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Phenology and agar yield of *Gracilaria blodgetii* in the tropical water, Okinawa, Japan

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Abstract: Seasonal variation of the three reproductive thalli of *Gracilaria blodgetii* agarophyte were collected monthly from tropical waters of Okinawa, Japan. Majority of thr plants from the natural population were tetrasporic plants (43.82%) which could be explained by the enhanced survival of carpospore germlings; 32.04% of plants were female while the remaining 24.14% consisted of sterile plants. The mean wet weight of the terasporic, female and sterile plants was 4. 11, 3.42 and 3.25g, respectively. The mean thallus length in female plants was 12.87 cm which was higher than both of variation in two reproductive stages, tetrasporic plants (12.24 cm) and female plants (11.81 cm). Mean agar yield in one year periode was higher in female plants (35.00%) than sterile plants (32.33%) and tetrasporic plants (31.67%). High agar yield were found to coincide with high temperapure.

Key words: phenology, agar yield, *Gracilaria blodgetii,* tropical waters

INTRODUCTION

Members of the genus *Gracilaria* are distributed throughout temperate and tropical waters of the world. Nelson (1989) reported that the proportion of reproductive stages was dependent on season, and that the tetrasporic plants were dominant over female and male plant throughout the year.

Ager yiled and gell strength of several species of *Gracilaria* from the different geographical origins were reported (e.q. Philippine, Hurtado-Ponce and Umezaki, 1988; Micronesia and Taiwan, Nelson *et al,* 1983). *Gracilaria blodgetii* growns commonly in the tropical waters of southern Asia. The thalli of this species are characterized by having an altermate or irregular branching slightly constricted at the bases, terete with length less than 50 cm as described by Yamamoto (1978) for the Japanese material, and by Silva *et al* (1987) for the Philippines material. *G. blodgetii* is utilized for agar extraction Southern Asia.

This study was cunducted to determine the seasonal variation of the reproductive stages of *G. blodgetii* and to determine the optimal harvesting period from the natural population of this species for agar production

MATERIALS AND METHODS

Samples of *Gracilaria blodgetii* were taken monthly from February 1993 to January 1994 from the intertidal region of the coast of Kin Town, Okinawa Island. Water temperatures was measured by the digital thermometer (Horiba Co., Japan) while salinity was measured using a refractometer (Atago Co., Japan).

After filed collection each plant was cleaned free of sendiments by washing in running water. The collected materials were then examined for their reproductive status. The number of steril

plants, female plants (i.e. bearing cystocarp) and tetrasporic plants were determined. The length and weight of thalus were also measured. For agar extraction, the methods of Nelson *et al* (1983) was used. Three grams of dried *Gracilaria blodgetii* was washed with distilled water and then alkali treated with 3% NaOH for 24 hours. This is followed by boiling the samples in 300 ml distilled water at 60 °C for 1 hour and replacing water is required. The sample were then filtered through a cheese cloth under vacuum. The agar extracts were then cooled for 3 hours at room temperature and then frozen at -4 °C for 24 hours. The frozen agars were then thawed to remove the impurities and dried at 60 °C until constant weight was obtained. Three extractions was performed monthly for each reproductive stages.

RESULTS AND DISCUSSION

Observation on habitat and phenology of reproductive stages

Gracilaria blodgetii was collected in shallow water at low tidal zone from areas of flat sandy bottons, where it grows solitarily attached to fragments of coral or shell. The thalli were visible from the surface water at low tides.

Seawater temperature ranged from 19 °C in January to 34 °C in July while salinity ranged from 29 ‰ in February and March to 34 ‰ in July (Fig.1). *Gracilaria blodgetii* was absent from the collection site in July and August which corresponded to the increase in seawater temperature. During this period, the thalli began to bleach and gradually decayed apically and were easily fragmented by water movement. Jones (1959) assumed that bleaching of thalli which occurred during high temperature, was caused by loos of photolabile phycoerythrin. The sea water temperature might have some effect on their survival. Wang *et al.* (1984) suggested that *Gracilaria* could not survive at high temperatures in natural populations. In this study *G. blodgetii* failed to survive at temperatures higher than 36°C (Table 1) and agrees well with what have been previously observed by other researchers.

The ratio between tetrasporic and both of female and sterile plants showed seasonal changes (Fig. 2) The tetrasporic plants varied from 26.9% of the population in September to 53.6% in May. Famale plants range from 26.1% in May to 43.3% in September, while the sterile plants ranged from 19.3% in April to 32.2% in March.

Fig. 1. Seasonal changes in water temperature and salinity at the study area

Table 1. Temperatures tolerance of the *G. blodgetii* which were kept from 27°-39°C.

