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Seasonal Growth, Phenology and Spore Shedding in *Polysiphonia platycarpa* Børgesen (Ceramiales, Rhodophyta) of Visakhapatnam Coast, India

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Variation in seasonal growth, phenology and periodicity in spore shedding in *Polysiphonia platycarpa* Børgesen occurring on the coast of Visakhapatnam, India, have been described to know the growth behaviour, reproductive periodicity and spore producing capacities. This alga occurs for a short period from December to May in the intertidal region of the Visakhapatnam coast, showing maximum growth during January/February. Tetrasporophytic, carposporophytic and antheridial plants were observed in all months of their occurrence in the field. But the vegetative plants were not seen in January and February and all the plants collected were reproductive. The tetraspore and carpospore shedding was observed during all the six months of their occurrence.

Key Words: growth, phenology, *Polysiphonia platycarpa*, Rhodophyta, spore shedding

INTRODUCTION

Many investigations on the species of *Polysiphonia* reveal only the general growth and reproductive periodicity (Conover 1964; Edwards 1970; Coleman and Mathieson 1975; Reynolds and Mathieson 1975; Agadi and Untawale 1978; Kapraun 1978; Mathieson *et al.* 1981; Yarish and Edwards 1982). No detailed studies were made on the spore producing capacity of *Polysiphonia* species. Detailed investigations were made on the ecology and physiology of some Ceramiales of the Visakhapatnam coast (Sudhakar 1992) and in this paper, only the growth, phenology and spore shedding of *Polysiphonia platycarpa* were described. Species of *Polysiphonia* are also economically important, since *Polysiphonia ferulaceae* consists of 13-16% of proteins (Dave *et al.* 1987).

MATERIALS AND METHODS

The material for the present study was collected randomly from the infralittoral fringe zone at fortnightly intervals from the Visakhapatnam Coast (17° 41' 45"N and 83° 16' 22"E) from December 1987 to May 1988. Twenty five to thirty tufts or plants of *Polysiphonia platycarpa* were brought to the laboratory in polyethylene bags containing seawater and used for the estimation of growth and spore liberation experiments. Details of the methods followed for analyzing the growth and fruiting behaviours have been described by Kaliaperumal and Umamaheswara Rao (1982) and Subba Rangaiah (1983). The percentage frequency of carposporophytes, antheridial and tetrasporophytes and vegetative plants present in the samples was estimated. The length of the erect filaments in different phases was measured to estimate the mean length of the carposporophytes, antheridial, tetrasporophytes and vegetative plants. Methods used for liberation and estimation of spores are followed from the previous papers published by Subba Rangaiah (1983), Subba Rangaiah and Umamaheswara Rao (1983). An average of eight to ten replicates were used every month for estimating the tetraspore and carpospore outputs and the data collected on day one are plotted in Figs 1 E & F.

RESULTS

Data collected on seasonal variation in the mean length of the erect filaments of all generations in the

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Table 1. Percentage frequency of sexual, tetrasporic and vegetative plants in the population of *Polysiphonia platycarpa*

Year 1988-89	December	January	February	March	April	May	Mean
Cystocarpic plants	40.0	43.3	44.1	37.9	32.0	39.1	39.4
Antheridial plants	20.0	16.6	9.3	24.1	24.0	17.3	18.5
Tetrasporic plants	33.3	40.0	46.5	31.0	28.0	21.7	33.4
Vegetative plants	6.6	0	0	6.8	16.0	21.7	8.5

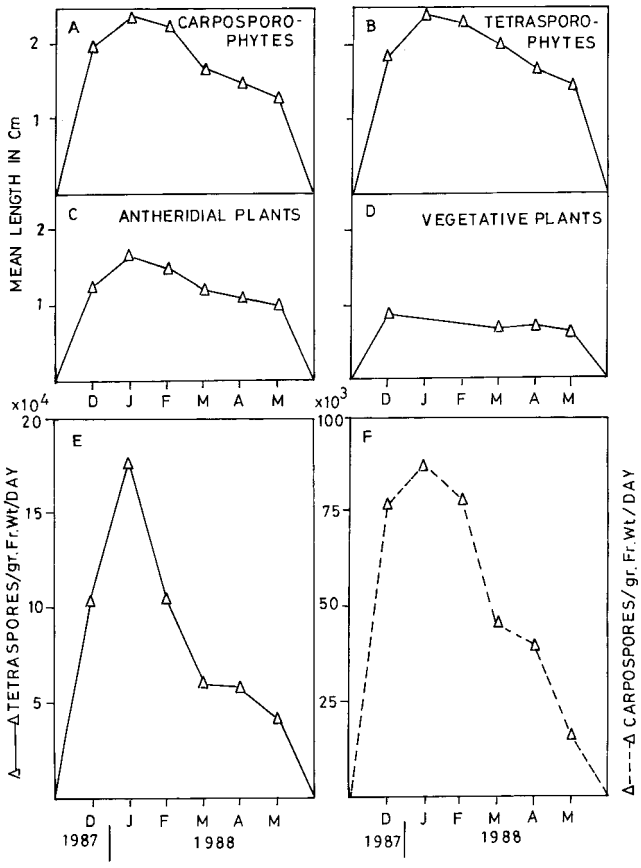

Fig. 1. Seasonal changes in growth behaviour and spore output of *Polysiphonia platycarpa*. A. Monthly variation in Carposporophytes. B. Monthly variation in tetrasporophytes. C. Monthly variation in antheridial plants. D. Monthly variation vegetative plants. E. Monthly variation in tetraspore output. F. Monthly variation in carpospore output.

