Growth, Reproduction & Sporulation of Marine Alga *Gelidium pusillum* (Stackhouse) Le Jolis

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Seasonal aspects of growth, reproduction and spore output in *G. pusillum* growing (Sept. 1976-Feb. 1979) at Visakhapatnam coast were described. Plants occurred throughout the year with maximum growth in Sept. and Oct. and minimum between Jan. and April. Tetrasporophytes were predominant over the cystocarpic plants and seasonality was not observed in the abundance of these fruiting plants. Under laboratory conditions tetraspore and carpospore shedding was maximum on the 1st d and spore output gradually decreased from 2nd d onwards. Seasonal variations were not observed in the formation of sori and discharge of spores.

Gelidium pusillum (Stackhouse) Le Jolis (Gelidiales, Rhodophyta), an agar-yielding red alga grows in the intertidal habitats of Visakhapatnam coast. Standing crop and seasonal variations in yield and physical properties of agar-agar extracted from this alga have been reported[1]. Data on the seasonal aspects of growth, fruiting behaviour and spore shedding of *G. pusillum* are presented in this communication.

Materials and Methods

Plants of *G. pusillum* growing as small clumps or tufts, were collected fortnightly (Sept. 1976- Feb. 1979) during the spring tide periods from 2 stations along the Visakhapatnam coast (17° 41'45" N and 83° 16' 22" E). Clumps or tufts (20-25) of *G. pusillum* were collected randomly from the same area of each station and brought to the laboratory in seawater. Methods followed for growth analysis and spore shedding were same as published[2]. Percentage frequency of reproductive and undeterminable plants in the samples was estimated and the length of 20 to 25 erect shoots was measured from each clump of the sexual, asexual and vegetative plants present in samples to determine seasonal changes in the stature of tetrasporophytes, carposporophytes, vegetative plants and also the total population. The erect fronds measured were divided into group I (<1 cm) and group II (>1 cm), for estimating the relative frequency of these 2 size classes in the population. Data collected at 15 d intervals from 2 stations were pooled for each month ($n=40$-50), since there was no significant variations between the 2 samples collected in a month and between the samples of 2 stations.

Every month the number of tetrasporangial sori and cystocarps present on 5 plants was counted and the fresh weight recorded to estimate monthly changes in the tetrasporangial sori and cystocarps per gram fresh weight of *G. pusillum*.

Small clumps with well developed tetrasporangial sori and cystocarps were used for estimating the spore production. Tetraspore and carpospore outputs were estimated[3]. Every month 8 experiments were conducted for estimating the tetraspore output. Depending on the availability of carposporophytes, information was collected on carpospore shedding. Daily output of tetraspores was estimated for 4 days and carpospores for 20 days. Data obtained on the 1st d of the experiments was finally plotted to follow seasonal changes in spore production.

Results

Growth cycle— Increase in length of fronds was observed from May/June and maximum growth occurred once in a year during Sept. and Oct. (Fig. 1A). In the 2nd y (1977-78) maximum increase in length of fronds was seen up to Nov. (Fig.1A). Decrease in frond length was noticed from Dec. onwards and fronds with minimum length were seen during Jan. to March/April. The *t* value, calculated from mean length of fronds during the maximum growth period (Sept.-Oct.) and minimum growth period (Jan.-April), was 3.729 indicating that the changes in growth were significant at 1% as well as 5% levels ($df=14$). These seasonal changes in the stature were more distinct in tetrasporic and vegetative plants (Figs 1B and D) than

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in cystocarpic plants (Fig.1C) with maximum development of plants in Sept. and Oct.

Data on seasonal abundance of fronds of the 2 size classes are shown in Fig.1E. Maximum percentage (82.8-96.9) of group I fronds was seen between Jan. and March/April, while of group II fronds was during Sept.-Oct. These observations on the 2 size classes of erect shoots also support the above finding that a single annual peak growth period occurs in *G. pusillum* from Sept. to Oct.

