ECOLOGICAL OBSERVATIONS ON SOME INTERTIDAL ALGAE OF MANDAPAM COAST*

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This paper deals with the observations made on zonation and seasonal changes of some intertidal algae growing on the Gulf of Mannar and Palk Bay sides near Mandapam. The vertical distribution of plants and important animals on the intertidal rocky surfaces are described and the zonation observed on Mandapam coast is in agreement with the universal scheme of Stephenson and Stephenson. Seasonal variations in the growth and abundance of *Enteromorpha compressa, Gracilaria corticata* and *Sargassum* spp. followed for a period of 30 months from August 1965 to January 1968, are given together with the changes observed in the tidal behaviour and other environmental conditions. From the results obtained in this study, the relationships between the variations in the periods of submergence and emergence caused by tides and the zonation and seasonal changes in the algal growth are indicated.

INTRODUCTION

Ecological studies on the intertidal algae of India and Mandapam area in particular are few and mainly concerned with the colonization of algae (Varma 1959) and a few other aspects on the flora of the coral-reef areas (Krishnamurthy 1965; Umamaheswara Rao 1969 *a*). The general features of zonation on the Mandapam coast and the seasonal changes observed in some common algae from August 1965 to January 1968 are presented here, together with an account on the environmental conditions.

AREA INVESTIGATED

Mandapam is situated (79° 8′ E, 9° 17′ N) on a narrow tongue of land projecting from the southern part of the east coast of India (Fig. 1). To the north of this peninsular extension is the Palk Bay and to the south the Gulf of Mannar. For studying the algal vegetation in detail, two stations situated one on the Gulf of Manner side and the other on the Palk Bay side, were selected. Boulders and platorms of compressed sandstones with rough and uneven surfaces occur at different levels from high water to low water at Station I. In Station II much of the intertidal area is sandy and patches of dead coral debris and coral heads occur at low water levels.

The near-shore environment in the two stations selected is influenced by the direction and force of the monsoonal winds, since the coastline is in the east-west

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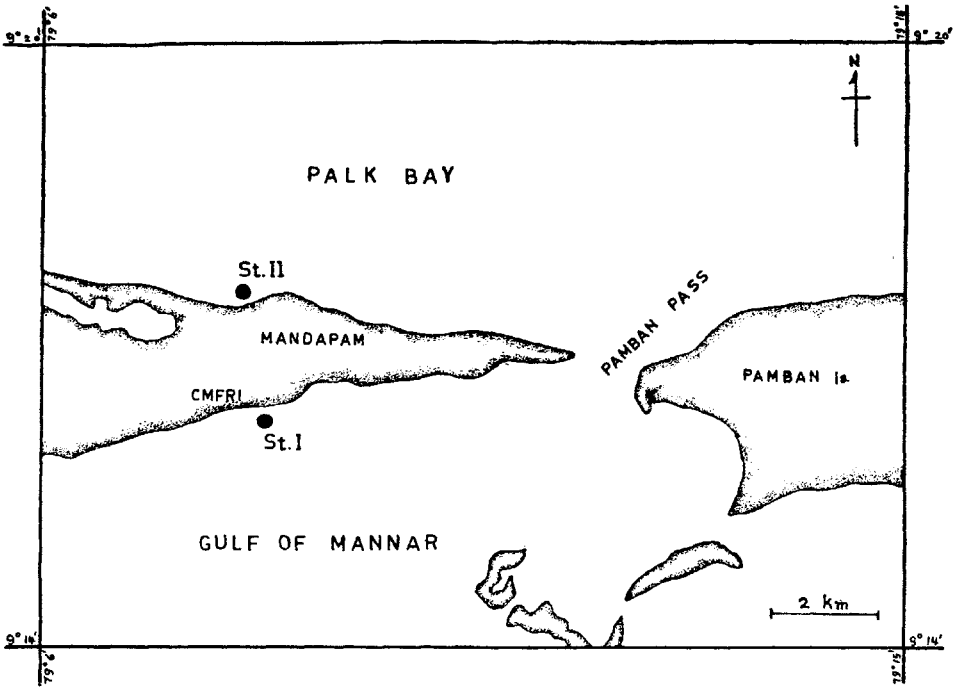

