like macroalgae. In addition, due to a potential increase in temperature, algae might simultaneously be exposed to two different kinds of abiotic stress.

The influence of an increased temperature on the UV response in context to photosynthesis and the antioxidative potential (measured as the activity of superoxide dismutase, SOD) of two green macroalgae from different locations on the southern hemisphere was investigated.

Results

The results of the PAM-measurements exhibit a decrease in optimal PS II-quantum yield (Fv/Fm) in both algae due to exposure to ultraviolet radiation (UV-A and UV-B) in comparision to the control (PAR). Cultivation at 0 °C resulted in a stronger reduction in Fv/Fm than in 10 °C, whereas *E. clathrata* was more influenced than *E. bulbosa* (Fig. 3 and 4). In contrast to the exposure at 0 °C the treatment at 10 °C caused only a slight reduction in Fv/Fm in both species, to a similar extent. The determination of the catalytic activity of SOD adduced no difference between temperature treatments and between the tested species. On the 4th day of exposure to ultraviolet radiation, an increase in SOD activity was measured in *E. bulbosa* kept at 10 °C (Fig. 5), whereas *E. clathrata* did not show any changes in SOD activity (Fig. 6).

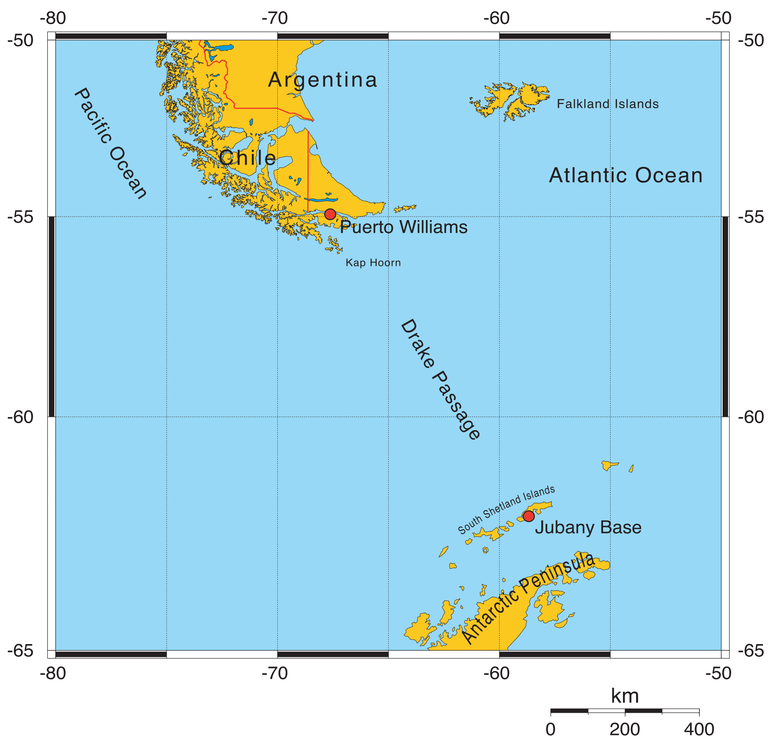

Fig. 1: Isolation sites of the used green algae *E. bulbosa* (Jubany Base, King-Georg-Island, South Shetland-Islands, Antarctica) and *E. clathrata* (Puerto Williams, Chile). Map created by www.aquarius.geomar.de.

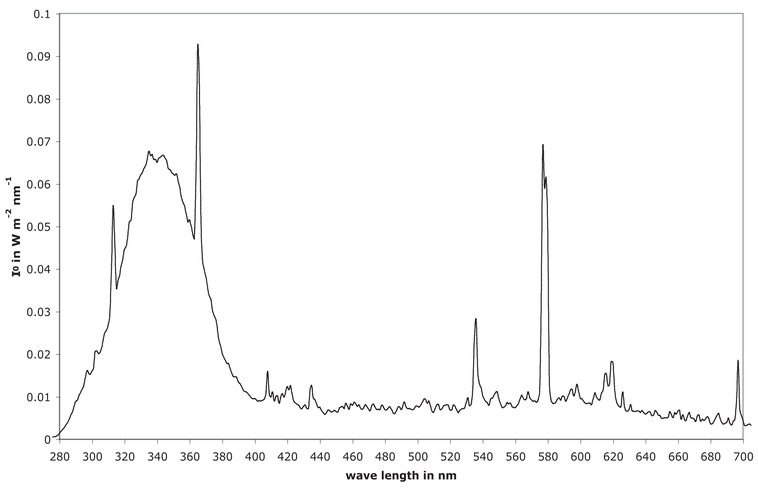

Fig. 2: Spectral composition in the experimental setup. The mercury-arc lamp Philips HPL-R 250W was applied for photosynthetically active radiation (PAR). A Q-Panel UV-A 340 lamp, which has got its maximal emission at 340 nm, provided the light in the UV-A range while the special lamp Philips TL /12 was used as the UV-B source. The spectrum of the latter is not exactly observable in the chart but it supplements and enhances the UV-B radiation emmitted by the Q-Panel lamp.

