

SEASONALITY IN GROWTH, REPRODUCTION AND SPORE  
LIBERATION OF *PORPHYRA VIETNAMENSIS* TANAKA  
et HO (RHODOPHYTA, BANGIALES)

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ABSTRACT

*Porphyra vietnamensis* Tanaka et Ho occurs in the intertidal region of the Visakhapatnam coast from November to August. Data were collected monthly on seasonal changes in growth, biomass and fruiting behaviour of this alga for a period of two years from November 1984 to August 1986. Maximum growth and biomass were observed in February and March in 1985 and 1986. Maximum liberation of monospores and carpospores was observed in the months of February and March respectively.

*Key-words:* *Porphyra vietnamensis*, growth, reproduction, spore liberation, Visakhapatnam.

INTRODUCTION

*Porphyra*, which is an economically important red alga, received much attention of the scientific community for its biology, ecology and life cycle (Drew, 1949, 1954; Kurogi, 1953; Tseng and Chang, 1955; Miura, 1961; Iwasaki, 1961; Conway, 1964a, b; Dixon and Richardson, 1969; Chen, Edelstein, Ogata and Mc Lachlan, 1970; Bird, Chen and Mc Lachlan, 1972; Bird, 1973 and Avila, Santelices and Mc Lachlan, 1985). Very little information was available on *Porphyra vietnamensis* Tanaka et Ho growing in Indian waters (Umamaheswara Rao and Sreeramulu, 1963 and 1964; Dhargalkar, Agadi and Untawale 1981). For mass cultivation of *Porphyra* under outdoor conditions, studies on seasonal growth, fruiting behaviour such as availability of carposporic and monosporic plants in the nature and on seasonal spore shedding of monospores and carpospores will be essential. These basic studies will be guidelines to find out suitable months for harvesting the *Porphyra* beds from the natural habitats and maintaining the conchocelis phase from carpospores or cultivation of *Porphyra* from monospores. In view of its commercial importance, detailed investigations were carried out to find out the maximum growth period, different phases and monospore, carpospore liberation of *P. vietnamensis* growing along the coast of Visakhapatnam from November 1984 to August 1986.

MATERIAL AND METHODS

Visakhapatnam lies between 17° 14' 30" and 75° 45' N and 83° 16' 25" and 83° 21' 30" E, on the east coast of India. The temperature of surface water, pH and salinity were measured by a thermometer, portable pH meter and salinometer respectively. Plants of *P.*

*vietnamensis* were collected from the mid-littoral zone of the intertidal rocky surfaces. For estimation of biomass, quadrats of 0.25 x 0.25 m were sampled on the rocky surfaces. The *P. vietnamensis*, which was present in the quadrats was taken with a scalpel and brought to the laboratory. The materials were carefully separated from other algae and then dried to a constant weight in an oven at 60°C temperature. Each month 3 to 4 samples were collected and average monthly values of biomass collected between November 1984 and August 1986 were expressed as g. dry weight m<sup>-2</sup>. 20 plants of *P. vietnamensis* were collected at monthly intervals to compute relative abundance of different generations. Antheridial, carposporic and vegetative/monosporic plants present in the collections were sorted out by examining them under microscope and relative abundance of the fruiting and vegetative plants in the population was estimated. Using these samples, the length of 10 to 15 individual fronds of the antheridial, carposporic and vegetative/monosporic plants was measured and data on mean frond length of different phases was obtained.

Spore liberation experiments were conducted with monosporic and carposporic plants of *P. vietnamensis*. Fertile fronds selected for the experimental work were washed with sterilized seawater and 2-3 fronds were placed in petri-dishes filled with sterilized seawater. Spore liberation experiments were conducted for 24 h (from 1800 to 1800 h) at room temperature (30 ± 2°C) and the petri dishes were illuminated by cool white fluorescent illumination of 9 Em<sup>-2</sup>s<sup>-1</sup> for 8 h during the day time from 0900 to 1700. To count the spores, the seawater containing spores was transferred to a measuring cylinder with a pipette. The spore suspension was then diluted to a known volume depending upon the quantity of spores liberated. Taking a subsample of 1 ml of the spore suspension, the spores were counted in a plankton counting chamber, under a microscope. Average values of three counts were used for computing the spore output in each experiment. Wet weight was noted at the end of the experiments and spore liberation was expressed as spores /g fresh weight/day.

## RESULTS AND DISCUSSION

### *Seasonal growth and biomass*

Data collected on hydrographical conditions namely water temperature, salinity and pH are presented in Table I. Data collected for two growth seasons (November 1984 to August 1986) on the biomass and frond length of the alga are shown in Fig. 2. In *P. vietnamensis*, minimum dry weight of plants per m<sup>2</sup> area of rocky surface was observed in November. Biomass of this alga increased rapidly and maximum biomass was observed in February (Fig. 1D). From April onwards the biomass of *P. vietnamensis* decreased and dry weight per m<sup>2</sup> area of the rocky surface was observed by end of August in each year. The alga disappeared completely from the study sites in the month of September. Data collected on frond length of *P. vietnamensis* also showed similar seasonal growth behaviour in the antheridial, carpogonial (Fig. 1B) and vegetative/monosporic plants (Fig. 1C), with slight difference in the maximum development of sexual and sterile plants. Maximum length of

antheridial and carpogonial plants of *P. vietnamensis* was observed in the month of March and of sterile plants in the month of February.