FIG. 1. Map of Mandapam area showing the position of the two stations selected on either side of the coastline.

direction (Fig. 1). During the south-west monsoon season (From May to August) the Gulf of Mannar side becomes rough with more wave action, whereas calm conditions occur on the Palk Bay side during the same period, with little wave action in the intertidal region. Exactly opposite conditions occur on either side of the coastline during the north-east monsoon season from September to February or March.

Slight seasonal changes in the sand levels on the shore were observed during the regular visits to the coast line and in Station I rocks were found to be uncovered for a short period from March to May and in Station II from November to January.

ENVIRONMENTAL CONDITIONS

To show the seasonal changes in the climatic conditions around Mandapam, data on the monthly averages of maximum and minimum temperatures, relative humidity, wind speed and monthly total of rainfall obtained for the period, from August 1965 to January 1968, from the daily weather reports published by the Meteorological Office, Poona, are plotted in Fig. 2*A*. Seasonal fluctuations in the surface temperature, salinity and other hydrographical conditions of the inshore waters of the Gulf of Mannar and Palk Bay near Mandapam were reported by Prasad (1954) and Jayaraman (1954).

Tides on the Mandapam coast are of irregular semi-daily or mixed type. The maximum tidal range in spring tides is about 1.0 m and during the neap-tides very

often slight changes occur in the water levels with a rise or fall of 2 to 5 cm (*see* Admirality chart No. 3581). Although from the field observations it can be said that the rise and fall of the tides on the Gulf of Mannar and Palk Bay sides is greatly affected by the force and direction of the winds, resulting in considerable changes in the duration of submergence and emergence at successive levels on the shore, details of these variations could not be given here, as the tide-gauge data are not available separately for the Gulf of Mannar and Palk Bay sides. In the present study the predicated data given in the Tide Tables for Pamban Pass (Fig. 1) are, therefore, used to calculate the hours of submergence at different levels on the shore. The seasonal variations in the hours of submergence calculated for 0.2 m, 0.4 m and 0.6 m levels on the shore (above the chart datum) from August 1965 to January 1968 are shown in Fig. 2*B*. The percentage of high and low tides reaching different levels on the shore and the yearly means for the hours of submergence per tide, estimated for 1966 and 1967, have also been plotted in Figs. 2 *C* and *D*, to examine the tidal features of Mandapam coast in some detail.

ZONATION

Information on the zonation or vertical distribution of the intertidal algae and some important zones indicating animals is given here based on the observations made in Station I and other places around Mandapam. The limits of the different zones and the organisms present were determined by the method of Evans (1947 *a*, *b*) and the nomenclature used in the present study is that of Stephenson and Stephenson (1949). Although the tidal range is small, three basic zones were seen in the distribution of the flora and fauna on the rocky surfaces of Mandapam coast, agreeing with the universal scheme of Stephenson and Stephenson (1949). The vertical distribution of plant and animal populations observed in the three zones is given below :

Supralittoral fringe—This is a bare rocky zone extending approximately from 0.65 or 0.70 m C. D. to extreme high-water level on the shore. Algae are totally absent and this zone can be recognised by the presence of *Littorina* sp.

Mid-littoral zone.—On the sandstones of this coast the mid-littoral zone is sparsely populated with plants and animals and the zone indicating barnacle, *Chthamalus,* is scattered here and there; the upper limit of the barnacle line is not well developed. Definite *Chthamalus* band was, however, seen on the concrete pillars of CMFRI jetty and other hard substrata present in Station I. The width of the mid-littoral zone is about 25–30 cm in areas protected from wave-action, roughly from 0.4 m to 0.65 or 0.70 m C.D. Algal growth is very poor in this zone. *Enteromorpha compressa* is the most common alga occupying the entire zone during the period of its maximum growth. *Chaetomorpha antennina, Ulva lactuca, Bachelotia antillarum* and *Brachytrichia quoyi* are the other algae found in this zone as small patches or scattered individuals.

