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Influence of temperature on the photosynthetic response of benthic diatoms: Fluorescence based estimates

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Abstract: The short-term effects of temperature increase on the photosynthetic and photophysiological characteristics of benthic diatoms (*Navicula* sp., *Nitzschia* sp., *Cylindrotheca closterium* and *Pleurosigma elongatum*) were investigated by measuring the PSII-fluorescence kinetics of cultured specimens. Photosynthesis versus irradiance curves were measured at six temperatures (10, 15, 20, 25, 30 and 35°C) every two hours over the course of twenty-four hours. For most of the species, the effective quantum yield of PSII ($\Phi_{PS\,II}$) showed a reducing trend with temperature increase. The relative maximum electron transport rate (rETRmax) was significantly stimulated by temperature increase up to the optimum temperature, and then sharply decreased. Relative to the values of other parameters, the maximum light use coefficient (α) was insensitive, decreased significantly only under high temperatures (30 and 35°C). With respect to the species's temperature acclimation ability with time, *Navicula* sp. and *C. closterium* acclimated to short-term change in temperature through photophysiological adjustment. *Pluerosigma elongatum*, however, was not affected photophysiologically, due to parallel changes in the α and rETRmax. Moreover, the impact of photosynthetic ability on the benthic diatoms changed relatively to cell-size. *Pleurosigma elongatum*, with large cell-size, has a very small SA/V ratio. Because it was not significantly affected by temperature change, even at very high temperatures. We speculate therefore, that *P. elongatum* manifests a high degree of photosynthetic activity even under high-temperature conditions. The PAM techniques are useful way to study the physiological response of photoautotrophs, particularly, the influence of environmental factors such as temperature.

1. Introduction

Benthic diatoms maintain high production levels despite living under potentially stressful conditions such as tidal changes, and highly variable temperatures and light. Nonetheless, benthic diatoms can acclimate to various light and temperature conditions. However, it isn't widely known their photosynthetic and photophysiological characteristics.

In this study, the short-term effects of temperature on the photosynthetic and photophysiological characteristics of benthic diatoms were investigated by measuring the PSII-fluorescence kinetics.

2. Methods

Unialgal cultures of *Navicula* sp.(B-159), *Nitzschia* sp.(B-131), *Cylindrotheca closterium* (B-62) and *Pleurosigma elongatum* (EB-44) were grown in f/2 medium (Gillard and Ryther 1962). All cultures were grown at 15±1℃, 100 $\mu mol \cdot m^{-2} \cdot s^{-1}$, 12h:12h, light:dark photoperiod. The sub-sample (200ml) is filtered on a glass microfiber filters (Whatman 47mm). Filter paper with diatom cell is punched using a stick with a hole and put on tissue culture plate is filled with agar medium. Variable Chlorophyll fluorescence was measured using a Diving-PAM (Walz, Effecltrich, Germany). Photosynthesis versus irradiance curves were measured at six temperatures (10, 15, 20, 25, 30 and 35°C) every two hours over the course of twenty-four hours. Photosynthetic activity was assessed using rapid-light curves (RLCs), where samples were exposed to eight incremental steps of irradiance ranging from 0 to 988 $\mu mol\ photons \cdot m^{-2} \cdot s^{-1}$. To estimate photosynthetic parameters, RLCs were fitted the model of Platt et al. (1980). Photosynthetic parameters as α (maximum light utilization coefficient), rETRmax (relative maximum ETR) and E_K (light-saturation coefficient) were derived.

3. Results

3.1 Result-1. Effect of temperature on the photosynthetic parameters

For most of the species, the effective quantum yield of PSII ($\Phi_{PS\,II}$) showed a reducing trend with temperature increase. The maximum relative electron transfer rate (rETRmax) continued to increase up to an optimum temperature, beyond which it declined rapidly. Relative to the values of other parameters, the maximum light use coefficient (α) was insensitive, decreased significantly only under high temperatures (30 and 35°C).