Table I – Hydrographical conditions of Visakhapatnam coast.

	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug
1984 - '85										
Water temperature (°C)	26.0	27.2	27.5	28.0	28.1	29.0	32.1	30.0	29.0	29.2
Salinity (‰)	23.8	24.9	30.1	31.1	32.5	33.8	34.8	34.8	32.1	32.2
pH	7.5	7.6	7.8	7.8	7.8	7.9	8.0	8.0	7.8	7.4
1985 - '86										
Water temperature (°C)	27.0	26.2	28.0	27.7	28.5	29.5	30.5	31.2	32.3	30.2
Salinity (‰)	22.4	24.4	29.2	31.2	31.5	32.5	33.5	33.8	33.6	30.0
pH	7.2	7.0	7.9	7.7	7.7	7.9	7.8	7.6	7.8	7.6

Table II – Relative abundance of gametophytic and vegetative plants of *Porphyra vietnamensis* growing at Visakhapatnam.

Generations	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Mean
1984 - '85											
Vegetative	100	65	55	40	35	25	25	20	30	20	41.5
Antheridial	0	35	20	25	30	30	35	35	25	30	26.5
Carpogonial	0	0	25	35	35	45	40	45	45	50	32.0
1985 - '86											
Vegetative	100	75	50	45	25	20	25	20	25	20	40.5
Antheridial	0	25	30	25	35	35	30	35	35	30	28.0
Carpogonial	0	0	20	30	40	45	45	45	40	50	31.5

#### Fruiting behaviour and seasonal spore shedding

Data collected on fruiting behaviour of *P. vietnamensis* are shown in Table II. In the month of November only vegetative thalli of *P. vietnamensis* were found in the plants sampled and antheridial plants were seen in December each year. Carpogonial plants were found in the populations from January onwards, and the number of antheridial and carpogonial plants increased from February. The abundance of vegetative plants decreased from March onwards, and 25 to 35% of vegetative plants were observed in the populations occurring between March and August. Carpogonial plants were more abundant than the antheridial plants.

Seasonal data collected on liberation of monospores and carpospores in *P. vietnamensis* during the two seasons of the years 1984-'85 and 1985-'86 are presented in Fig. 2. In *P. vietnamensis* monospore shedding was seen from November and the output increased from December to February. Peak output of monospores was obtained in the month of February with  $39.5 \times 10^5$  spores  $g^{-1}d^{-1}$  in 1984-'85 and  $42 \times 10^5$   $g^{-1}d^{-1}$  was in 1985-'86. From March onwards monospore production decreased rapidly up to July/August.

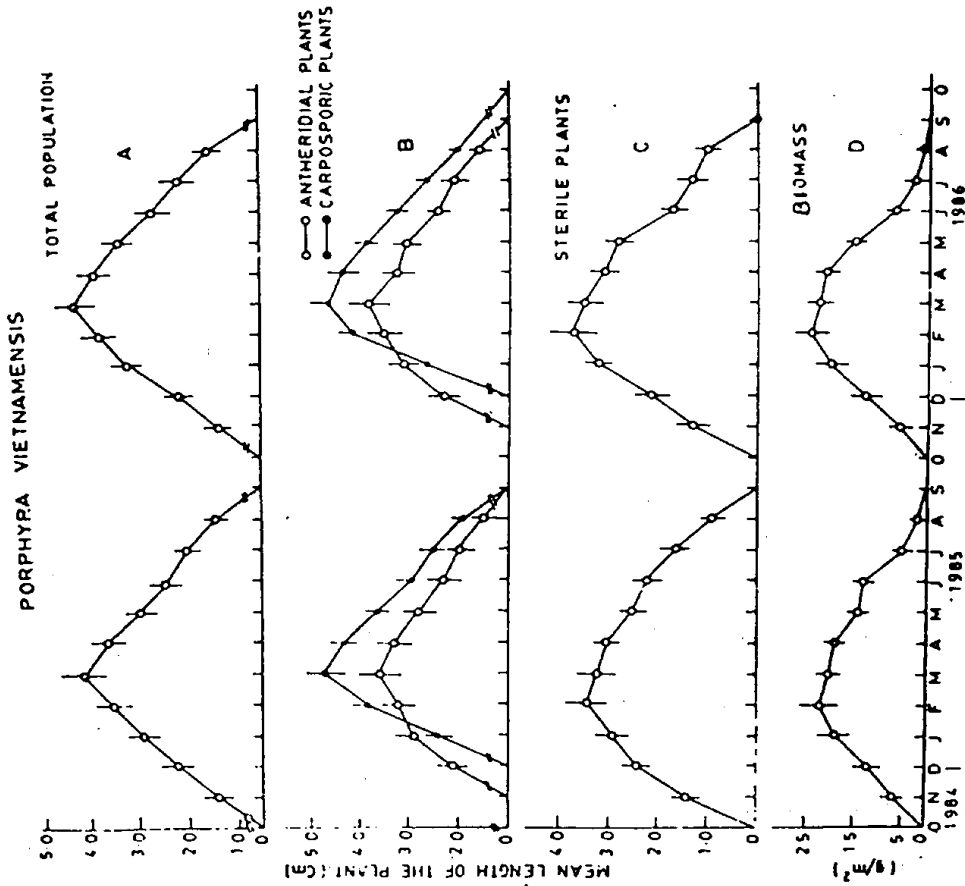


Fig. 1. Seasonal changes in growth behaviour of *Porphyra vietnamensis*. (A) Total population, (B) Anthieridial and Carposporic Plants, (C) Sterile Plants, (D) Biomass