Plants	27°C	30°C	33°C	36°C	39°C
1	+	+	×	−	−
2	+	+	+	×	−
3	+	+	+	×	−
4	+	+	×	−	−
5	+	+	+	×	−

(+, healthy ; ×, bleached ; −, death)

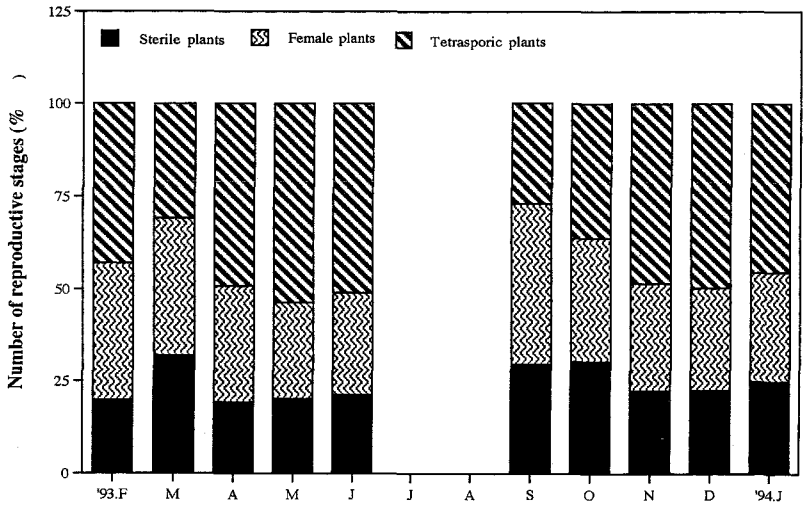

Fig. 2. Proportion in the reproductive stages of *G. blodgetii*

Tetrasporic plants become predominate in the population, except in March and September when the female plants were dominant. The percentage sexual ratio of plant over a year show that tetrasporic plants were higher value (43.8%) in the population. In Thailand, the tetrasporic plants were found in larger number than those of male and female plants (Chirapart *et al.* 1992). This phenomenom shown that carpospores were able to survive a wide range of salinity and temperature than tetraspores.

The ratio of tetrasporic plants to the combined female and steril plants was similar in April, May, June, November and December. High peaks of carposporic plants occured in March, September and October and coincided with the peaks of sterile plants among the three reproductive stages

Spore release of the reproductive materials of *G. blodgetii* which were kept at tempratures of 17, 20, 23, 26, and 29 °C is shown in Table 2. Female plants released much spores in temperature 23 °C and salinity 34 ‰, which survived for five weeks until young erect thalli appeared. However, spores from tetrasporic plants failed to germinate after release. This observation could be due to certain environmental factors, such as temperature and salinity, affecting spore development.

Table 2. Spore released from the reproductive stages of *G. blodgetii* at different temperature conditions from 17°-29°C.

Plants	17°C	20°C	23°C	26°C	29°C
Carposporic	−	−	+	+	−
Tetrasporic	−	−	+	−	−

(+, released; −, unreleased)

Seasonal variation of thallus length and wet weight

Seasonal variation in growth of *G. blodgetii* plants based on wet weight and thallus length is shown in Fig. 3. The wet weight and length of thalli from February to June, gradually decreased as temperature increased. Tetrasporic plants had minimum length of 9.6 cm in September and attained maximum length of 15.9 cm in February. Mean thallus length of female and sterile plants was 10.6 cm and 9.2 cm in September respectively, with a maximum length of 14.0 cm in March and 14.2 cm thallus length in January, respectively. The present study also found mean thallus length of female plants were higher than those tetrasporic plants and steril plants.

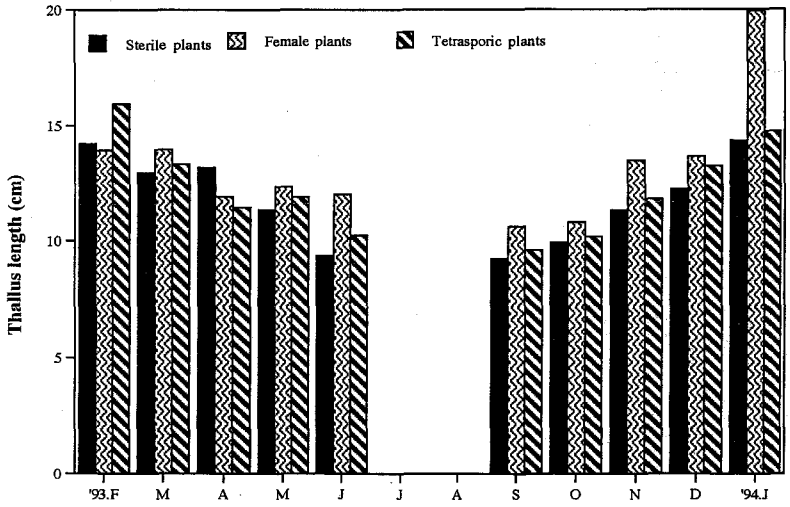

Fig. 3. Seasonal changes in the thallus length of *G. blodgetii*

Wet weight of tetrasporic plants was at minimum (1.0g) in September which gradually increased to maximum of (9.7g) in February. Famale plants were a minimum (1.3g) in September to maximum 6.2g in March. Sterile plants had minimum wet weight in September (1.1g) and maximum in February (6.7g). The mean wet weight of tetrasporic plants throughout the year was much greater than the female and sterile plants (Fig. 4). This observation indicate that high seawater temperature is an inhibiting factor for the growth of *G. blodgetii* since maximum wet weight and thallus length gradually decreased in spring (March to May) to summer (June) as temperatur increasd.

