A-5.3 Assessment of the Effects of Enhanced UV-B on Marine Algae

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Total Budget for FY1990 - 1992 14,053,000 Yen

Abstract UV-absorbing components of several red algae, which are suggested to be concerned with the protection against solar UV radiation, were estimated, and experimental cultivations with and without UV irradiation were carried out. The ethanol extractions of red algae usually had two peaks of optical density in their UV absorption spectra, which indicated UV-absorbing components. However, some species of red algae examined here lacked one of, or both of two peaks. Effects of UV-B radiation on red algae were observed as one of, or some of, decline of growth rate, discoloration or necrosis of cells, decrease of photosynthetic pigments, and increase of UV-absorbing components. However, responses to UV-B irradiation differed with species of red algae. The relationship between the tolerance or acclimatization to enhanced UV-B and UV-absorbing components of seaweeds is needed to be examined.

Key Words Seaweed, UV-B, Growth, Photosynthetic pigments, UV-absorbing component

1. Introduction

The stratospheric ozone layer is presumed to be depleted in the near future, by which enhanced UV radiation should reach to the surface of the earth. Especially, enhanced UV-B radiation ranging from 280 to 320 nm in wavelength is feared to exert harmful influences on human beings and other terrestrial lives.

In the ocean, UV radiation had been expected to be attenuated completely in the surface layer of seawater, and have very little effect as one of the environmental factors affecting marine lives. However, the data measured in the ocean showed that solar UV radiation penetrates at considerable rate up to 80%/m in clear seawater. The role of solar UV radiation in marine ecosystem is studied mainly about planktonic primary production and lower levels of consumption, or about benthic animals on tropical coral reefs. A few studies about seaweeds are available and suggests that UV radiation may inhibit the photosynthesis and be a potential factor determining the inhabiting depth.

2.Research Objective

This study purposed mainly to demonstrate responses of seaweeds to artificial UV-B irradiance simulating enhanced solar UV-B radiation, and to examine the responses varying with species in reference to their ecological characters. UV-absorbing components, which are contained in algal body and suggested to be concerned with the protection against solar UV radiation, were also estimated with some species of red algae, and the ecological role of the components was discussed.

3.Research Method

Fifteen species of red algae were used for this study. Two of them, Porphyra okamurai and P. pseudolinearis, were indoor cultivated materials originating from wild gametophytes collected at rock beach in Kashiwazaki Niigata, Japan. Others were wild materials from Kashiwazaki and its vicinities.

Experimental cultivations of red algae with UV-B exposure were carried out in a culture chamber where controlled temperature and white-cool fluorescent lamp illumination were available. The visible light illumination produced light-dark period with 24hour cycle. UV-B irradiance in the chamber was supplied by a transilluminator (TL-33, UVP INC.; Fig.1) only during light periods. UV-B intensity was measured by a digital radiometer (UVX-31, UVP INC.; Fig.2). Materials with Provasolli's enriched seawater were stored into 500ml or 1000ml flat-bottomed flasks of quartz glass for UV-B exposure treatments, or of ordinary glass for references, which were set in the chamber. During cultivations for several days, growth, photosynthetic pigments, and UV-absorbing components of red algae were followed.

For UV-absorbing components estimation, UV absorption spectra ranging from 200 to 400nm of wavelength were measured with ethanol extraction from materials. When the spectra had some peaks, each peak indicated some component absorbing radiation at a specific wavelength. Optical density of each peak was calculated for unit amount of algal body and recorded as an indicator for the concentration of UV-absorbing components.

