Growth and reproduction of *Porphyra columbina* Mont. (Bangiales, Rhodophyceae) from southern New Zealand*

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**Abstract**

Changes in biomass and chemical composition, and the reproductive phenology of *Porphyra columbina* Mont. were monitored at three sites in southern New Zealand over two growing seasons. Both temporal and spatial variations were found. Seasonal changes in biomass and chemical components were correlated with seawater nitrate concentrations and temperature. The summer decline in biomass was a result of the onset of unsuitable environmental conditions and the release of reproductive tissue. Under more suitable conditions, the decline in biomass was delayed. There was an inverse relationship between vegetative growth and reproduction. Reproductive plants first appeared in August at a time of increasing temperature, irradiance and daylength. Only larger plants which were mainly found in subsites low on the shore became reproductive. Plants sampled from high subsites had a shorter growth season, were generally smaller, had lower nitrogen and pigment content and were non-reproductive.

**Introduction**

Of the four species of *Porphyra* listed in the marine flora of New Zealand (Chapman, 1969) the most common is the monostromatic lithophyte, *Porphyra columbina* Mont. While considerable variation in blade form can be found, Conway & Wylie (1972) considered it more appropriate to recognize just one polymorphic species rather than to separate it into several species or varieties as proposed by earlier workers (Laing, 1928; Levring, 1956).

Conway & Wylie (1972) established the presence of a filamentous conchocelis phase in the life history of this species and noted the formation of reproductive structures on it which gave rise to macroscopic foliose plants, thus confirming the biphasic pattern reported for a number of other species of *Porphyra* (Cole & Conway, 1980). The role of temperature and photoperiod in the regulation of the life history of *P. columbina* from central Chile has recently been investigated by Avila et al. (1986).

*P. columbina* is now being considered for aquaculture in New Zealand and a pilot farm has been established recently. Despite its widespread occurrence in New Zealand there is little detailed information on its ecology and physiology.

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Various aspects of the biology and chemistry of naturally growing and cultivated plants are being investigated in this laboratory (e.g. Brasch et al., 1981; Brown, 1987; Aitken, 1987; Friedlander et al., 1989). Here we report on the timing of and environmental parameters affecting the growth and reproduction of the blade phase of *P. columbina* in southern New Zealand.

**Description of sites studied**

Three sites in southern New Zealand were visited at least once per month between August 1986 and December 1987. Two of the sites, Lee Bay and Horseshoe Point, are on Stewart Island at the southern end of South Island. Lee Bay (46° 51.5' S; 160° 06.5' E) is a relatively sheltered site, situated at the western edge of a small sandy beach. It has a northerly aspect, and the substrate consists of diorite boulders. The depth of the sea 200 m offshore is 6 m. Horseshoe Point (46° 52.4' S; 160° 08.4' E) is an exposed site situated on the northern side of a rocky promontory. It has a northerly aspect and the substrate consists of large granite boulders. Depth of sea at 200 m offshore is 20 m. The third site, Kuri Bush (46° 01.2' S; 170° 13.3' E) is on the eastern coast of South Island. It is an exposed shore on the northern edge of a sandy beach. The substrate consists of a gently sloping schist platform. The depth of the sea 200 m offshore is 6 m.

**Materials and methods**

**Sampling techniques**

At each of the three sites, eight permanent 0.5 m² subsites, with *P. columbina* present, were randomly selected within a 30 x 5 m sampling area of the shore. The upper and lower boundaries of the sampling zone coincided with the distributional limits of the species. Changes in plant biomass within each subsite were assessed each month over two growing seasons by randomly sampling six 25 cm² quadrats per subsite. No quadrat was harvested more than once during the study. All plants within each of the quadrats were removed by hand, rehydrated in seawater, spun for 30 s in a salad drier to remove excess moisture and then weighed. In addition an estimate of growth was obtained by measuring the length and width of individual plants from each sample and their reproductive status determined by microscopic examination. The material was then frozen and stored at –20 °C to await chemical analyses. Results were analysed by ANOVA using the SAS statistical package.

**Chemical composition**

Each month the concentrations of chlorophyll a, phycocyanin and phycoerythrin in ten randomly selected plants from each subsite were determined, following the extraction procedures outlined by Jeffrey & Humphrey (1975) and Beer & Eshel (1985). The total carbon and nitrogen content of pooled samples of oven dried, ground plants from each subsite was measured monthly using a Hewlett Packard CHN elemental analyser. Each analysis was done in duplicate. Dry matter content was determined on twenty plants, collected from outside the permanent subsites at each location, by oven drying at 80 °C to constant weight. Data were analysed by ANOVA using the SAS statistical package.

**Environmental parameters**

On each sampling trip the subsurface seawater temperature was measured using an immersion thermometer (Zeal N₂ filled model). Seawater samples were collected and analysed for nitrate, ammonium and phosphate using a continuous flow autoanalyser (Chemlab ‘Systems 4’). Total monthly radiation values and hours of daylight were obtained from the New Zealand Meteorological Service, Dunedin (approx. 46° S).