

## Physiological responses of *Pterocladia* and *Gelidium* (Gelidiales, Rhodophyta) from the Azores, Portugal

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### Abstract

Manometric studies were conducted on *Pterocladia capillacea*, *Gelidium latifolium* and *Gelidium spinulosum* from the Azores, Portugal to determine optimal values of temperature, light and salinity for growth. Physiological responses were considered in relation to vertical distribution patterns of these species commonly observed throughout the Azores. Optimal parameters for the growth of *Pterocladia capillacea*, *Gelidium latifolium* and *G. spinulosum* were 17 to 25 °C, a photon flux density between 200 and 300  $\mu\text{mol m}^{-2} \text{s}^{-1}$  and salinities of 25 to 35‰.

### Introduction

Numerous authors have studied the geographic and vertical distribution of the Gelidiales. Much of this work has been summarized by Santelices (1974); however, literature is lacking in information on the physiological-ecology of gelidioid species from the Azores, Portugal. Two of three species of *Gelidium* and one species of *Pterocladia* were included in this study: *Gelidium spinulosum* (Agardh) J. Agardh, *Gelidium latifolium* (Grev.) Bornet et Thuret and *Pterocladia capillacea* (S. Gmelin) Bornet et Thuret. Each of the species occupies a different vertical niche with only minimal overlap occurring between *G. latifolium* and *P. capillacea* (Fig. 1).

Several reasons combine to make this project of interest. First, there are few published data to account for intertidal benthic macroalgal distributions in the Azores; second, there is potential economic value in these species for two existing

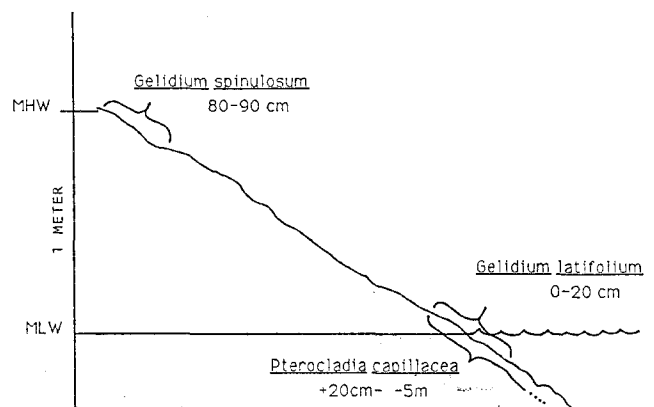


Fig. 1. Zonation profile for *Pterocladia* and *Gelidium* spp. from the Azores, Portugal.

agar-producing plants, and third, there is a need to determine optimal growth parameters for these species in anticipation of a proposed aquaculture pilot study. Harvesting impacts of Azores *Pterocladia* over the past decade have created a need

for additional knowledge of gelidioid species in the area, which are required to sustain a declining industry.

*Pterocladia capillacea* is the sole source of raw material for the agar factories. Another species, *Gelidium spinulosum*, referred to locally as 'Cabalhão' has reportedly been used to improve the gel strength of agar-agar extracted from *Pterocladia*. Our personal observations on the islands of Terceira and São Miguel indicate that small amounts of *G. spinulosum* are collected, dried, kept separate from *Pterocladia* collections and when necessary used specifically for this gel-enhancing purpose.

The purpose of this work was to obtain a fundamental understanding of the optimal physiological parameters for growth of Azores gelidioid algae. In addition, we were interested in their physiological tolerances to temperature changes in relation to their intertidal distribution patterns.

## Materials and methods

Specimens of *Pterocladia* and *Gelidium* were collected in the intertidal zone of the Island of Faial, Azores, Portugal during June, 1988. Additional material was collected on the island of São Miguel, Azores in January, 1989. Specimens were placed in a cooler with ice and transported within 12 h to Plymouth, New Hampshire, USA and stored under conditions of 10:14 (LD) at  $84 \mu\text{mol m}^{-2} \text{s}^{-1}$  and  $10^\circ\text{C}$ . The thalli were maintained in a culture media made from UV filtered seawater enriched with alga-grow nutrient concentrate from Carolina Biological Supply Co. The media was changed every 10 days throughout the study. Apparent photosynthesis rates were recorded in a Gilson Differential Respirometer equipped with a series of 50 Watt incandescent light bulbs. Light intensities (Fig. 2) were varied using a rheostat and were measured with a LI-COR (Li 185 B) Quantum/Radiometer/Photometer. Respiration experiments were undertaken in a darkened room. All fronds were equilibrated for a minimum of 30 min prior to each

