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BRIEF COMMUNICATION

Effect of UV radiation on pigments of the Antarctic macroalga *Leptosomia simplex* L.

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Abstract

Impact of UV-A and UV-B radiation on pattern of pigments of the Antarctic macroalga *Leptosomia simplex* L. was studied during the Polarstern cruise (ANT XII/2) 1994/95 under controlled laboratory conditions. An 8 h exposure to UV-A of 17.6 W m^{-2} led usually to an increase of carotenoid contents, but to a decrease in contents of chlorophyllide (Chlide) *a* and chlorophyll (Chl) *a*. UV-B irradiation (300-320 nm) caused a decrease in contents of Chlide *a*, lutein, and zeaxanthin, but an increase in contents of Chl *a* and carotenes. Enhancement of carotenoid contents was attributed to a protection of the photosynthetic apparatus. UV effects on the ^{15}N-ammonium uptake were correlated with the changes in pigment contents.

Additional key words: α- and β-carotenes; chlorophyll; chlorophyllide; lutein; UV-A and UV-B radiation; zeaxanthin.

Recent studies on the impact of UV radiation on cell components and metabolic processes indicate a different species-dependent response of macroalgae to UV (Döhler *et al.* 1995; reviews of Wiencke 1996, Franklin and Forster 1997, Häder and Figueroa 1997, as well as references therein). Macroalgae are exposed to variations in solar irradiance and temperature during the tide in the temperate zone (Döhler *et al.* 1997). Therefore, different effects of photoinhibition, *e.g.*, on photosynthesis were observed (Hanelt *et al.* 1994, Wilhelm *et al.* 1997). The inhibitory effects are dependent on the fluence rate and duration of UV irradiance (Nultsch *et al.* 1987). The extent of UV damage on metabolic processes of macroalgae varies in dependence on the life history and time of season (Dring *et al.* 1996a,b, Hanelt *et al.* 1997). Seasonal variations in pigment contents of the Antarctic macroalga *Desmarestia* indicate an increase in Chl *a*, Chl *c*, and fucoxanthin contents in spring-summer (Gomez and Wiencke 1997). No data are available from the UV effects on Antarctic macroalgae (Häder and Figueroa 1997). The present study deals with the

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impact of UV-A and UV-B radiation on pigments of the Antarctic macroalga *Leptosomia simplex*.

The macroalga *L. simplex* L. (*Rhodomeliaceae*) was collected near Elephant Island, Antarctica during the Polarstern cruise (ANT XII/2) 1994/95. The thalli were cleaned from epiphytes, washed with sea water, and exposed to UV radiation under controlled laboratory conditions at 4 °C. UV-transparent plexiglas vessels (No *2458, Röhm*, Darmstadt, Germany) and UV-opaque chambers (No. *233*) were used for irradiation experiments. Macroalgae were irradiated with special *Philips* lamps *TL 60 W/09 N* for UV-A (330-380 nm) or *TL 40 W/01* for UV-B (300-320 nm): spectral energy distribution of the lamps was published by Döhler and Buchmann (1995) and Döhler and Kugel-Anders (1994). Slide projectors applied "white light" during the UV experiments. Fluence rates were estimated with a radiometer (*IL 1700, Int. Light*, USA) in combination with detectors *SED 038 # 1370* ("white light"), *SED 033 # 3716* (UV-A), and *SED 240 # 2100* (UV-B). Fluence rates were 103 W m^{-2} for "white light", 17.6 W m^{-2} for UV-A, and 1.5 W m^{-2} for UV-B. The applied UV doses are similar to those of a sunny day in Antarctica (Döhler 1997).

Pigments were separated and analyzed with a HPLC system according to the method of Döhler and Lohmann (1995). The solvent system of Wright *et al.* (1991) and calibration curves of defined amounts of pigment standards were used. For preparation of the samples and the equipment see Döhler and Lohmann (1995).