3.2 Result-2. Photophysiological characteristics

With respect to the species's temperature acclimation ability with time, *Navicula* sp. and *C. closterium* acclimated to short-term change in temperature through photophysiological adjustment. *Pluerosigma elongatum*, however, was not affected photophysiologically, due to parallel changes in the α and rETRmax.

3.3 Result-3. Relation between SA/V ratio and temperature acclimation

The impact of photosynthetic ability on the benthic diatoms changed relatively to cell-size. Small-cell-size species are more susceptible to temperature increase due to their large SA/V

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ratio. This is owed to the fact that those species are more temperature-sensitive than large-cell-size species. On the other hand, *Pleurosigma elongatum*, with large cell-size, has a very small SA/V ratio. Because it was not significantly affected by temperature change, even at very high temperatures.

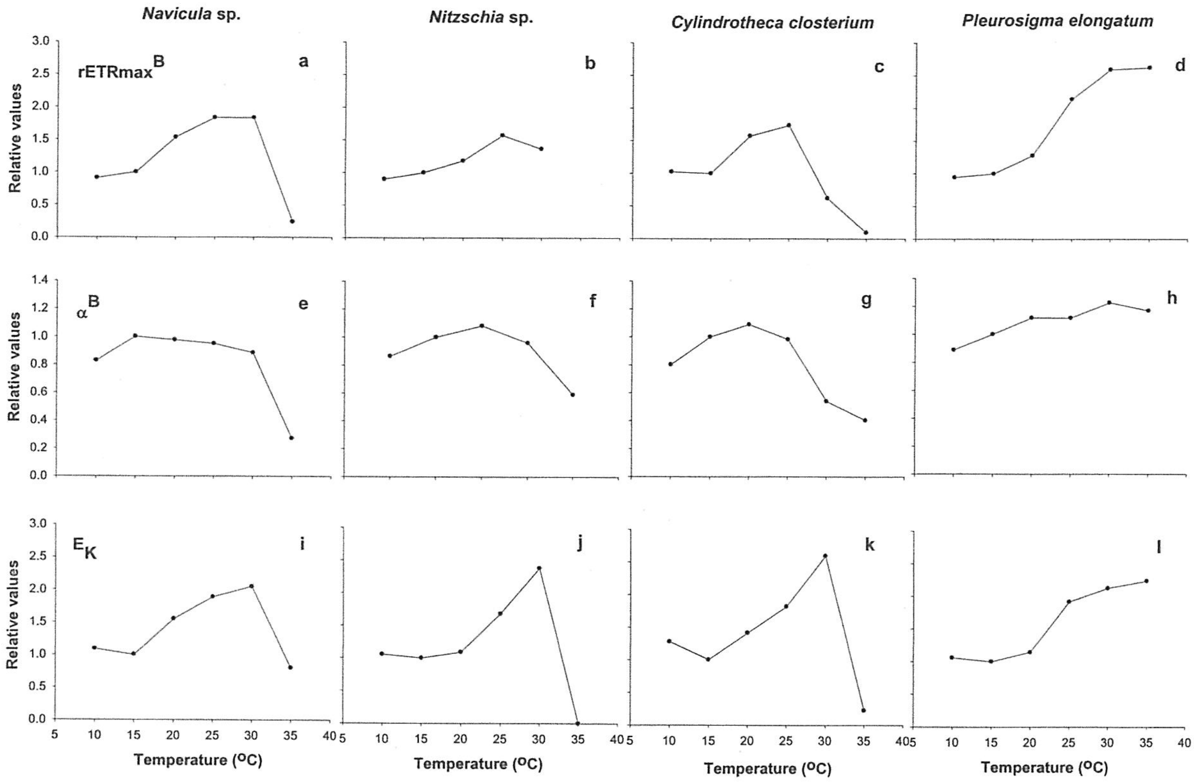

Fig. 1. Relative effect of temperature on the relative maximum electron transport rate (rETRmax ^{B}, upper panel), the maximum light use coefficient (α^{B}, middle panel), and the light saturation coefficient (E_K, lower panel) for *Navicula* sp. (left), *Nitzschia* sp. (left middle), *Cylindrotheca closterium* (right middle), and *Pleurosigma elongatum* (right). All parameters were normalized to the data at 15℃, respectively.