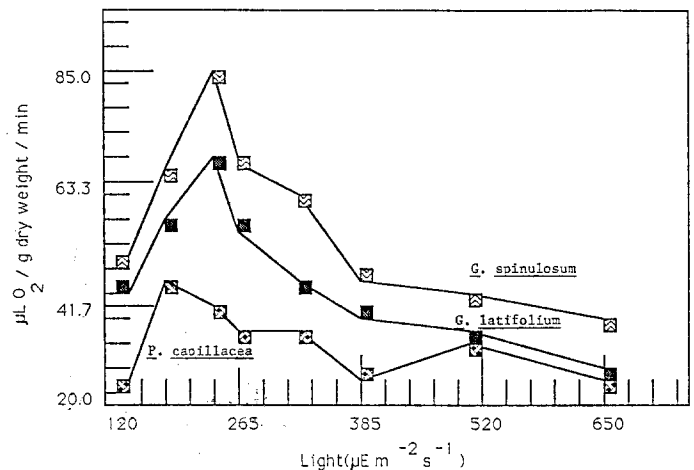


Fig. 2. Apparent photosynthesis for *Pterocladia* and *Gelidium* spp. at different light intensities.

trial; each experiment had 10 replicates. In general, the methodology for these experiments followed those of Fralick & Mathieson (1975), Dawes (1981) and Mathieson & Dawes (1986).

## Results

### Photosynthesis and light

Optimal photosynthesis for *Pterocladia capillacea* occurred at  $177 \mu\text{mol m}^{-2} \text{s}^{-1}$  and for *Gelidium spinulosum* and *G. latifolium* at  $225 \mu\text{mol m}^{-2} \text{s}^{-1}$  (Fig. 2). Oxygen production values for *P. capillacea* remained high up to  $320 \mu\text{mol}$ , but were minimal at light levels of  $125 \mu\text{mol}$  and beyond  $385 \mu\text{mol}$ . The optimal ranges for *G. spinulosum* and *G. latifolium* were similar with higher values occurring between  $250 \mu\text{mol}$  and  $385 \mu\text{mol}$ . Minimal ranges for oxygen production for both *Gelidium* species occurred at  $120 \mu\text{mol}$ .

### Photosynthesis and temperature

Minimal oxygen evolution values were recorded for all species at temperatures below  $10^\circ\text{C}$  (Fig. 3). Optimal values for *Pterocladia capillacea* were recorded between  $15$  and  $25^\circ\text{C}$ . Beyond this *P. capillacea* showed some degree of tempera-

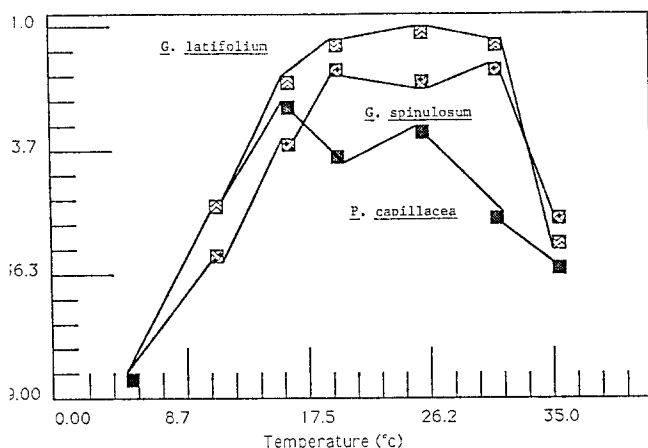


Fig. 3. Apparent photosynthesis of *Pterocladia* and *Gelidium* spp. at different temperatures.

ture tolerance up to about 30 °C, but the values declined substantially at that point.

Apparent photosynthesis for *Gelidium spinulosum* increased in a linear manner from 5 to 15 °C. Optimal values were exhibited between 15 and 30 °C. *Gelidium latifolium* values also increased in a linear manner from 5 to 15 °C and remained constant to 30 °C. The rates of photosynthesis declined beyond 30 °C for these species.

