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Seasonal growth, reproduction and spore shedding in *Pterocladia heteroplatos*

N KALIAPERUMAL* and M UMAMAHESWARA RAO

Department of Botany, Andhra University, Waltair 530003, India

* Regional Centre of Central Marine Fisheries Research Institute, Marine Fisheries, Tamil Nadu 623520, India

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Abstract. Results on seasonal growth, fruiting behaviour and spore output in *Pterocladia heteroplatos* are presented. Populations of *P. heteroplatos* were recorded in all months of the year with a maximum development of plants from November to January. Tetrasporophytes occurred throughout the year without any seasonal variation in their abundance but carposporophytes were rarely found in natural population. The tetraspore and carpospore outputs ranged from 1427–7 94 055 and 39 996–1 67 040 spores/g fresh weight of the plant respectively. Seasonal changes were not found in the formation and liberation of reproductive bodies in *P. heteroplatos*.

Keywords. Spore shedding; reproduction, growth; seasonal changes; Pterocladia heteroplatos.

1. Introduction

Species of *Pterocladia* (Gelidiaceae) are used as a source of agar-agar (Boney 1965). *P. heteroplatos* grows at Visakhapatnam (Rao and Kaliaperumal 1980). Results obtained on the yield and properties of agar extracted from *P. heteroplatos*, growing at Visakhapatnam (Rao and Kaliaperumal 1980) have been published recently. The present paper reports the biological data collected on the growth and reproductive phenology and spore shedding for a period of two and a half years from September 1976 to February 1979.

2. Material and methods

P. heteroplatos growing in the infralittoral fringe zone was collected randomly at fortnightly intervals from two stations along the Visakhapatnam coast (17° 41′ 45″ N and 83° 16′ 22″ E). Twenty to twenty-five tufts of *P. heteroplatos* were brought to the laboratory in polythene bags containing sea-water and used for growth analysis and spore liberation experiments. Details of the methods followed for analysing the growth and fruiting behaviours have been described by Kaliaperumal and Umamaheswara Rao (1982). The percentage frequency of tetrasporophytes, carposporophytes and vegetative plants present in the sample was estimated. The length of the erect fronds in different phases of the life cycle of the alga was measured to estimate the mean height of the tetrasporophytes, carposporophytes and vegetative plants and the fronds were divided into 2 groups: group I (<2 cm) and group II (>2 cm), for determining the abundance of these two size classes in the population of *P. heteroplatos*. The number of tetrasporangial sori present in 3 to 5 tufts and cystocarps present on carposporophytes were counted every month and the fresh

