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Seasonal variation in the biochemical constituents of *Gracilaria* spp. with reference to growth

Reeta Jayasankar
Central Marine Fisheries Research Institute, Cochin -682014, Kerala, India
and
G Kulandaivelu
School of Biological Sciences, Madurai Kamaraj University, Madurai -625021, Tamil Nadu, India

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The Biochemical constituents such as protein, carbohydrate and lipid of three different species of *Gracilaria* viz. *G.edulis*, *G.corticata* and *G.crassa* were analysed and compared with the growth of the plant in different months. Carbohydrate content showed significant positive correlation with the growth (g/m^2) of the plant but a reciprocal relationship was obtained with protein and lipid content in different species of *Gracilaria*. The relationship between the size and the biomass could be able to establish the recruitment pattern of the plants in different period in *G.edulis* and *G.corticata*. The carbohydrate content was found to be more in *G.edulis*, whereas the protein content was dominant in *G.corticata*.

The genus *Gracilaria* comprising more than 150 species is distributed throughout the world. The size of the genus suggests that there is considerable potential for exploitation of large number of these species. It is exploited as a source of phycolloids, agar, or may be consumed directly as a green vegetable or in the preparation of feed for the invertebrate . The biochemical constituents of these algae are very much essential to use such algae as the feed for invertebrates or human consumption. Many reports are available on the biochemical constituents of marine algae from different coasts of India [1-6]. The present work is aimed to study the seasonal variation in the biochemical constituents of marine red alga *Gracilaria* with reference to growth .

Considering the location specificity of seaweeds in their distribution, two centres namely Pudumadam and Thonithurai (9^0 16' N and 79^0 10'E) along the Tamil Nadu (south-east coast of India) were selected for the regular sampling of *Gracilaria corticata, Gracilaria edulis* and *Gracilaria crassa. Gracilaria corticata* grows abudantly at the intertidal area of Pudumadam having a rocky coast and sandy bottom. *Gracilaria edulis* and *G.crassa* are found mostly in Thonithurai where the coast is sparcely rocky and seabottom is muddy covered by seagrasses.

Gracilaria edulis, G.crassa and *G.corticata* were collected from September '93 to August '94 during low tide. Quadrat sampling was done by placing three quadrat of 0.5 cm^2 randomly in different areas. Samples were cleaned off epiphytes, epifauna, pebbles and other gastropod shells, washed several times in fresh water, blotted and weighed. Biomass was expressed in g fresh weight /m^2. The length of the plants were taken by a scale and the average length of 25 to 50 numbers was expressed in centimeter as the mean size of the plant of a particular observation.

The fresh samples were dried in the hot air oven at 90°C for 24 h. The plants were dried, powdered and sieved. Total protein was estimated by the method of Lowry *et al.*[7]. Absorbance was measured at 750 nm in Hitachi 557 spectrophotometer comparing with Bovine serum albumin as standard.Total carbohydrate was estimated by phenol sulfuric method[8]. Absorbance was taken at 490 nm using sucrose as standard. Total lipid was extracted by Folch method[9] and estimated by phosphovanillin method[10]. Absorbance was measured at 520 nm using cholesterol as standard.

Protein,carbohydrate and lipid content of three different species of *Gracilaria* were analysed and expressed in percentage (Fig.1). These biochemical constituents were compared among the species, in different seasons and correlated with the growth data. It was observed that the lipid content was least in all

the species of *Gracilaria*. As the seaweed is rich in polysaccarides, due to its high agar yielding characteristics, the carbohydrate content was dominant. Among the 3 species, *G.edulis* contains maximum carbohydrate and lipid quite comparable with the species of *G.crassa*, whereas protein content was more in *G.corticata* ranging from 4.16-9.94%.

Seasonal variation in the biomass of *G.edulis* (Fig.1.A) exhibited bimodal growth pattern showing the peak biomass in January and July and showed a gradual increase from the month of September to January and then declined till June. While comparing the length of the plants with the biomass, it was observed that the mean length of the plants were more in January and July,being 13.32 and 13.22 cm ,corresponding to the maximum biomass. Observations were made in this context explained that the plant having size 9.58 cm in October and 9.50 cm in May attained a similar size of 13.32 and 13.22 cm in January and August exactly after four months of growth but no significant correlation was established between these two plant characters.