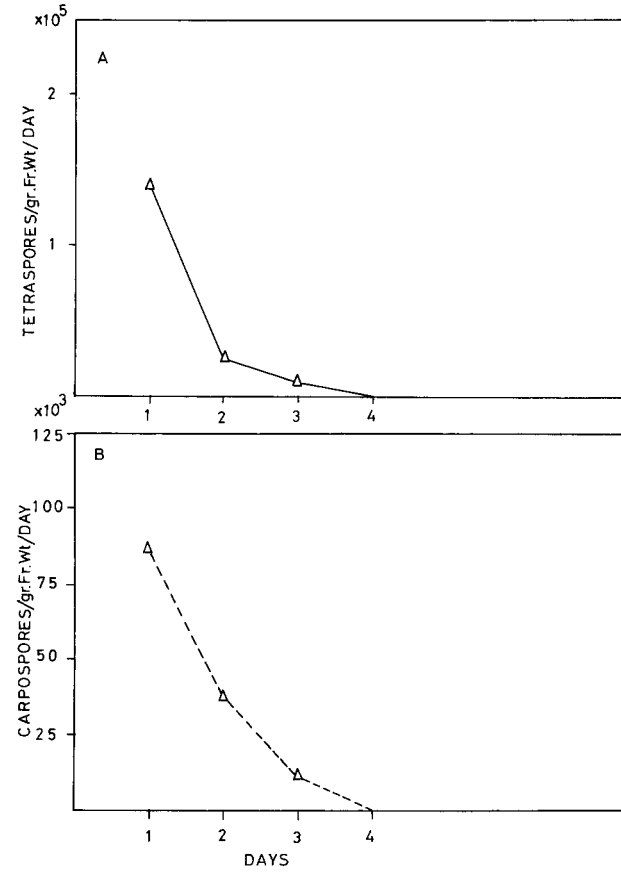

Fig. 2. Daily liberation of spore output of *Polysiphonia platycarpa*. A. Changes in tetraspores. B. Changes in carpospores

population, mean length of the carposporic, antheridial, tetrasporic and vegetative or undeterminable fronds are shown in Fig. 1. Populations of *Polysiphonia platycarpa* occur (Figs 1A to D) for only six months i.e. from December to May. The plants attained their maximum size during January/February and from there onwards slow decrease in size was noticed upto May and after May onwards, no plants were seen in the field. Similar growth behaviour was noticed in the carposporophytic, antheridial, tetrasporophytic and also in the vegetative plants (Figs 1A to D) and all the phases were observed and collected in all the six months of its occurrence in the field. The vegetative plants were found to be smaller in size than the sexual and tetrasporic plants.

Monthly percentage frequency of sexual, tetrasporic and vegetative plants collected from December 1987 to May 1988 are given in Table 1. From the yearly means shown in the last column of Table 1, it is evident that the percentage occurrence of fruiting plants varied. In general 91% of reproductive plants were recorded in *Polysiphonia platycarpa*. The relative preponderance of

cystocarpic, antheridial and tetrasporic plants vary significantly. Cystocarpic plants were found to be almost double the number of antheridial plants. Plants of asexual generations (tetrasporic) were not more abundant than sexual generations and it is surprising to note that the asexual plants were roughly half the number of sexual plants (Table 1). In the maximum growth period i.e., during January / February, all the plants collected are reproductive.

Daily liberation of tetraspores and carpospores is shown in Fig. 2. Maximum liberation of tetraspores and carpospores was seen on day one and the spore output decreased rapidly from day two onwards and the spore shedding lasts for 3 to 4 days only (Fig. 2). Mean monthly values of tetraspores and carpospores estimated from December 1987 to May 1988 are depicted in Figs 1E and F. Spore shedding was observed in all the six months of its occurrence in the field. The tetraspore and carpospore shedding was maximum during December to February. The spore shedding varied from 43,515 to 178,697 tetraspores $\cdot gr^{-1}$ fw $\cdot day^{-1}$ and 16,580 to 86,994 carpospores $\cdot gr^{-1}$ fw $\cdot day^{-1}$.