#### Photosynthesis and salinity

Apparent photosynthesis for *Pterocladia capillacea*, *Gelidium spinulosum* and *G. latifolium* along

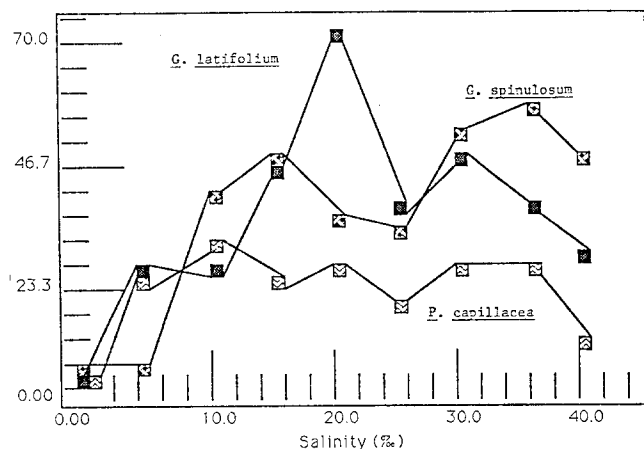


Fig. 4. Apparent photosynthesis of *Pterocladia* and *Gelidium* spp. at different salinities.

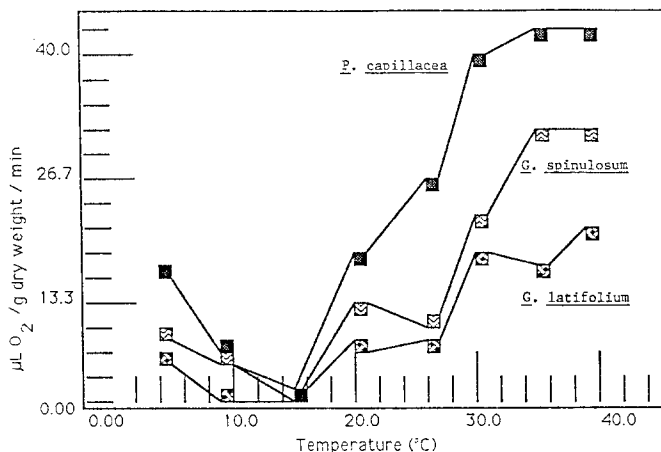


Fig. 5. Respiration values for *Pterocladia* and *Gelidium* spp. at different temperatures.

a salinity gradient at 15 °C is seen in Fig. 4. The values were nearly constant for each of the species at salinities of 15‰ and greater with the exception of *G. latifolium*, which showed an unusual increase at 20‰. A slight increase in optimal salinity at 35‰ was observed for *G. spinulosum*.

#### Respiration and temperature

Respiration values for *Pterocladia capillacea*, *Gelidium spinulosum* and *G. latifolium* at different temperatures are shown in Fig. 5. The lowest values for all three species occurred at 15 °C. The rate of respiration for *P. capillacea* increased rapidly at temperatures above 15 °C and continued to increase up to 30 °C but remained steady beyond this temperature. The rate of increase in respiration differed for the two *Gelidium* species with increases continuing up to 30 °C and then also remaining steady from 35 to 40 °C for *G. spinulosum*.

#### Discussion

Photosynthesis was reduced at temperatures above 25 °C and 30 °C for *Pterocladia* and both *Gelidium* species, respectively. This suggests that temperatures above 25 °C may stress *Pterocladia* plants and restrict their distribution in the upper

intertidal zone. Tolerance to temperatures from 25 °C to 30 °C for both *Gelidium* species may provide the plants with a means for survival in both the upper intertidal for *G. spinulosum* and in the lower intertidal for *G. latifolium*.

Respiration rates show a lower temperature tolerance for *Pterocladia* and a slightly higher tolerance for both *Gelidium* species. Minimal respiratory stress for all three species occurred at 15 °C. No stress-related values were recorded for *Pterocladia* or *Gelidium* at salinities below 15‰. However, all species showed a slight decrease in photosynthesis at salinities of 40‰.

Temperature may be a significant factor among others influencing the vertical distribution of *P. capillacea*, *G. latifolium* and *G. spinulosum* in the intertidal zone of the Azores. However, more long-term field data is necessary to clearly understand the influence of other variables on vertical distribution. Such variables as herbivory, temperature and porosity of the substratum, exposure to sunlight and high energy wave action should be considered on a seasonal basis and compared with manometric results to clarify intertidal algal stratification.

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