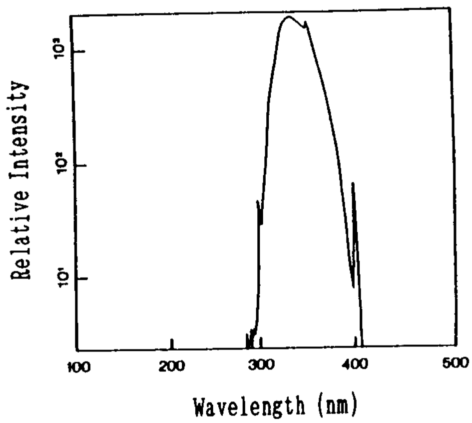

Fig.1 Transilluminater, TL-33, UVP INC.
Wavelength composition.

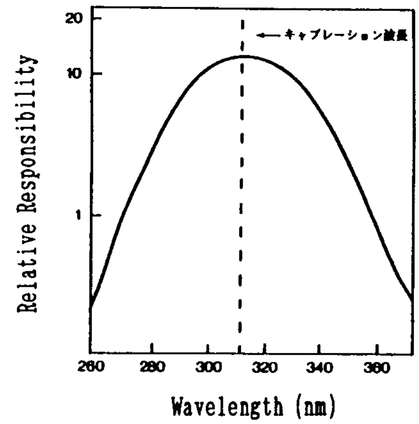

Fig.2 Digital radiometer, UVX-31, UVP INC.
Responsibility.

4.Result

Twelve red algae were cultivated with UV-B exposure for 5 to 28 days, where UV intensity ranged from 100 to 300 $\mu W/cm^2$. While UV-B effects like the decline of growth rate or other extraordinariness were not observed about some species like P. okamurai and P. pseudolinearis inhabiting littoral zone to supralittoral fringe, discoloration for Schizymenia dubyi and necrosis of cells for Symphyocladia marchantiodes were exhibited. Some of other species tended to lower growth rate without anything abnormal.

For some species like Pterocladia capillacea (Fig.3), visible light absorption spectra of acetone extractions from red algae, for the photosynthetic pigments estimation, did not vary independently of UV-B treatments. However, photosynthetic pigment concentration of Sc. dubyi and Sy. marchantiodes (Fig.4) tented to decrease with UV-B exposure.

UV absorption spectra of ethanol extractions from red algae, for the UV-absorbing components, had usually two peaks like the case of Laurencia nipponica (Fig.5). However, Campylaephora hypnaeoides (Fig.6) lacked one of, and Sy. marchantiodes (Fig.7) lacked both of two peaks. Some species like Gracilaria asiatica (Fig.8) showed a tendency of UV-absorbing components to increase with UV-B exposure.

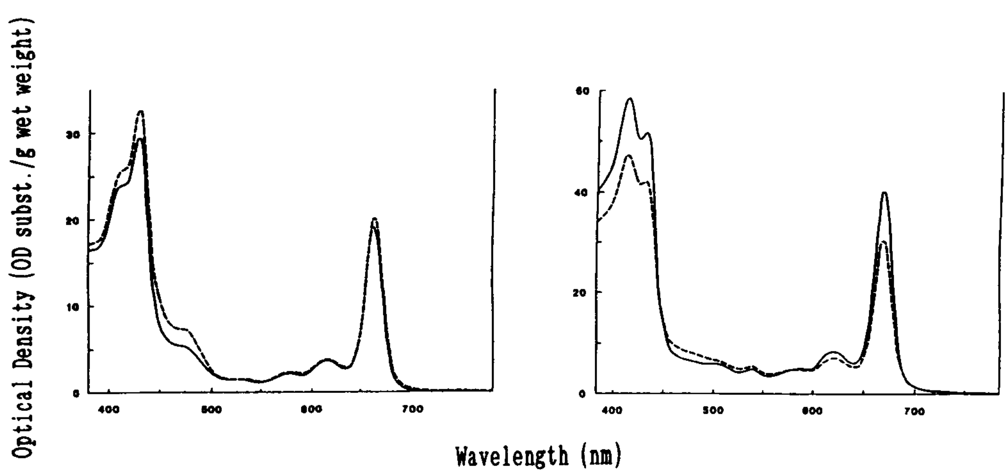

Fig.3-4 Visible light absorption spectra of acetone extractions from red algae for the photosynthetic pigments estimation.
Left; Pterocladia capillacea. Right; Symphyocladia marchantiodes. Dashed line, UV exposure; solid line, reference. UV intensity, 300μW/cm^2. PAR intensity, 1400μW/cm^2. Temperature, 15°C. 12L:12D. 5th day.