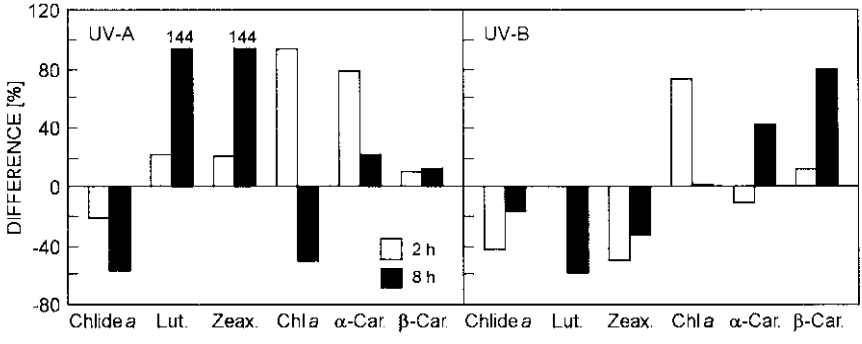

Fig. 1. Effects of 2 and 8 h UV-A (17.6 W m^{-2}) and UV-B (1.5 W m^{-2}) irradiation on pigments of *Leptosomia simplex*. Values are means of 2 replicates, expressed as increase or decrease to those of not UV-exposed cells. Car. - carotene, Chl *a* - chlorophyll *a*, Chlide *a* - chlorophyllide *a*, *Lut.* - lutein, *Zeax.* - zeaxanthin.

Main pigments of *Leptosomia* were Chl *a*, carotenes, xanthophylls, and phycobiliproteins. The influence of UV-A and UV-B on the pattern of pigments was determined up to 8 h exposure time. The values are averages of two measurements from two experiments. Values were compared and calculated to not UV-irradiated thalli and presented as % increase or decrease. An enhancement of all the tested pigments (Fig. 1) was found after UV-A irradiation, except of Chlide *a* and Chl *a* (after 8 h). The significant increase of the contents of xanthophylls (lutein and zeaxanthin) after the 8 h exposure time can be probably attributed to a protection of

the photosynthetic apparatus. The photoprotective role of xanthophyll cycle was found in brown algae *Dictyota* and *Lobophora* (Uhrmacher *et al.* 1995). An increase in contents of all pigments was also observed in the Antarctic brown alga *Desmerestia menziesii* after a 4 h UV-A irradiation, but the extent of stimulation of pigment synthesis was different: synthesis of Chl *c* was markedly enhanced (values not shown). These experiments with *Desmerestia* were performed during the same Polarstern cruise under laboratory conditions.

UV-B radiation led mainly to a reduction of the pigment contents (Fig. 1) compared to the UV-A effects. However, the damage was not so strong as that in macroalgae of the North Sea, Germany (Döhler *et al.* 1995). The reason for the less pronounced inhibition of pigment synthesis of *Leptosomia* might be the different spectral energy distribution of the used UV sources; no UV-B below 300 nm was applied. A 2 h UV-B exposure did not affect the lutein content. The increase in carotene contents after an 8 h UV-B irradiation can be interpreted as a protecting reaction. Results of Uhrmacher *et al.* (1995) support this interpretation.

Uptake of ^{15}N-ammonium (300 µM final concentration) by *Leptosomia* was reduced after 2 or 8 h UV-B irradiation up to 26 % whereas an increase of 20 % after 2 h UV-A exposure and no effect after 8 h was found. These findings are correlated to the UV effects on pigments: stronger damage after UV-B irradiance.

References

Döhler, G.: Impact of UV radiation of different wavebands on pigments and assimilation of ^{15}N-ammonium and ^{15}N-nitrate by natural phytoplankton and ice algae in Antarctica. - J. Plant Physiol. **151**: 550-555, 1997.

Döhler, G., Buchmann, T.: Effects of UV-A and UV-B irradiance on pigments and ^{15}N-ammonium assimilation of the haptophycean *Pavlova*. - J. Plant Physiol. **146**: 29-34, 1995.