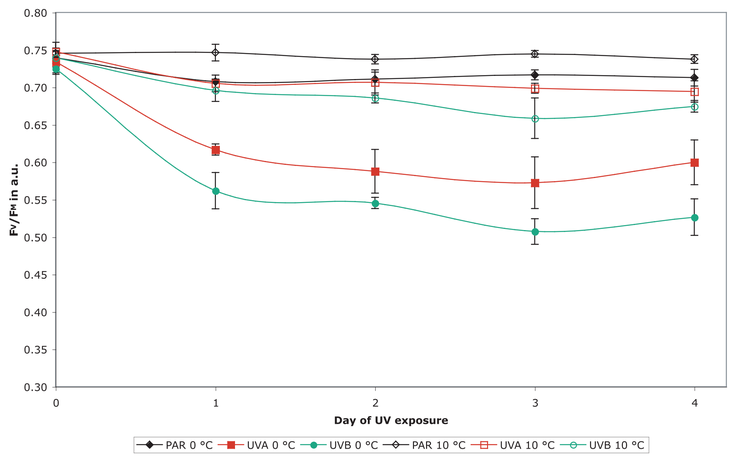

Fig. 3: Optimal PS II-quantum yield of *E. bulbosa* over a 4-day UV-exposure and two different temperatures: 0 °C and 10 °C.

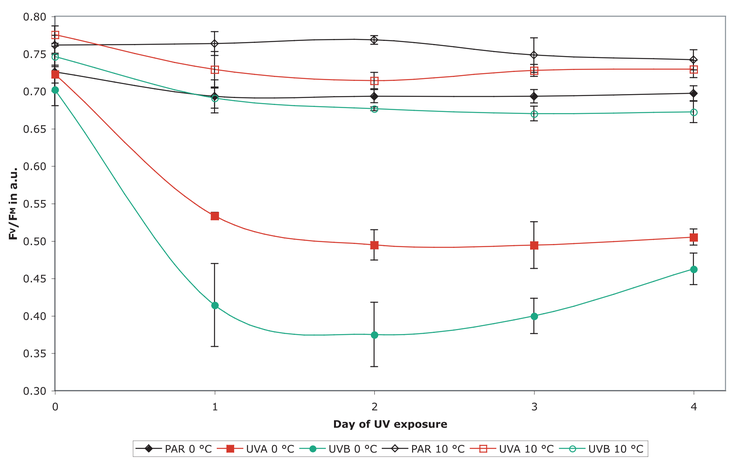

Fig. 4: Optimal PS II-quantum yield of *E. clathrata* over a 4-day UV-exposure and two different temperatures: 0 °C and 10 °C.

Discussion

Being exposed to artificial UV radiation at 0 °C, the Antarctic strain of *E. bulbosa* exhibited a minor reduction in optimal quantum yield of photosynthesis (Fv/Fm) as compared to the isolate of the cosmopolitan *E. clathrata*, obtained from cold-temperate waters. This may indicate the higher potential of *E. bulbosa* to cope with UV-stress at lower temperatures. With respect to the seasonal development of the Antarctic ozone hole, *E. bulbosa* is able to compensate for increasing oxidative stress more efficiently, than *E. clathrata*. For SOD, one of the most important scavenging enzymes involved in the antioxidative defense, this compensation is not likely to be regulated via the specific activity of the enzyme, but rather by its cellular concentration.

With increasing temperature (10 °C), both species maintain higher values of Fv/Fm, indicating a minor impairment of the photosynthetic apparatus. Increased SOD activities in *E. bulbosa* on the fourth day of exposure do also point towards elevated enzyme activities at higher temperatures. Here we did not find any hints for physiological differences reflected by the different geographical distribution of species.

