

Phenology of *Chondrus ocellatus* in Cheongsapo near Busan, Korea

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Abstract

The reproductive phenology of *Chondrus ocellatus* and the effects of temperature and light on its growth were examined in Cheongsapo near Busan, Korea, from September 1994 to August 1995. The vegetative plants dominated over the year, with a peak occurrence in January. Gameto- and tetrasporophytes were most abundant in November and August. All vegetative and reproductive plants had a peak both in length and weight in October, when seawater temperature was highest (24 °C). In laboratory culture, the maximum relative growth rate (RGR) of 2.94% day⁻¹ was obtained at 20 °C and 100 μmol photons m⁻² s⁻¹, whereas the lowest value was recorded at 25 °C and 100 μmol photons m⁻² s⁻¹ in a 12: 12 h LD photoperiod regime. Among the three photoperiod regimes (8:16 h, 12:12 h, 16:8 h LD) tested, there was evidence of a higher RGR in the 12:12 h LD cycle. This result suggests that the growth and reproduction of *C. ocellatus* are correlated with the seawater temperature based on laboratory culture and field observations.

Introduction

The genus *Chondrus* Stackhouse, which is widely distributed in temperate and cold-temperate waters (Lüning, 1985), has long been used as a source of gelling and stabilizing agent in foods (Taylor & Chen, 1994). Because of its commercial importance, there have been numerous studies on the genus to elucidate its biology and ecology (see Taylor & Chen, 1994). However, most studies have been based on Irish moss, *Chondrus crispus* Stackhouse. *Chondrus ocellatus* Holmes is mainly distributed on the coasts of Korea, Japan, China and Taiwan (Taylor & Chen, 1994). Although there are several reports on the life history, morphology and growth of this species (Ji & Guo, 1992; Brodie et al., 1993; Li et al., 1994), little is known about its phenology of growth and reproduction. In Korea, *C. ocellatus* inhabits the lower intertidal zone and is abundant on moderately exposed rocky shores (Kang, 1968). Recently, Choi and Kim (1999) reported that carrageenans from the Korean species have valuable anticoagulant properties.

Thus, the aim of this study was to investigate the reproductive phenology of *C. ocellatus*, in Cheongsapo near Busan in Korea, as baseline information for its management in the future. The present work provides new information on seasonal patterns in the proportions of reproductive phases and the sizes of individual thalli, in *C. ocellatus*. In addition, the effects of temperature and light on its growth are also examined in laboratory culture to compare with field observations.

Materials and methods

Cheongsapo is on the south eastern coast of Busan (129° 12'E, 35° 9'N), Korea. This site has a shallow and gently sloping intertidal zone. *Chondrus ocellatus* was sampled monthly from September 1994 to August 1995. Fifty fronds were randomly collected on the rocks of sampling areas, including rock pools, at each time. Plants were transported to the laboratory, then sorted by reproductive status (i.e. vegetative, gametophytic or tetrasporic), using visual examination

and confirmation under a microscope. The occurrence of each reproductive stage was expressed as a percentage of the total number of plants analyzed. The length and fresh weight of each plant was measured after it had been rinsed in tap water, drained, and blotted.

Single apices of 5 mm length were excised from the plants and their growth evaluated in an experimental matrix (after a 24 h acclimatization period) under temperatures of 15, 20 and 25 °C and 40, 60 and 100 $\mu\text{mol photons m}^{-2} \text{s}^{-1}$ at 12:12 LD photoperiod regime. Apical segments were cultured at 15 °C and 60 $\mu\text{mol photons m}^{-2} \text{s}^{-1}$ at three photoperiod regimes (8:16 LD, 12:12 LD and 16:8 LD) for 60 days. Irradiance was measured using a Li-Cor Model Li-1400 quantum meter. For each condition, 30 segments were individually weighed and inoculated into a culture vessel containing 200 ml of culture medium (PES) (Provasoli, 1968). Media were changed every seven days. Each treatment was replicated 3 times. The relative growth rate (RGR) using fresh weight data was calculated for each replicate according to the following formula:

$$\text{RGR} = \ln(W_t/W_0)t^{-1} \times 100$$

where W_0 is initial wet weight and W_t is the wet weight after t days. The seawater temperature data were obtained from NFRDI (National Fisheries Research and Development Institute).