Döhler, G., Hagmeier, E., David, C.: Effects of solar and artificial UV irradiance on pigments and assimilation of ^{15}N ammonium and ^{15}N nitrate by macroalgae. - J. Photochem. Photobiol. B **30**: 179-187, 1995.

Döhler, G., Kugel-Anders, A.: Assimilation of ^{15}N-ammonium by *Lithodesmium variabile* Takano during irradiation with UV-B (300-320 nm) and complemental monochromatic light. - J. Photochem. Photobiol. B **24**: 55-60, 1994.

Döhler, G., Lohmann, M.: Impact of UV radiation of different wavebands on the pigmentation of the haptophycean *Pavlova*. - J. Photochem. Photobiol. B **27**: 265-270, 1995.

Döhler, G., Lohmann, M., Hagmeier, E.: Effect of solar radiation on pigments of *Fucus* and *Porphyra* under natural conditions at the North Sea. - Beitr. Biol. Pflanzen **70:** 1-8, 1997.

Dring, M.J., Makarov, V., Schoschina, E., Lorenz, M., Lüning, K.: Influence of ultraviolet radiation on chlorophyll fluorescence and growth in different life history stages of three species of *Laminaria* (*Phaeophyta*). - Mar. Biol. **126**: 183-191, 1996a.

Dring, M.J., Wagner, A., Boeskov, J., Lüning, K.: Sensitivity of intertidal and subtidal red algae to UV-A and UV-B radiation as monitored by chlorophyll fluorescence measurements: influence of collection depth and season and length of irradiation. - J. Phycol. **31**: 293-302, 1996b.

Franklin, L.A., Forster, R.M.: The changing irradiance environment: consequences for marine macrophyte physiology, productivity and ecology. - J. Phycol. **32**: 207-232, 1997.

Gomez, I., Wiencke, C.: Seasonal growth and photosynthetic performance of the antarctic macroalga *Desmarestia menziesii* (*Phaeophyceae*) cultivated under fluctuating Antarctic daylengths. - Bot. Acta **110**: 25-31, 1997.

Häder, D.-P., Figueroa, F.L.: Photoecophysiology of marine macroalgae. - Photochem. Photobiol. **66**: 1-14, 1997.

Hanelt, D., Li, J., Nultsch, W.: Tidal dependence of photoinhibition of photosynthesis in marine macrophytes of the South China Sea. - Bot. Acta **107**: 66-72, 1994.

Hanelt, D., Wiencke, C., Nultsch, W.: Influence of UV radiation on photosynthesis of arctic macroalgae in the field. - J. Photochem. Photobiol. B **38**: 40-47, 1997.

Nultsch, W., Pfau, J., Materna-Weide, M.: Fluence and wavelength dependence of photoinhibition in the brown alga *Dictyota dichotoma*. - Mar. Ecol. Progr. Ser. **41**: 93-97, 1987.

Uhrmacher, S., Hanelt, D., Nultsch, W.: Zeaxanthin content and the degree of photoinhibition are linearly correlated in the brown alga *Dictyota dichotoma*. - Mar. Biol. **123**: 159-165, 1995.

Wiencke, C.: Recent advances in the investigation of Antarctic macroalgae. - Polar Biol. **16**: 231-240, 1996.

Wilhelm, C., Bida, J., Domin, A., Hilse, C., Kaiser, B., Kesselmeier, J., Lohr, M., Müller, A.M.: Interaction between global climate change and the physiological responses of algae. - Photosynthetica **33**: 491-503, 1997.

Wright, S.W., Jeffrey, S.W., Mantoura, R.F.C., Llewellyn, C.A., Bjørnland, T., Repeta, D., Welschmeyer, N.: Improved HPLC method for the analysis of chlorophylls and carotenoids from marine phytoplankton. - Mar. Ecol. Prog. Ser. **77**: 183-196, 1991.