Agar yield

Agar extract from *G.blodgetii* shows monthly variations in yield (Fig. 5). Agar yield the tetrasporic plants ranged between 25.7% in January to 36.7% in March-April. Sterile plants varied in agar yield from a minimum of 26.7% in January to a maximum of 39.0% in March. Female

plants yielded agar greater than either the tetrasporic and sterile plants obtained in April (40.00%), May (42.3%), June (40.0%), September (36.6%), November (32.3%) and January (29.0%). Percentage agar yield throughout the year were was highest in female plants (35.0%) followed by terasporic plants (31.7%) and sterile plants (32.3% ; Fig. 5)

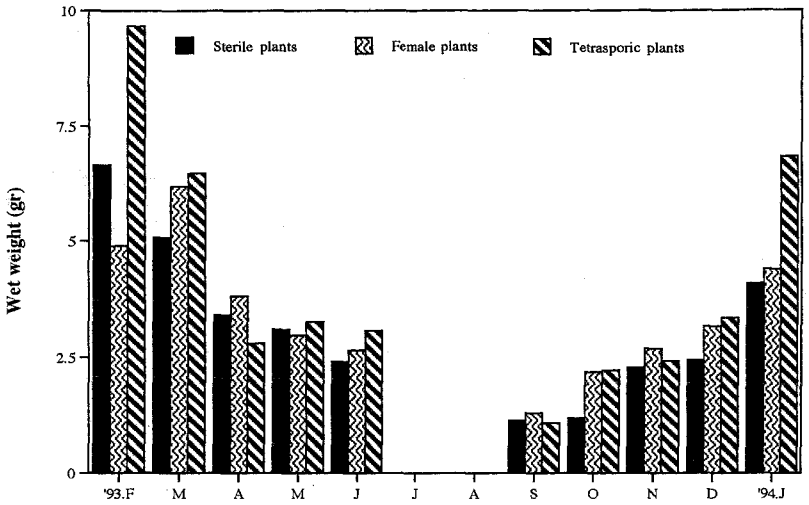

Fig. 4. Seasonal changes in the wet weight of *G. blodgetii*

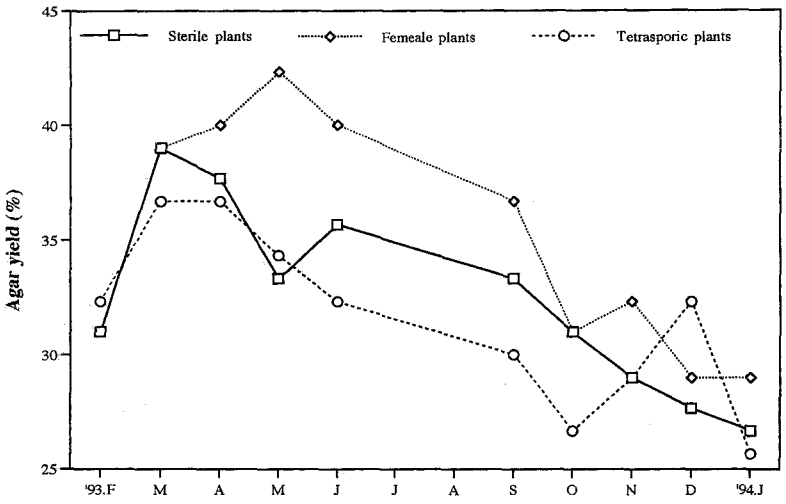

Fig. 5. Seasonal changes in the agar yield of *G. blodgetii*

This variations in agar yield could be explained by the reproductive stage where in female plants predominated throughout the year. It is evident that the seasonal fluctuation in agar yield of *Gracilaria biodgetii,* closely related to environmental factors and reproductive conditions.

Based on studies of environmental factors on agar yield, Dougherty and Bird (1988) and Friedlander and Lipkin (1982) found agar yield appeared to decrease when both of salinity and

temperature increased, and sugested that the location for cultivating this species is very important.

Based on the present study, the three reproductive stages seems to have similar patern in agar yield throughout the year in the relation to temperature. High agar yield were obtained in plants grown at increasing temperature and low yield when the temperature is gradually decreased as shown in female plants, suggesting temperature effect on agar yield. The present study agree with Hoyle's (1978) findings of high agar yield in summer and indicated seasonality in the from of low winter agar production, and tends to indicate a winter reduction in phycocolloid production.

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