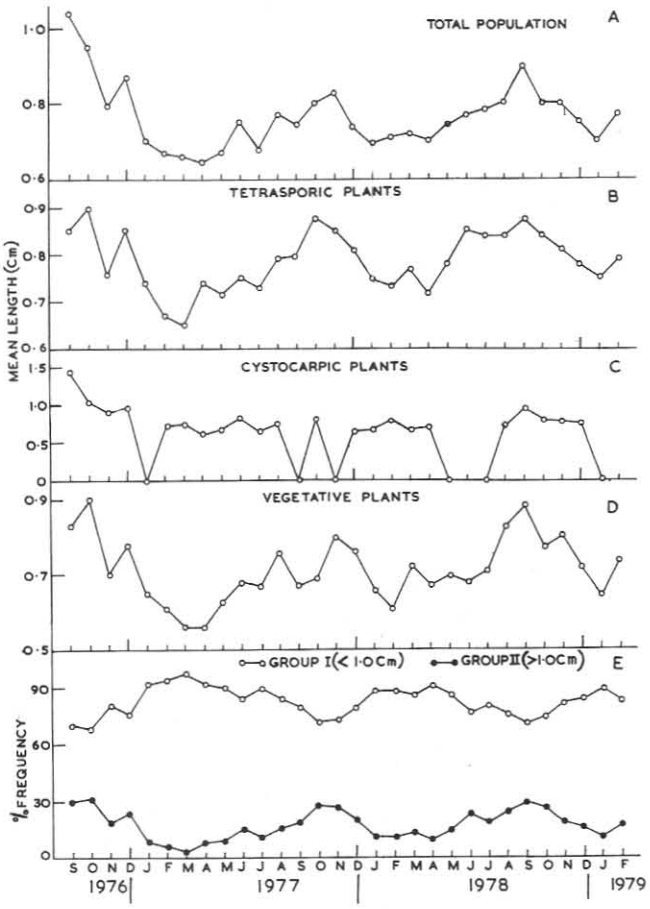

Fig. 1— Monthly changes in length and frequency of 2 size classes of fronds of *G. pusillum*

Fruiting behaviour— Frequency of tetrasporophytes and carposporophytes in the natural population of *G. pusillum* is shown in Table 1. Nearly 75% of plants occur in fruiting condition in different months of the year. Male plants were not recorded in this study. Tetrasporophytes were more abundant (52-80.6%) in samples. The frequency values of cystocarpic plants ranged from 0.7 to 4.5%. Seasonal variations were not observed in the abundance of tetrasporic and cystocarpic plants (Table 1).

The number (no. g^{-1} fresh wt) of tetrasporangial sori varied from 352 to 1,529 and cystocarps from 95 to 5,444 without any seasonal fluctuation in the formation of these reproductive bodies (Figs 2A and C).

Spore output— Monthly data on the liberation of tetraspores and carpospores from *G. pusillum* are shown in Figs. 2B and D. Under laboratory conditions, shedding of tetraspores was seen for 4 days and carpospores continuously for 20 days. The quantity of spores liberated decreased rapidly from 2nd d onwards. Maximum number of tetraspores was liberated between April and Aug. 1977 and thereafter peak discharge of spores was observed from Aug.1978 to Feb.1979 with low values in Oct. and Dec. During the study period output (no. g^{-1} fresh wt) of tetraspores ranged from 1,149 to 10,78,505 and that of carpospores from 1,176 to 6,99,943. Though spore output is high in *G. pusillum*, definite relationship was not observed between the growth cycle and the production and liberation of reproductive elements in different months of the year.

Discussion

Except for the brief report on seasonal growth of *G. pusillum* growing at Visakhapatnam[4], detailed studies were not made in India on the ecology and biology of this agar-yielding red alga. The present study reveals

Table 1— Percentage Frequency of Tetrasporophytes and Carposporophytes in *G. pusillum* Population

	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	March	April	May	June	July	Aug.	Mean
						Tetrasporophytes							
1976-77	24.8	52.5	83.5	81.0	42.0	52.0	62.0	76.0	75.8	57.0	75.0	83.0	63.7
1977-78	88.0	84.0	74.8	83.0	77.0	76.0	42.0	80.0	69.0	74.0	74.0	78.2	74.2
1978-79	85.0	84.0	70.0	68.2	82.0	88.0	—	—	—	—	—	—	79.5
Mean	65.9	73.5	76.1	74.1	67.0	72.0	52.0	78.0	72.4	65.5	74.5	80.6	72.5
						Carposporophytes							
1976-77	9.0	2.5	5.0	3.0	0	5.0	1.0	7.0	3.0	3.0	9.0	4.0	4.3
1977-78	0	6.0	0	1.0	2.0	6.0	4.5	1.0	0	0	0	2.0	1.9
1978-79	2.0	1.0	7.5	3.0	0	0	—	—	—	—	—	—	2.3
Mean	3.7	3.2	4.2	2.3	0.7	3.7	2.8	4.0	1.5	1.5	4.5	3.0	2.8