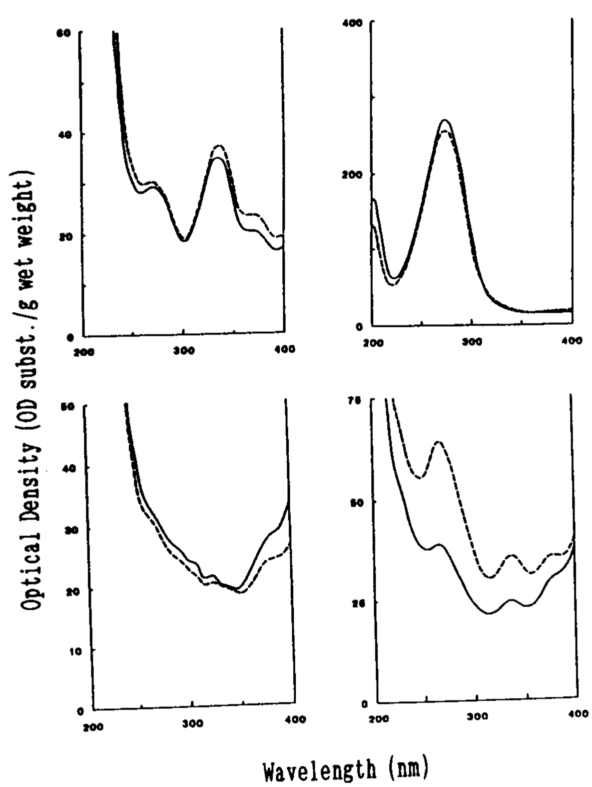

Fig.5-8 UV absorption spectra of ethanol extractions from red algae for the UV-absorbing component estimation.
Upper left; Laurencia nipponica. Upper right; Campylaephora hypnaeoides. Lower left; Symphyocladia marchantiodes. Lower right; Gracilaria asiatica. Dashed line, UV exposure; solid line, reference. UV intensity, 300μW/cm^2. PAR intensity, 1400μW/cm^2. Temperature, 15°C. 12L:12D. 5th day.

5.Discussion

Each species of seaweeds has specifically an inhabiting depth, a distributing area, and a role in communities. Every species is considered to be adapted to its habitat by some means or other. On the other hand, each species has a specific seasonality. Every species is considered to perform its germination, growth, mature, and withering, as a respondence to environmental factors changing with season.

In this study, while UV-B effects on seaweeds were observed as one of, or some of, decline of growth rate, discoloration or necrosis of cells, decrease of photosynthetic pigments, and increase of UV-absorbing components, the responses to UV-B exposure varied with species. The variation of the responses, especially about decline of growth rate and discoloration or necrosis of cells, is concerned with the variation of UV tolerance of species, which is considered to depend on the ecological characters of each species.

While UV absorption spectra for UV-absorbing component estimation had usually two peaks, some species lacked one of, or both of peaks. If UV-absorbing components is concerned with the protection against UV radiation as many reports suggested, the presence or not, or the concentration of the components is considered to depend on the ecological characters of each species. However, not all of species, which lacked one of or both of peaks, were deep-water or shaded-habitat species. To examine the mechanism of UV protection of seaweeds, morphological characters of individuals and structural characters of communities are needed to be regarded in addition to UV-absorbing components.

UV-absorbing components was suggested to increase with UV exposure for some species of seaweeds. It is needed to examine the relationship between the changes of UV-absorbing component concentration and UV tolerance, and to examine the potential ability of seaweeds to acclimate to enhanced UV-B radiation.