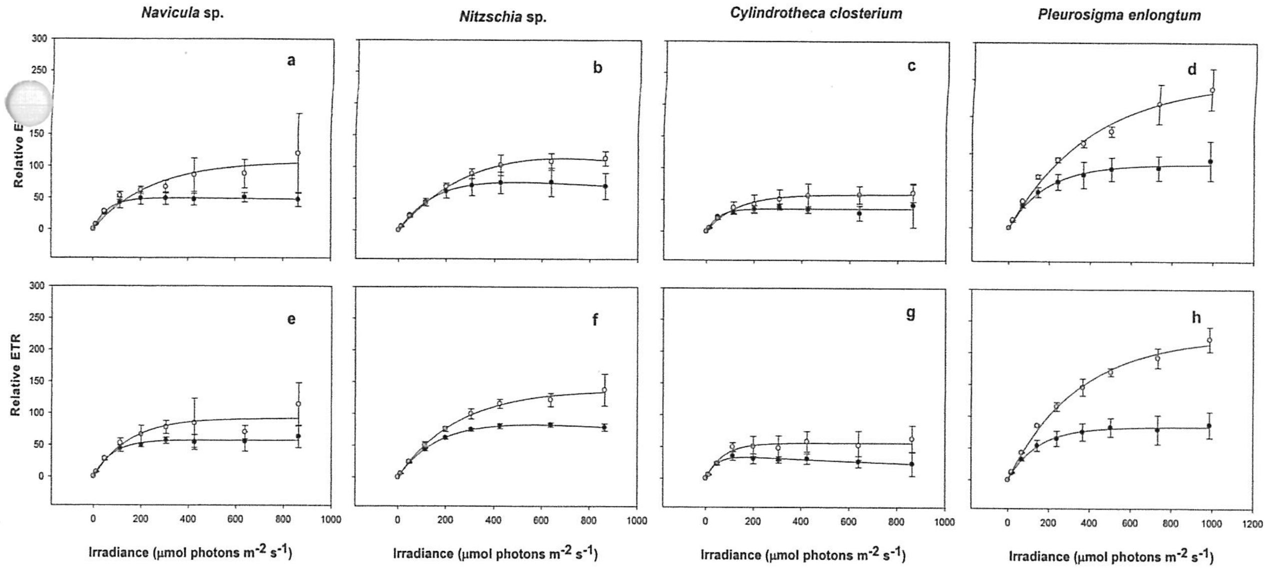

Fig. 2. Photosynthesis versus irradiance (P-I) curves were measured by PAM fluorescence for *Navicula* sp. (left), *Nitzschia* sp. (left middle), *Cylindrotheca closterium* (right middle), and *Pleurosigma elongatum* (right). Upper panels were measured after elapse of two-hours and lower panels were measured after elapse of eight-hours. The data were compared culture temperature (filled symbols) with temperature showed maximum photosynthetic capacity (open symbols).

4. Conclusions and Discussion

The short-term temperature effect on photosynthetic parameters varies according to the species, which variation reflects the different photophysiological acclimation abilities of each species. The response of maximum relative electron transfer rate to short-term changes in temperature in *Navicula* sp. and *Nitzschia* sp. is typical of most unicellular algae (Davison, 1991). The slight decrease of α with temperature could be explained by an apparent decrease of the chlorophyll a, given that light absorption was correlated with chlorophyll a. Moreover, the ability to acclimate to temperature varies according to the SA/V ratio difference. Through this study, we found that the PAM technique can be useful way to study the physiological response of photoautotrophs, particularly, the influence of environmental factors such as temperature.

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