Infralittoral fringe zone—This zone is distinguished by the presence of a large number of algae in the form of mixed algal turf. It extends roughly from 0.4 m to –0.1 m below the chart datum. *Sargassum* and *Gracilaria corticata* are the dominant constituents of this zone which appear as regular bands in certain areas along the

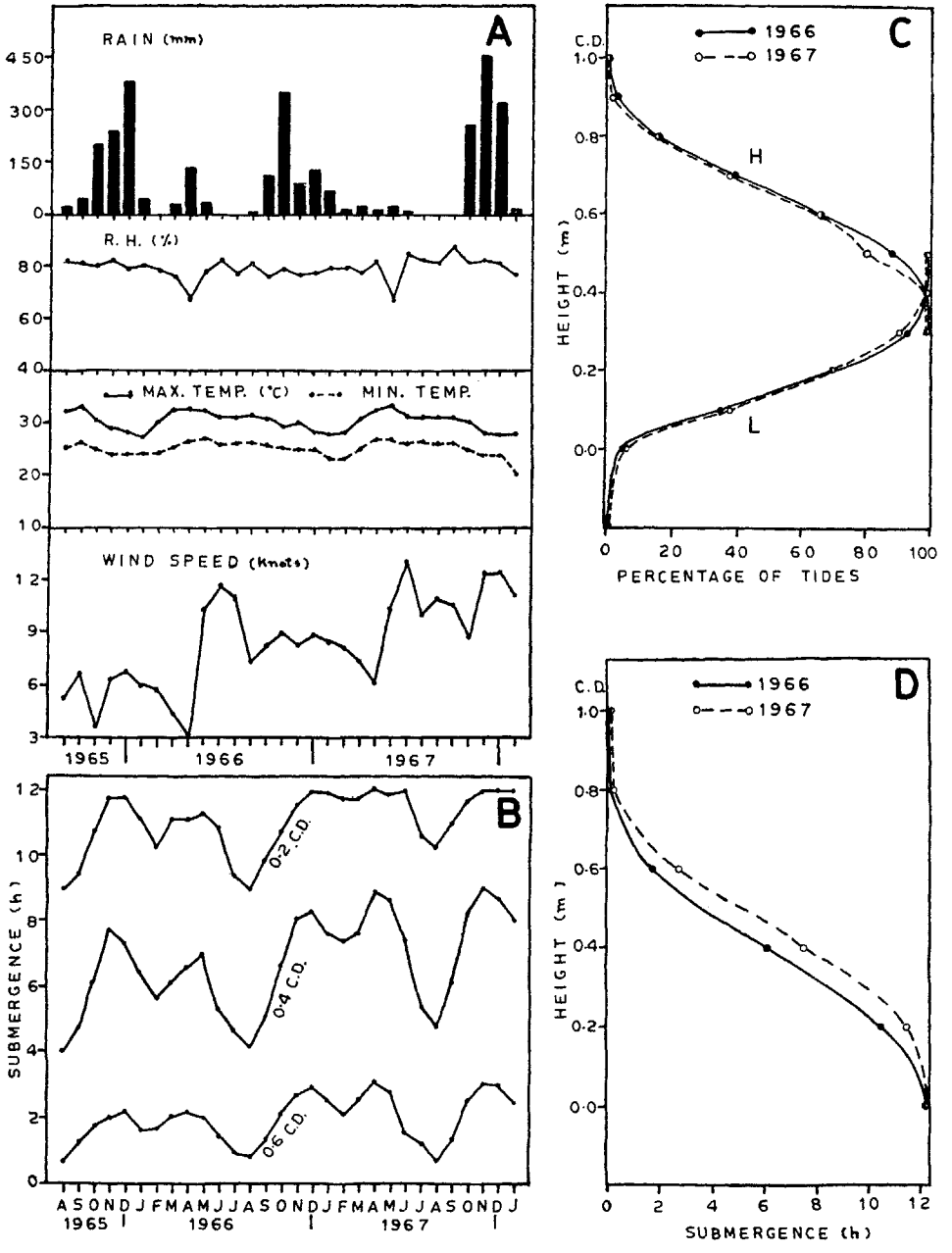

FIG. 2. Climatic conditions and tidal behaviour of Mandapam area. *A*, seasonal changes in the climatic conditions from August '65 to January '68 ; *B*, changes in the duration of submergence ; *C*, percentage of high (H) and low (L) tides reaching successive levels on the shore for 1966 and 1967 ; *D*, hours of submergence per tide for the years 1966 and 1967.

shore. Species of *Caulerpa, Padina, Hypnea, Centroceras clavulatum, Gracilaria crassa* and *G. foliifera* are the other common inhabitants of the infra- or sub-littoral fringe zone. As less common and rare forms *Cladophora* spp, *Valoniopsis pachynema, Valonia aegagropila, Boergesenia forbesii, Cladophoropsis zoolingeri, Penicillus sibogae, Dictyota* spp, *Stoechospermum marginatum, Acanthophora spicifera, Laurencia papillosa, Polysiphonia* spp, *Ceramium* spp., *Liagora* spp, *Gelidium pusillum, Gelidiopsis variabilis, Gelidiella acerosa, Spyridia filamentosa, Chondria* spp, *Grateloupia lithophila, Cheilosporum spectabile, Jania rubens, Amphiroa fragilissima, Gigartina acicularis, Gymnogongrus pygmaeus, Asparagopsis taxiformis, Champia* spp, and many others grow in the fringe zone.

Mid-littoral algae like *Enteromorpha compressa, Ulva lactuca,* and *Chaetomorpha antennina* were also seen in the infralittoral fringe zone of this coast and though a large number of algae of the fringe zone grow in the shallow sublittoral zone, plants like *Gracilaria corticata, Cheilosporum spectabile, Asparagopsis taxiformis* and *Gracilaria crassa* are largely confined to the infralittoral fringe zone.

Seasonal Changes in the Algal Growth