Material & Methods

Two green macroalgae from different locations on the southern hemisphere were selected. An Antarctic strain of *Enteromorpha bulbosa* was isolated near Jubany Base (62°S, 59°W) on King Georg Island (South Shetland Island, Antarctica). *Enteromorpha clathrata* was obtained from Puerto Williams (55°S, 67°W) in Chile. The locations of isolation are shown in Figure 1. *E. bulbosa* represents a cold-temperate species from Southern Oceans, whereas *E. clathrata* is regarded as rather a cosmopolitan species. Isolates were kept as stock cultures at the Alfred Wegener Institute for Polar and Marine Research (Bremerhaven, Germany). Experimental material was raised from stock cultures at 10 µmol m^{-2} s^{-1} PAR at 0 °C.

Experimental treatments were as follows: Specimens were exposed to 30 µmol m^{-2} s^{-1} PAR (400-700 nm) supplemented with 6.0 W m^{-2} UV-A (320-400 nm) and 1.0 W m^{-2} UV-B (280-320 nm) (Fig. 2) . By the use of different cut-off foils, algae were either exposed to PAR+UV-A+UV-B (295 nm foil), PAR+UV-A (320 nm foil) or PAR (400 nm foil) alone. Algae were exposed for 16 hours for 5 subsequent days.

Photosynthetic activity was measured as optimal quantum yield of PS II (Fv/Fm) with a PAM-2100 (Walz, Germany) chlorophyll fluorometer. Catalytic activity of SOD was determined according to a modified protocol of McCord & Fridovitch (1969) and Aguilera *et al.* (2002).

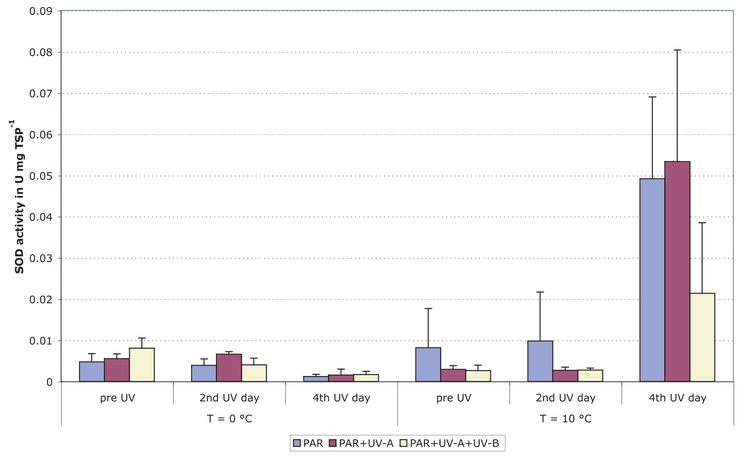

Fig. 5: Catalytic activity of SOD of *E. bulbosa* before and during 2nd and 4th day of UV-exposure at the experimental temperatures of 0 °C and 10 °C.

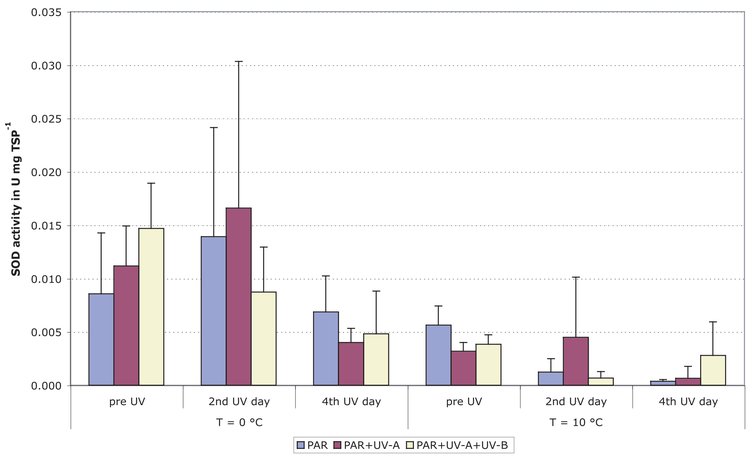

Fig. 6: Catalytic activity of SOD of *E. clathrata* before and during 2nd and 4th day of UV-exposure at the experimental temperatures of 0 °C and 10 °C.

References:

McCord JM, Fridovich I (1969) Superoxide dismutase: an enzymatic function for erythrocuprein (hemocuprein). J Biol Chem 244(22):6049–6055

Aguilera J, Dummermuth A, Karsten U, Schriek R, Wiencke C (2002) Enzymatic defence against photooxidative stress induced by ultraviolet radiation in Arctic marine macroalgae. Polar Biol 25:432–441