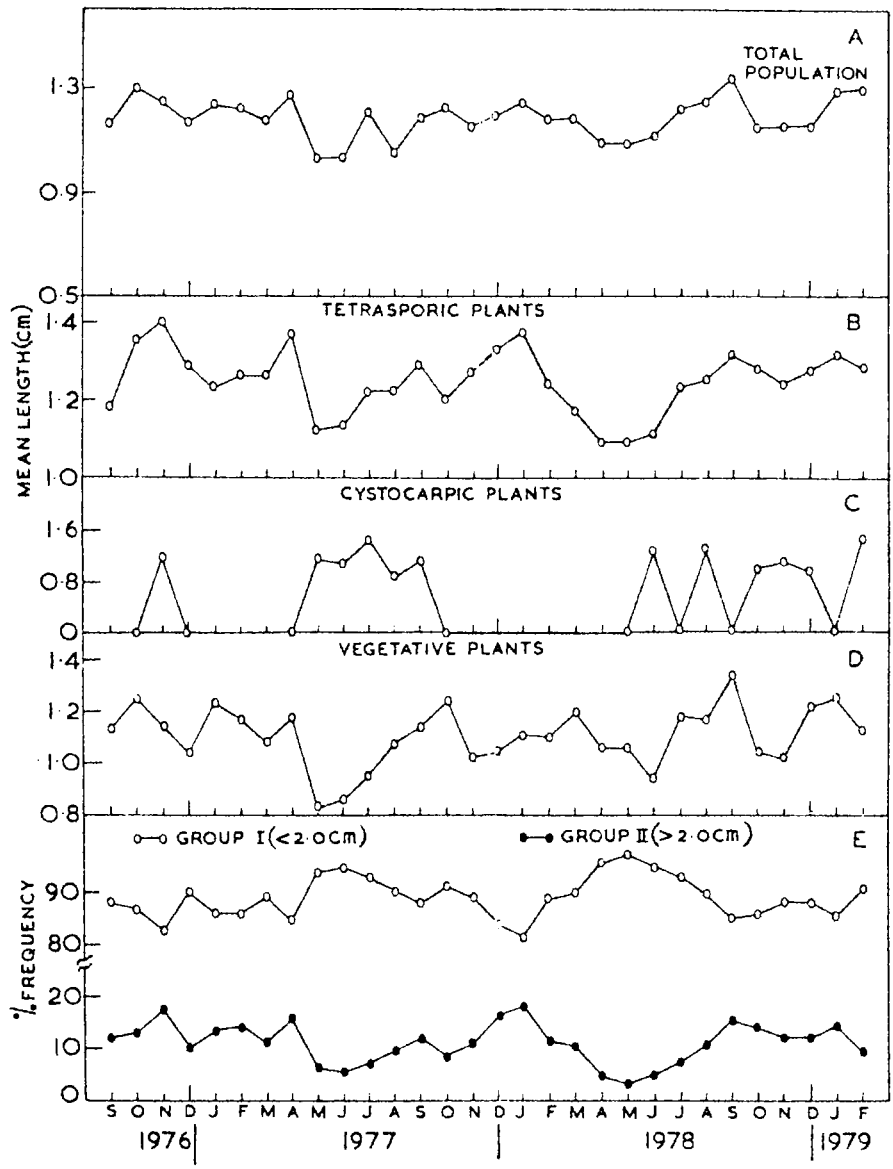

Figure 1. Seasonal changes in length and frequency of two size classes of fronds of *P. heteroplatos*.

weight of the tufts was noted to estimate the seasonal abundance of tetrasporangial sori and cystocarps/g fresh weight of the plant. Methods used for the liberation of spores and estimation of seasonal production of tetraspores and carpospores are described in an earlier communication (Umamaheswara Rao and Kaliaperumal 1983). Eight replicates were used each month for estimating the tetraspore output and data collected on the first day are plotted in figure 2. Since carposporophytes were rarely

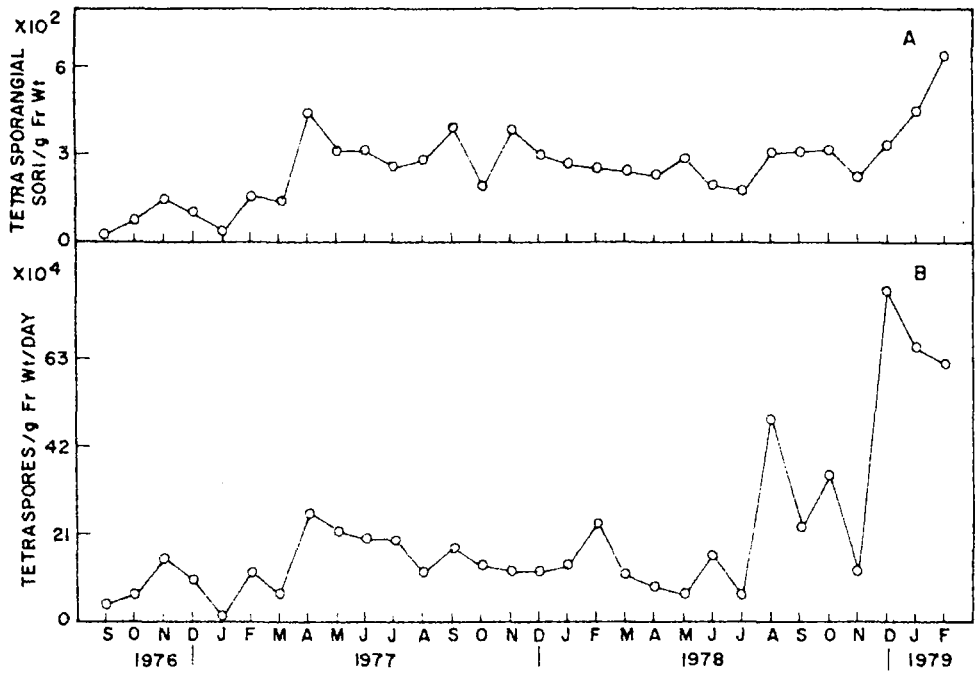

Figure 2. Seasonal variations in the tetrasporangial sori and tetraspore output of *P. heteroplatos*.

found in the population of *P. heteroplatos*, carpospore shedding experiments were conducted in three different months (table 2).

3. Results

3.1 *Growth behaviour*

Monthly changes in frond length and percentage frequency of the two size groups of erect fronds of *P. heteroplatos* are shown in figure 1. Since the data collected at fortnightly intervals from two stations did not vary significantly, mean values obtained for each month ($n = 40-50$) are plotted in figure 1. Though monthly variations in growth were rather irregular in the total population (figure 1A), increase in frond length was seen from May or June and Maximum development of the plants from November to January. The t-value calculated for all the maximum and minimum growth periods of this alga was significant (5·934) at 1 and 5% levels (d.f. = 12), indicating the occurrence of a single peak growth period in a year in *P. heteroplatos*. A single peak growth period can be seen more clearly in the tetrasporic plants (figure 1B) than in the entire population (figure 1A) and vegetative plants (figure 1D). Male plants were not observed in the population analysed and since female plants with cystocarps occurred only for some months, growth data could not be collected separately on this gametophytic phase of the alga.

Figure 1E shows the seasonal fluctuation observed in the abundance of fronds of the

two size classes. Group I fronds occurred in maximum numbers (84·6–96·9 %) during April, May and June and group II fronds from November to January. These seasonal variations in the stature of the plants also suggest that a single peak growth period occurs between November and January in *P. heteroplatos*.