In order to collect information on the changes in growth and abundance of some representative algae growing on the Gulf of Mannar side (Station I) and the Palk Bay side (Station II), *Enteromorpha compressa* of the mid-littoral zone, *Gracilaria corticata* and *Sargassum* spp, of the infralittoral fringe zone were chosen. Quantitative data on the percentage basal cover or the mean height of the plants were obtained at monthly intervals by marking permanent quadrats or by measuring the height of the plants as was done by Umamaheswara Rao and Sreeramulu (1964) and Umamaheswara Rao (1969 *b*). Seasonal changes in the growth of the algae studied in the two stations are described below :

Station I (Gulf of Mannar side)—Results obtained on *E. compressa* and *G. corticata* from August 1965 to January 1968 are presented in Fig. 3 *A*. From the data it is evident that *E. compressa* occurs during most part of the year in Station I with its maximum growth between June and August. Another peak in the growth was obtained during November or December of each year, but the percentage basal cover between October 1966 and February 1967 was higher than that observed from October 1965 to February 1966. No secondary peak was noticed in the third year from October 1967 to January 1968 as the rocks with the marked quadrats were covered by sand during this period. The seasonal growth behaviour of *G. corticata* is more or less similar to that of *E. compressa* with its peak growth during the period from June to September and another small peak in November or December. Details of the data collected in the same station on the growth cycles of *Sargassum wightii* of the fringe zone and *Turbinaria conoides* growing just below the infralittoral fringe zone (Umamaheswara Rao 1969 *b*) indicate that in these two brown algae slow growth occurred between March and August and maximum growth only once in a year from October to December or January. Many other algae growing in this station exhibited similar patterns in their annual growth cycles with a well-developed growth either in the period from June to August or September or from October to December or January.