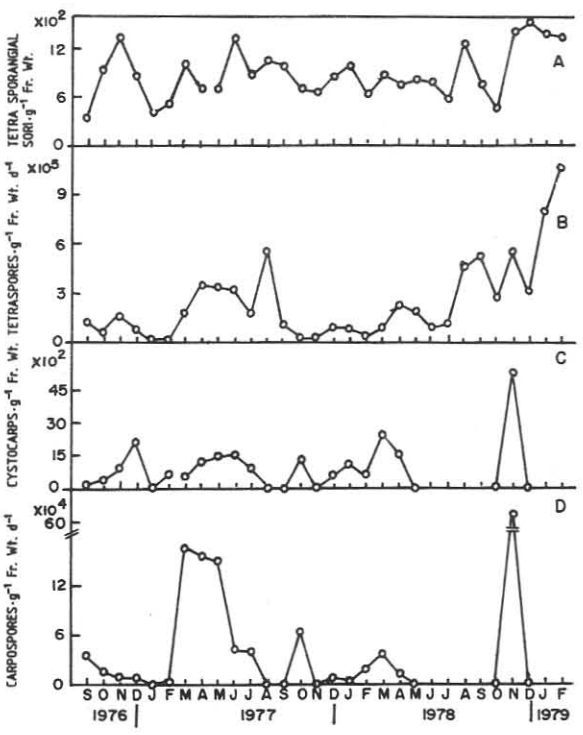

Fig. 2—Monthly variations in number of (A) tetrasporangial sori, (B) tetraspores, (C) cystocarps and (D) carpospors in *G. pusillum*

that *G. pusillum* occurs throughout the year in the intertidal region at Visakhapatnam with maximum development of plants in Sept. and Oct. In other geographical areas also maximum development of fronds of *G. pusillum* was found once in a year[5,6]. Single peak growth period was observed in other species, *G. amansii*[5,7,8], *G. divaricatum*[5,6], *G. japonicum*[5], *G. pacificum*[5], *G. corneum* and *G. robustum*[10]. In the occurrence of a single peak growth period, the results of the present study agree with the above findings. However, the period of maximum development varied in all these species of *Gelidium* investigated by different workers. Only in *G. robustum*[10] maximum elongation of axes was found during August and September and this observation on *G. robustum* is in agreement with *G. pusillum* growing at Visakhapatnam.

Tetrasporophytes occurred throughout the year in *G. cartilagineum*[11,12] and they were found to be predominant in the population over the cystocarpic plants in *G. amansii*[13], *G. cartilagineum*[11,12], *G. pulchellum*[14] and *G. latifolium*[14]. Similar trend in the abundance of tetrasporophytes existed in *G. pusillum* growing at Visakhapatnam (Table 1). Seasonal changes in the abundance of tetrasporophytes had been observed in *Gelidiella acerosa*[15] and *Gelidiopsis variabilis*[2]. But in the present study seasonal abundance of tetrasporophytes was not found and in this respect *G. pusillum* agreed with *G. cartilagineum*[11]. Matsuura[5] reported seasonal occurrence of cystocarpic plants in *G. pusillum*, *G. amansii*, *G. divaricatum*, *G. japonicum* and *G. pacificum* growing in Japan. On the other hand in Visakhapatnam cystocarpic plants of *G. pusillum* occurred throughout the year.

Spore producing capacity of *G. pusillum* was very high and it can be compared to *G. amansii*[16]. As in *G. amansii*[17] maximum shedding of spores was on the 1st d in *G. pusillum*. In *G. robustum* carpospore output was more[18], whereas in *G. pusillum* tetraspore output was higher than the carpospore output (Fig.2). Seasonality had been reported in the shedding of tetraspores of *Gelidiella acerosa*[15,19] and tetraspores and carpospores of *G. robustum*[18] with peak discharge of spores at a particular period of the year. Though spore discharge was seen in all months of the year in *G. pusillum*, definite seasonal rhythm was not found in the liberation of spores (Fig.2). Further more in *Gelidiella acerosa*[15] and *Gelidiopsis variabilis*[2] peak production and liberation of reproductive elements were found during maximum growth periods. In the present study similar positive relationship was not observed between the seasonal growth and fruiting cycle of *G. pusillum*.

G. pusillum is a good source for extracting high quality agar[1]. The present information on the less conspicuous growth changes and occurrence of fruiting plants and liberation of spores throughout the year suggests that a single harvest in a year during Sept. and Oct. may not disturb natural population of *G. pusilum* in the intertidal habitats. Because of discontinuous distribution with low biomass of 0.5 to 1.3 kg.m^2 in the vicinity of Visakhapatnam[1], this alga can be used for agar extraction by mixing with other agar yielding red algae.

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