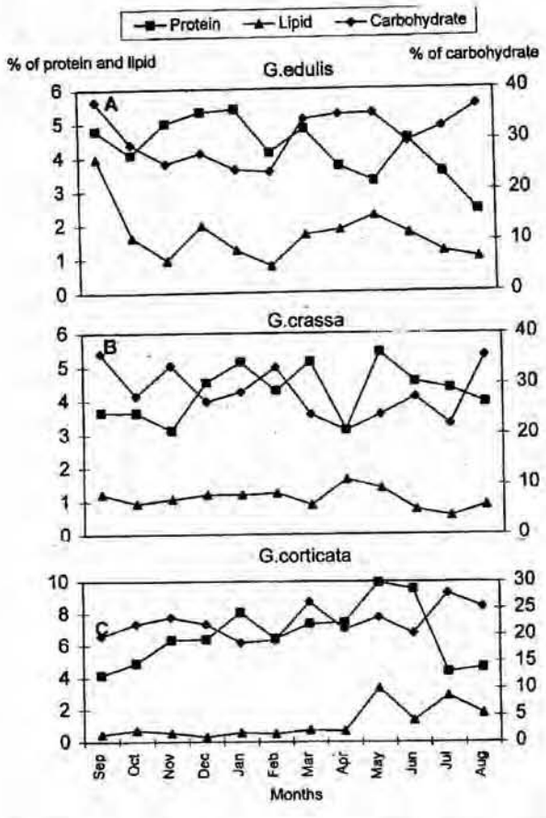

Fig. 1—Seasonal variation in carbohydrate, protein and lipid (expressed in percentage of dry weight) in different species of *Gracilaria*

The carbohydrate content of *G.edulis* showed a declining trend from September to November and then increased till January with a peak value of 48.4%. Further the carbohydrate content declined till April and then increased exhibiting similar trend like the biomass. Lipid also showed correlation with biomass (r = –0.395). The lipid content was found to be more in September and May ,being 3.97 and 2.26% respectively but it varied between 0.78 to 3.97% annually. The protein content of *G.edulis* showed minor variation throughout the year from 2.40 to 5.41%. The protein content showed a similar pattern like the biomass till April but no significant relationship was established between these two. The length of the plant showed a gradual increase till January and then declined till May. Further ,it showed an increasing pattern from June reaching a maximum length during August (13.22 cm). This observation explained the bimodal growth pattern but it may not be able to confirm the age of the plants.

The biomass of *G.crassa* declined from November to April and then increased till August (Fig. 1B). As the plant is very fragile, short and bulbous, it is very difficult to take the size of the plant.Seasonal variation in the carbohydrate content of *G.crassa* showed a significant positive correlation with the biomass per unit area (r= .0.717) , which gradually declined till May with an intermittant increase in February. The protein content did not show any significant change throughout the year which varied from 3.13 to 5.45%. It increased from September to May with an intermittant decline in April and February. Further it declined till August. The lipid content of *G.crassa* varied from 0.56 to 1.65 % annually showing a peak value in April.

In *G.corticata* (Fig.1C), the biomass per unit area declined gradually from September to January almost a reverse trend than of *G.edulis*. The biomass increased from February till April. While comparing the size of the plants with biomass it was observed that the mean size of the plant increased gradually from May to August. Maximum size was noticed in September (14.47 cm). Further it declined till February, corresponding to the pattern observed in the biomass per unit area exhibiting positive correlation (r=0.572). The carbohydrate content , which was found to be less in this specis showed an irregular pattern throughout the year ranging between 18.54 to 27.88%. In *G.corticata*, the protein content

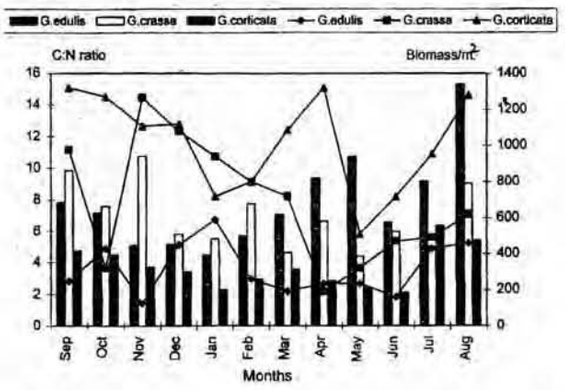

Fig. 2—Seasonal variation on the growth (biomass expressed as gram dry wt/ m^2) and C:N ratio of different species of *Gracilaria*

was found to be much higher than the other two species ranging between 4.16 to 9.94% annually. It increased from September to January and then declined till April. It exhibited a significant negative correlation with biomass (r = -0.730) and with the size of the plant (r= -0.829).

The protein and carbohydrate ratio (Fig.2) varied from 1:2 to 1: 16 in the three species of *Gracilaria*. The ratio was found to be very less in *G.corticata* ranging between 1:2 to 1:6. As observed from the data, the size of the plant was less from the month of February to June may be considered as the new recruitment of the plants and the active growth period corresponding to the less protein and carbohydrate ratio. The ratio increased as the growth rate reduced from July to October. In *G.edulis*, the ratio ranged between 1:5 to 1:15 defining the plant in rapid growth phase, slow growth phase and reproductive phase as explained by Dawes[11]. As observed in the month of November and December, the plants were in active stage of growth and reached to peak size in January showing the protein and carbohydrate ratio of 1:9. Further from April to June the ratio declined to certain extent and reached to maximum in August corresponding with the peak growth phase. In *G.crassa* there was no definite pattern in the protein and carbohydrate ratio but found to be less in the month of April and May corresponding to the new recruitment of plants and active growth phase.

From the above observations, it is clear that the biochemical constituents varied independantly of each other. The carbohydrate content showed a positive correlation with the biomass and the growth of all the species of *Gracilaria*, while the protein and the lipid content exhibited a negative trend with the growth. There was a general tendency for declining protein content in all the species of *Gracilaria* during summer in the month of April and May. This result is in agreement with Dawes[12].

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