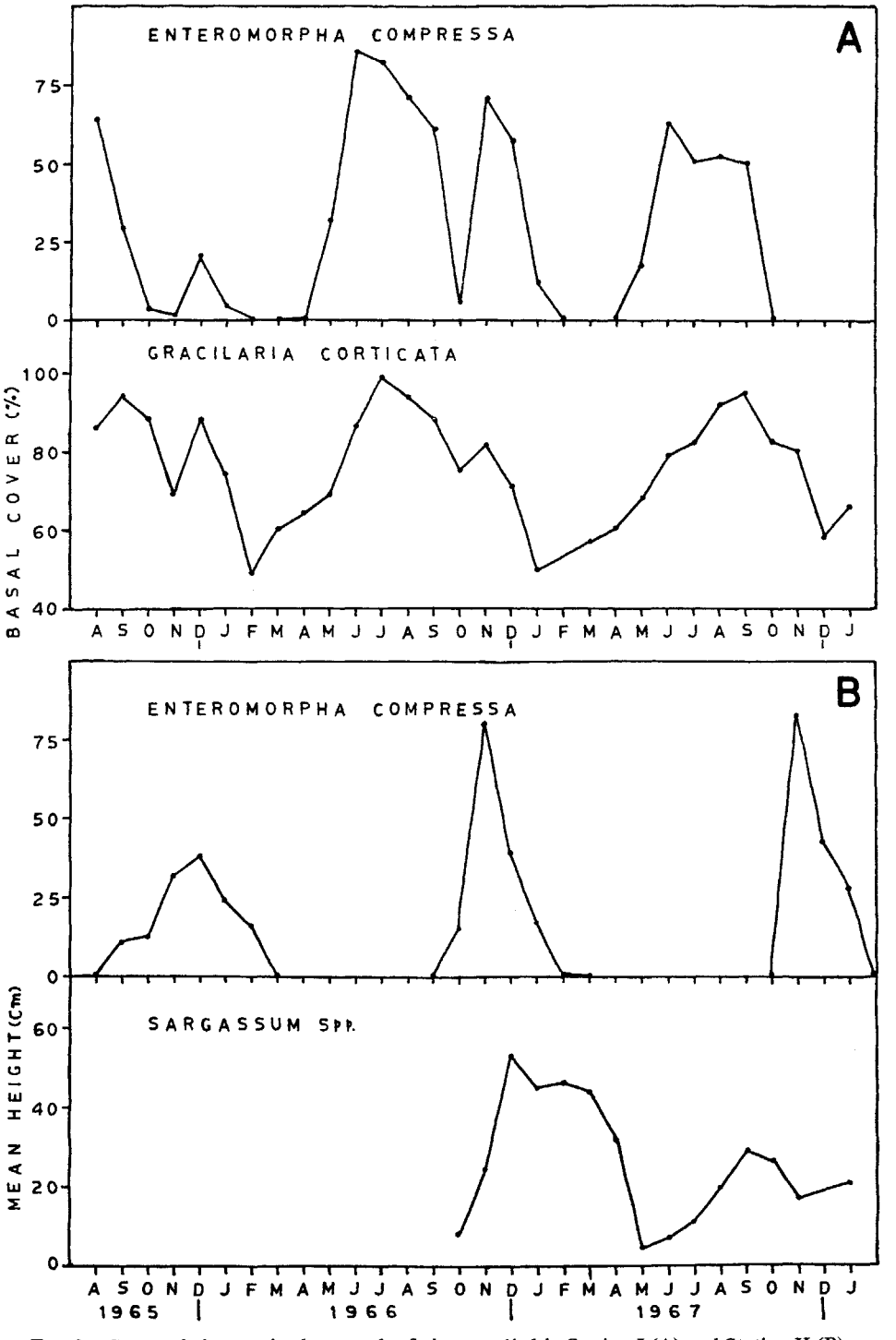

FIG. 3. Seasonal changes in the growth of algae studied in Station I (A) and Station II (B).