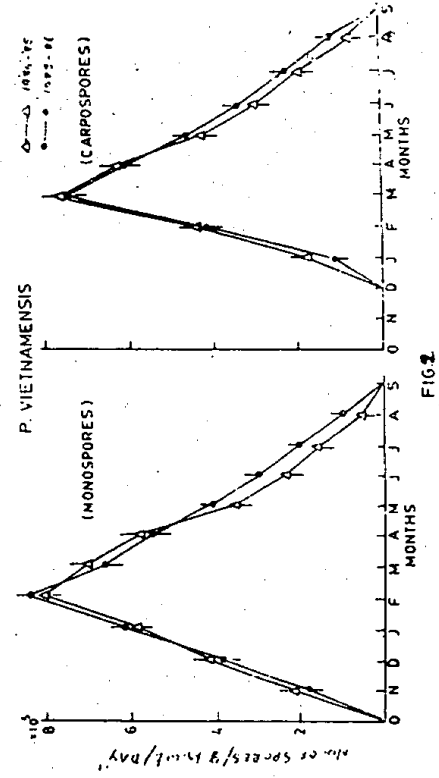


FIG. 2.

Fig. 2. Seasonal variations in the liberation of monospores and carpospores.

Carpospore liberation in *P. vietnamensis* was observed from January onwards. Maximum output of carpospores obtained was  $29 \times 10^5 \text{ g}^{-1} \text{ d}^{-1}$  in 1985- '86. From April onwards the liberation of carpospores decreased in *P. vietnamensis* and minimum output was seen in August. Monospores and carposporic plants of *P. vietnamensis* were not found after September.

In the present study on *P. vietnamensis*, peak values of biomass and growth in length of the thalli was seen in February and March, agreeing with the data collected on basal cover of this alga by Umamaheswara Rao and Sreramulu (1963) and also with the growth cycles of *Porphyra* and *Bangia* species investigated from other geographical areas (Krishnamurthy, 1969; Colinvaux, 1970; Kapraun and Zechman, 1982).

In seasonal studies on *Porphyra* some investigators related the seasonality in growth to the existing environmental conditions of the area. Working on *P. miniata*, a winter annual, Bird, Chen and Mc Lachlan (1972) suggested that increasing temperature and photoperiod caused death of the leafy thallus. Coleman and Mathieson (1974) related the occurrence of *P. leucostica* to low water temperatures and maximum salinities. Dhargalkar, Agadi and Untawale (1981) reported that water temperature, salinity and light intensity were low and nutrients were high during the maximum growth period of *P. vietnamensis* at Goa. Many workers also pointed out in the experimental and cultural studies (Iwasaki, 1961; Dixon and Richardson, 1969; Chen, Edelstein, Ogata and Mc Lachlan 1970; Bird, Chen and Mc Lachlan, 1972) that low temperature, high intensity and short days are suitable for the formation of leafy thalli of *Porphyra* species. At Visakhapatnam (present study) also maximum development of *P. vietnamensis* occurred between January and March, when temperature, salinity and duration and intensity of light were low. To support this view data on the environmental conditions of the winter and early summer, and summer months are given below to show the differences in the environmental factors during and after maximum growth periods of the alga investigated.

	Winter and early Summer (November - February)	Summer (March - June)
Air temperature (°C)	2 - 25	27 - 31
Water temperature (°C)	24 - 26	27 - 29
Solar irradiance (cal/cm <sup>2</sup> /day)	400 - 450	500 - 550
Salinity (‰)	24 - 31	33 - 34

In the present study carpospore formation was noticed after two months on leafy thallus of *P. vietnamensis* as reported by Conway (1964a & b) on *P. umbilicalis*. Bird, Chen and Mc Lachlan (1972) observed fruiting plants of *P. linearis* for five months during the growth period of the alga from November to March. In the present study, sexual plants were more than the sterile plants in the population of *P. vietnamensis* analysed for two years. Monospore discharge was observed November onwards, but liberation of carpospores was noticed after two months from the growth of this alga, i.e., from January onwards. Peak

shedding of all types spores was found in these seasonal algae during maximum growth period, i.e., between January and March (Fig. 2).

Data on seasonal spore shedding indicates that the *Porphyra* produces monospores to increase its population. Studies on growth behaviour of different generations and spore liberation will be necessary for the mass cultivation of *Porphyra* through monospores or carpospores.

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