3.2 *Fruiting cycle*

Monthly and yearly mean values of percentage frequency of tetrasporophytes and carposporophytes of *P. heteroplatos* are shown in table 1. From the annual means estimated it is evident that 80·6 % and 19·4 % fruiting and vegetative plants occur in the natural population respectively. Tetrasporophytes were more abundant than carposporophytes and their frequency in different months ranged from 60·5 to 92 %. The yearly mean value calculated for tetrasporophytes was 79·3 %. Monthly averages of carposporophytes given in table 1 show that these plants occur for certain months of the year and the frequency values varied from 0·3 to 7·8 %. The abundance of tetrasporophytes did not vary seasonally.

As shown in figure 2A, there was no seasonal variation in the tetrasporangial sori forming on the plants of *P. heteroplatos* and the number of sori ranged from 187 to 6378/g fresh weight of the plant during the period of study. Cystocarps per gram fresh weight of the plant varied from 766 to 2627 for three different months (table 2).

Table 1. Percentage frequency of tetrasporophytes and carposporophytes in the population of *P. heteroplatos*.

	Sept	Oct	Nov	Dec	Jan	Feb	March	April	May	June	July	Aug	Mean
Tetrasporophytes													
1976–77	14·8	63·5	84·0	80·0	42·0	61·0	76·0	79·8	87·0	88·0	76·0	72·3	68·7
1977–78	86·0	88·0	91·2	96·0	88·8	84·0	45·0	75·0	72·0	96·0	88·0	80·0	82·5
1978–79	94·0	76·0	91·0	94·0	88·0	78·0	—	—	—	—	—	—	86·8
Mean	64·9	75·8	88·7	90·0	72·9	74·3	60·5	77·4	79·5	92·0	82·0	76·1	79·3
Carposporophytes													
1976–77	0	0	1·0	0	0	0	0	0	2·0	3·0	5·0	11·5	1·9
1977–78	2·0	0	0	0	0	0	0	0	0	2·0	0	4·0	0·7
1978–79	0	3·0	1·0	1·0	0	2·0	—	—	—	—	—	—	1·2
Mean	0·7	1·0	0·7	0·3	0	0·7	0	0	1·0	2·5	2·5	7·8	1·3

— data not collected

Table 2. Abundance of cystocarps and carpospore output in *P. heteroplatos*.

Month	Cystocarps/g fr. wt.	Carpospores/g fr. wt./day
November 1976	1658	74215
July 1977	766	167040
September 1977	2627	39996

3.3 *Spore shedding*

Figure 2B and table 2 show the tetraspore and carpospore outputs respectively from *P. heteroplatos*. Maximum liberation of both tetraspores and carpospores was seen on the first day and spore output decreased from the second day onwards. Under laboratory conditions, tetraspore output was observed up to 4 days and carpospore output up to 14 days. Maximum shedding of tetraspores was from April to July in 1977 and from August to February in 1978–79 with low values in September and November. In this study, the tetraspore output varied from 1 427 to 7 94 055 spores/g fresh weight of the plant and the carpospore output from 39 996 to 1 67 040 spores (table 2).

4. Discussion

Occurrence of *Pterocladia* in India was reported recently (Umamaheswara Rao and Kaliaperumal 1980) and this is the first ecological study on this genus in India. In the present study on *P. heteroplatos* monthly changes in growth are not marked and maximum development of erect shoots occurs in this alga between November and January. These findings are in agreement with the results obtained by Matsuura (1958), Dixon (1958) and Santelices (1978a) who reported the occurrence of a single peak growth period in *Pterocladia pacifica, P. capillacea* and *P. caerulescens* with maximum development of plants between November and January.

The fruiting behaviour of *P. heteroplatos* was different from other species of *Pterocladia* investigated by Matsuura (1958), Stewart (1968) and Santelices (1978b). These authors observed seasonal variation in the abundance of tetrasporophytes of *P. capillacea* and *P. caerulescens* and carposporophytes of *P. pacifica*. Data presented here (table 1) clearly show that seasonal variations do not occur in the abundance of tetrasporophytes or carposporophytes of *P. heteroplatos* (table 1). However, as observed in *P. capillacea* (Stewart 1968; Oliveira Filho and Sazima 1973) tetrasporophytes were predominant in all months of the year in the natural population of *P. heteroplatos*. Antheridial plants were not found by Santelices (1978b) in *P. caerulescens*. In the present study also male plants were absent in the population of *P. heteroplatos*.

Little is known on the spore producing capacity of *Pterocladia* species. In the present study tetraspore shedding was observed in all months of the year and the spore output was high in *P. heteroplatos* with 7·9 lakhs spores/g fr wt in some months of the year. The values obtained are comparable with the estimates given by Suto (1950) for *Gelidium amansii* and by Kaliaperumal and Umamaheswara Rao (unpublished) for *G. pusillum*. In the occurrence of less marked seasonal growth behaviour, in the absence of seasonality in the fruiting plants and in the production and liberation of tetraspores, *P. heteroplatos* agrees well with *G. pusillum* growing in the same locality (Kaliaperumal and Umamaheswara Rao, unpublished).

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