Station II (Palk Bay side)—Data collected on *E. compressa* from August 1965 to January 1968 are given in Fig. 3 *B*. As *G. corticata* is not available in this station for comparison, data collected on *Sargassum* spp from September 1966 to January 1968 are given in the same figure. As shown in Fig. 3 *B*, *E. compressa* occurred on the Palk Bay side for a period of only 5–6 months in the year, exhibiting its peak growth in November or December and the alga disappeared completely during the period from April to August. For *Sargassum* spp maximum growth was observed between December and March, showing a gradual rise in the mean height of the plants from May onwards (Fig. 3 *B*). From October 1967 to January 1968 sudden decline in the mean height was found as *Sargassum* vegetation in this station was destroyed by the turbulent environmental conditions caused by strong winds (Fig. 2 *A*). Data collected after January 1968 showed again an increase in the growth of this alga. Many other algae growing in Station II also showed their maximum growth only in one period from November to April and their gradual degeneration was observed from May to August.

Factors Influencing the Zonation and Seasonal Changes of the Algae

From the data on the environmental conditions given in Fig. 2, it may be mentioned that the air temperature and relative humidity are high at Mandapam and they do not vary markedly during most part of the year. Although Mandapam area is influenced by both the south-west and north-east monsoons, much of the rainfall occurs for a period of 3–4 months during the north-east monsoon season (Fig. 2 *A*). The wind speed is very high from May to July or August and from November to December. Coupled with the high temperatures and dry external conditions which cause desiccation and heating of the algae, the tidal exposure and submergence, wave-action, and other conditions of the intertidal environment are altered markedly by the monsoonal winds on either side of the Mandapam coast.

It may be seen from Fig. 2 *C* that on Mandapam coast 99 to 100 per cent of the high tides cover the shore up to 0.4 m C. D. throughout the year. Similarly, all low tides expose the intertidal region at the same point and the duration of submergence estimated at this level is 6–8 hr per tide (Fig. 2 *D*). The boundary between the infralittoral fringe and the mid-littoral zone was found near 0.4 m C. D., coinciding with the tide level where marked changes occur in the continuous emersion and submersion of the tides. But a well-defined zone that is daily covered and uncovered by high and low tides does not occur on Mandapam coast (Fig. 2 *C*). About 88 per cent of the high tides cover the shore up to 0.5 m C. D. and 65 per cent of the high tides cover up to 0.6 m C. D., where the hours of submergence are about 2.5 hrs per tide (Fig. 2 *D*). These significant changes in the duration of submergence above 0.4 C. D. and high air temperatures and dry conditions for most part of the year may be responsible for the narrow mid-littoral zone of 25–30 cm and for the very poor algal growth observed in this zone.

A perusal of the data (Figs. 2 *B* and 3) indicates that the seasonal variations in the tidal submergence and other physical conditions of the intertidal environment on the Gulf of Mannar and Palk Bay sides of Mandapam are responsible for the changes in the algal growth observed. The curves given in Fig. 2*B* show that at

different levels on the shore the period of submergence was high between March and May, and again in November-December. The lowest values for submergence were obtained during June to August and a slight fall occurred in January to February, and the duration varied from one year to the other (Fig. 2 *B*). In Station I, increase in the growth of *E. compressa* and *G. corticata* was observed from March or April, corresponding with increase in the duration of submergence during this period (Fig. 2 *B*). Maximum development of these two algae found between June and August or September may be due to rise in the water levels by the monsoonal winds (Fig. 2 *A*) and the rough conditions existing in the intertidal region during this period with heavy surf action. Another peak in the growth of *E. compressa* and *G. corticata* was observed during the calm season from November to December which coincides with the second peak in the duration of submergence in the year (Fig. 2 *B*). In *S. wightii* and *T. conoides*, studied in the same area (Umamaheswara Rao 1969 *b*), only one peak was recorded during the calm period of the year from October to December or January and the rate of growth in these algae was found to be at minimum during the rough period from March to August.