Statistical analyses were performed using STATISTICA v. 5.0. A two-way ANOVA was used to test the effects of temperature and irradiance on the RGR of *Chondrus ocellatus*. A one-way ANOVA was applied to examine the effect of photoperiod in the RGR of the species. When significant differences between treatments were detected, the Tukey test was applied (Sokal & Rohlf, 1995).

Results

Monthly seawater temperature varied from 11 °C in March to 24 °C in September during the study period (Figure 1). Vegetative, gametophytic and tetrasporic plants were found in fluctuating ratios throughout the year (Figure 2). Vegetative plants were relatively abundant compare to reproductive plants during the entire study (above 36%) peaking in January (60%) with a minimum in November and August (36%). Maximum abundance of reproductive plants including both gameto- and tetrasporophytes was observed in November and August (64%) while minimum values were

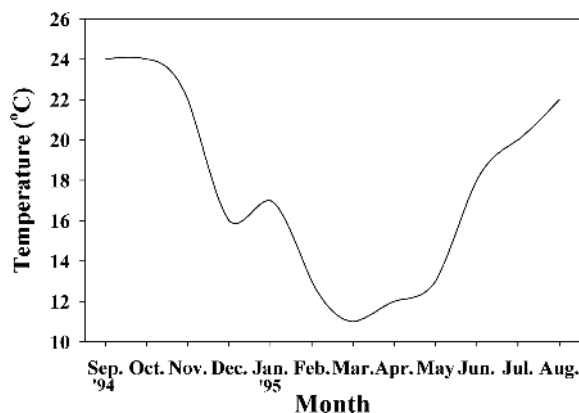


Figure 1. Monthly variations of seawater temperature at Cheongsapo in Korea.

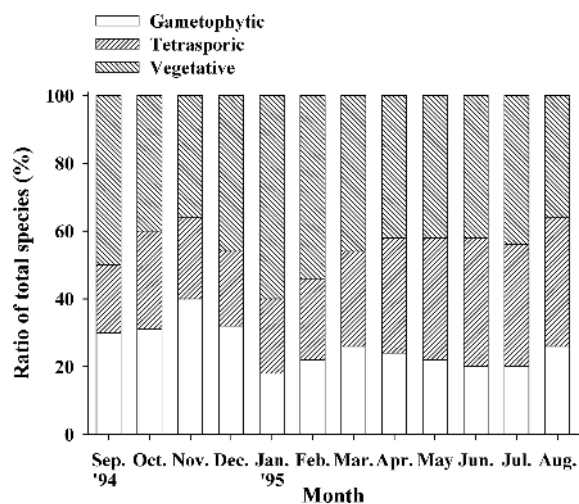


Figure 2. Monthly proportions of reproductive phases of *Chondrus ocellatus* during the sampling period.

found in January (40%). Gametophytes were most abundant from September to December (30–40%), when temperature and daylength decreased. By contrast, tetrasporophytes were relatively abundant in other months, particularly, from April to August (36–44%), when temperature and daylength increased.

The average length per plant was 6.99 ± 3.29 cm (mean \pm SD) for gametophytic plants, 7.93 ± 3.61 cm for tetrasporic plants and 5.99 ± 2.89 cm for vegetative plants (Figure 3). Vegetative plants were smaller than reproductive plants. Growth in thallus length of vegetative and reproductive plants was highest in October, May and August whereas it was lowest in February and March (Figure 3). Monthly size distributions of thalli including all reproductive phases varied during the study period (Figure 4). From December to February