DISCUSSION

The data collected on the seasonal growth behaviour of *Polysiphonia platycarpa* indicate that the alga is present only for six months in the intertidal region of the Visakhapatnam Coast. Both sexual and asexual plants show maximum growth during January / February. This growth period of *P. platycarpa* is in conformity with the growth behaviour of the *Polysiphonia* species reported from Visakhapatnam Coast (Umamaheswara Rao and Sreeramulu 1964) and from West Coast, Goa (Agadi and Untawale 1978) but differs from that of *Polysiphonia* species reported from other geographical areas where the species are available throughout the year (Conover 1964; Edwards 1970; Reynolds and Mathieson 1975; Kapraun 1977, 1978). Seasonal occurrence of different *Polysiphonia* species as observed in the present study was reported by Yarish and Edwards (1982); Cheung and Hodgkiss (1984); Hanisak and Blair (1988). Bimodel growth curve has been observed by Conover (1964) in *Polysiphonia ferulaceae.* This type of bimodal growth curves were obtained in other genera occurring on the Visakhapatnam coast, for example in *Centroceras clavulatum*, *Wrangelia argus* (Sudharkar 1992), *Gracilaria corticata* (Subba Rangaiah 1983), *Hypnea valentiae* (Subba Rangaiah and Umamaheswara Rao 1983), *Amphiroa fragilissima* (Subba Rangaiah and Vanilla Kumari 1997) *Jania rubens* and *Grateloupia lithophila* (Vanilla Kumari 1997). Sand movement on the shore might be the influencing factor on the growth of *Polysiphonia* at Visakhapatnam coast as reported in other coastal areas with outcrops of boulders (Daly and Mathieson 1977). Sand cut normally occurs from October to April and filling up of the beach from May to September (Umamaheswara Rao and Sreeramulu 1964). Algae like *Polysiphonia platycarpa* growing in the infralittoral fringe are mainly affected by these changes in sand levels in the shore, since this alga occurs on the rocks in the period of sand cut and disappears during the period of sand filling from June to November.

Size differences in the male, female and tetrasporic plants were reported by Austin (1960) in *Furcellaria fastigiata,* Waern (1952) and Garbary *et al.* (1978) in *Ceramium tenuicorne* and *C. rubrum*. Such variations in the size of the reproductive plants of *Polysiphonia platycarpa* were also observed in the present study. The vegetative and male plants were found to be smaller than the cystocarpic and tetrasporic plants as observed in *Centroceras clavulatum* and *Wrangelia argus* (Sudhakar 1992). The reason for the smaller size of vegetative plants, might be that they may later develop into fruiting plants after attaining certain size. Seasonality in the occurrence of different fruiting plants of various species of *Polysiphonia* was reported (Dixon 1970; Edwards 1970; Coleman and Mathieson 1975, Kapraun 1978; Mathieson *et al.* 1981; Yarish and Edwards 1982). However, in the present study, the sexual and tetrasporic plants were collected in all the six months of the occurrence of the alga in the field. Davis and Wilce (1987) had reported the presence of *Polysiphonia urceolata* throughout the year without any reproductive structures.

In the reproductive cycle of the red algae, there is a general dominance of the tetrasporophytic phase. Thus Dixon (1970) explained that in Europe, tetrasporophytic plants are more often reported than sexual plants. In the species of *Hypnea* (Mshigeni 1976; Rama Rao 1977; Subba Rangaiah and Umamaheswara Rao 1983), *Polysiphonia* (Kparaun 1978), *Gelidium* (Montalva and Santalices 1981, Kaliaperumal and Umamaheswara Rao 1986) and Gracilaria (Umamaheswara Rao 1973; Hoyle 1978; Subba Rangaiah 1983) the sexual plants formed a small proportion of the populations. In contrast, Cheung and Hodgkiss (1984) reported no significant differences in the proportions of sexual and asexual plants in *Polysiphonia harlandii* and Sudhakar (1992) in *Centroceras*

clavulatum and *Wrangelia argus.* Umamaheswara Rao and Sreeramulu (1970) also reported a kind of balance between the two phases. But in the present study, to our surprise, the sexual plants formed a large proportion (57.9%) of the population than asexual plants (33.4%).

The number of tetraspores and carpospores released on day one was maximum (Fig. 2). A similar trend was reported in *Gracilaria edulis* by Rama Rao and Thomas (1974), *Gracilaria corticata* by Umamaheswara Rao (1976), Subba Rangaiah (1983), *G. textorii* and *Gracilariopsis sjoestedtii* by Subba Rangaiah, (1984, 1985), *Gelidium* spp. by Suto (1950); Umamaheswara Rao (1974); Kaliaperumal and Umamaheswara Rao (1986), *Pterocladia heteroplatos* and *Gelidiopsis variabilis* by Kaliaperumal and Umamaheswara Rao (1982, 1985), some species of red algae by Boney (1960); *Hypnea valentiae* by Subba Rangaiah and Umamaheswara Rao (1983); *Centroceras clavulatum, Wrangelia argus* (Sudharkar 1992), *Amphiroa fragilissima* by Subba Rangaiah and Vanilla Kumari (1997), *Jania rubens* and *Grateloupia lithophila* by Vanilla Kumari (1997). This indicates that the plants collected from the field liberates maximum number of their spores on day one and slowly the number of spore shedding decreases from day two onwards and further it is assumed that the development of cystocarps and tetrasporangia are slow in the laboratory, thereby the shedding of spores is low from day two onwards. Corresponding with the maximum growth period, peak shedding of tetraspores and carpospores was observed during December / February (Fig. 1).

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