In Station II the highest development was observed for *E. compressa* in November and December, coinciding with the second seasonal peak in the duration of submergence at different levels on the shore (Fig. 2 *B*). *Sargassum* spp which grow at a lower level than *E. compressa* also showed maximum growth during the same period. But fully grown plants were seen till March in the year 1966 when comparatively calm conditions prevailed with a low wind spead of 7–8 knots and they were destroyed in November-December of 1967 when turbulent conditions occurred in the area with windspeeds higher than 12.0 knots (Fig. 2 *A*). Complete absence of *E. compressa* and degeneration of many algae on the Palk Bay side between May and August may be due to changes in the water levels caused by the south-west monsoon winds blowing from the opposite direction and marked reduction in the hours of submergence during this part of the year (Fig. 2 *B*).

Discussion

Interesting features of the Mandapam coast are the paucity of algal vegetation in the upper parts of the intertidal region and the differences observed in the nearshore environment of the Gulf of Mannar and Palk Bay sides during the south-west and north-east monsoon seasons of the year. From the observations reported in this paper it is clear that the majority of the algae grow in the infralittoral fringe zone. Due to irregular and narrow range of tides a small midlittoral zone was found on the intertidal rocky surfaces and the zones indicating *Chthamalus* and algae are poorly developed in this zone. The soft nature of the substratum may also be responsible for the ill-developed barnacle band on Mandapam coast, since sandstones were found to be less suitable for the colonization of barnacles (Lewis 1964). In spite of these variations in the tides and nature of the substratum, the vertical distribution or zonation of the algae and animals agrees with the universal scheme of classification proposed by Stephenson and Stephenson (1949).

Zonation of the intertidal algae has been studied in detail at Visakhapatnam (Umamaheswara Rao and Sreeramulu 1964) using Stephenson's classification and a comparison of the observations reveals that despite the variations seen in the number,

density and vertical extent of the algae occurring in the mid-littoral zone of Visakhapatnam and Mandapam coasts, the distribution of the dominant and stable algae of the infralittoral fringe zone such as *G. corticata* and *Sargassum* is similar in these two places with their upper limit near 0.4 C.D. Since the area between 0.4 m to 1.2 m C.D. is daily covered and uncovered by high and low tides on Visakhapatnam coast, *E. compressa, Chaetomorpha antennina, Ulva* and other algae of the mid-littoral zone occurred as regular bands. In the absence of a definite zone that is daily covered and exposed by tides on the Mandapam coast (Fig. 2 *C*), these algae were observed as small patches or rare plants and certain mid-littoral species were seen in the infralittoral fringe zone of Mandapam coast. These differences in the distribution of the algae in relation to changes in the tidal exposure and submergence of Mandapam and Visakhapatnam coasts clearly indicate the importance of the tide factor on the zonation of the intertidal algae.

Observations made on the seasonal growth behaviour of *Enteromorpha, Gracilaria, Sargassum* and other algae have shown that in the intertidal region of Mandapam coast many algae attain their maximum growth in two periods, one from June to August or September and the other from October to December or January, following the seasonal rise and fall of the sea level. These two periods correspond well with the maximum growth periods reported by Umamaheswara Rao and Sreeramulu (1964) on Visakhapatnam coast. Variations observed in the environment and the growth cycles of *E. compressa* growing on both sides of the Mandapam coast and in *Sargassum* spp also suggest that the local changes in the duration of tidal submergence and emergence, rough and calm conditions of the sea and other physical factors of the marine environment modify the growth behaviour of the algae, particularly those that grow and establish rapidly in the intertidal region. The seasonal changes in the algae observed in this study in relation to the variations in the exposure and submergence and other factors further confirm that the seasonal tidal behaviour and other changes in the physical conditions of the marine environment brought about by the monsoons are responsible for the fluctuations in the growth and abundance of the intertidal algae as suggested by Umamaheswara Rao and Sreeramulu (1964) from their Visakhapatnam data.

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