

## STUDIES ON THE SUCCESSION OF MARINE ALGÆ ON A FRESH SUBSTRATUM IN PALK BAY

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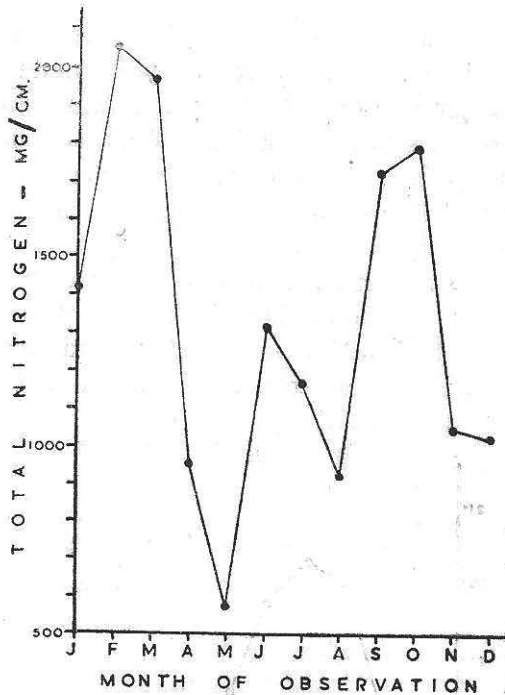
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DESPITE the numerous investigations on the ecology of marine plants, the subject has not advanced as much as the ecology of terrestrial plants, because, unlike the study of land vegetation, field experiments are more difficult in marine environments. In this connection, the studies of Gail (1918, 1922), of Hatton (1938) and of Rees (1940) indicate the possibility and essentiality of such experimental studies.

Contributions on the ecology of Indian marine algæ are limited to a few papers. Iyengar (1927) published a brief account on the algæ of Krusadai Island. Boergesen (1930, 1931, 1932 *a*, 1932 *b*, 1933 *a*, 1933 *b*, 1934, 1937 *a*, 1937 *b* and 1938) gave some notes on the ecology of the more important species in his papers on the taxonomy of the marine algæ of the Sub-Continent, while, Srinivasan (1946) and Krishnamurthy (1954) dealt with certain aspects of marine algal ecology with reference to Mahabalipuram and the estuary of the Adyar River respectively. From the neighbourhood of India, we have the studies of Svedelius (1906 *a* and 1906 *b*) on the vegetation of a coral reef of Ceylon and on the ecology and systematics of Ceylon species of *Caulerpa* as well as the publications by Anand (1940 and 1943) which include ecological accounts on the algal flora of the Karachi coast.

The present work, carried out over a period of 18 months, is on the growth and succession of marine algæ on a fresh substratum in the inter-tidal zone in Palk Bay. The place chosen for the study is at a distance of 76.2 metres from the mean shore line. The mean water level at low tide is 1.37 metres; while at high tide it is 1.82 metres. The substratum is mostly sandy; about 10 metres from the experimental spot toward the shore, the substratum has a dominance of corals, mostly dead ones; toward the left of the spot the shore is sandy clay. But for a small channel about 400 metres from the mean shore line, the Bay experimental area is more or less uniformly shallow (Text-Fig. 1).



EXT-FIG. 3. Monthly variations in the total organic nitrogen content of sea-water in Palk Bay

#### ALGAE CONCERNED IN THE COLONIZATION

##### (A) Chlorophyta

1. *Ulya reticulata* Forsskål
2. *Cladophora* sp.
3. *Chaetomorpha media* (Agardh) Kützing
4. *Caulerpa peltata* (Turner) Lamouroux
5. *Caulerpa racemosa* (Forsskål) J. Agardh
6. *Caulerpa taxifolia* (Vahl) C. Agardh
7. *Acetabularia mæbii* Solms-Laubach
8. *Neomeris annulata* Dickie
9. *Bergesenia forbesii* Harvey

##### (B) Chrysophyta

10. *Licmophora abbreviata* Agardh
11. *Chimacosphaenia elongata* Bailey
12. *Cocconeis* sp.
13. *Navicula* spp.
14. *Nitzschia closterium* (Ehrenberg) W. Smith

(C) *Phaeophyta*

15. *Sphacelaria tribuloides* Meneghini
16. *Dictyota bartayresiana* Lamouroux
17. *Dictyota maxima* Zanardini
18. *Padina gymnospora* (Kützing) Vickers
19. *Sargassum myriocystum* J. Agardh

(D) *Rhodophyta*

20. *Liagora farinosa* Lamouroux
21. *Gelidium micropterum* Kützing
22. *Amphiroa fragilissima* (Linnaeus) Lamouroux
23. *Jania rubens* (Linnaeus) Lamouroux
24. *Lithophyllum* sp.
25. *Hypnea esperi* Bory
26. *Hypnea valentiae* (Turner) Montagne
27. *Gracilaria lichenoides* (Linnaeus) Harvey
28. *Champia globulifera* Boergesen
29. *Champia parvula* (Agardh) Harvey
30. *Chondrococcus hornemanni* (Mertens) Schmitz
31. *Ceramium transversale* Collins et Harvey
32. *Spyridia fusiformis* Boergesen
33. *Roschera glomerulata* (Agardh) Weber van Bosse
34. *Acanthophora spicifera* (Vahl) Boergesen
35. *Laurencia obtusa* (Hudson) Lamouroux
36. *Laurencia papillosa* (Forsskål) Greville
37. *Leveillea jungermannioides* (Martens et Hering) Harvey

(E) *Cyanophyta*

38. *Lyngbya majuscula* Harvey
39. *Symploca hydroides* Kützing

PHASES OF COLONIZATION

(a) *Pioneer Communities*

It is well known that the nature of the pioneer community on a fresh substratum depends on the season of the year. In the present studies, the first colonizers on the substratum were observed after a period of 20 days from the date of starting the experiment, when, on the coral surface were seen 14 plants of *Chatomorpha media*, about 1.5 cm., in height, along with a fine uniform spread of *Padina gymnospora* attaining a height of 5-10 mm. There were a few *Lyngbya majuscula* growing in between the *Chatomorpha*

*media* plants. On the concrete vertical faces, toward the upper regions, *Padina gymnospora* sporelings of the same growth size as on the coral surface were seen, except on face 3 where there was poor colonization by it. There was no algal growth on the palmyra beams.

(b) *Succession*

(i) *Coral surface*.—On the coral surface, it was observed that the spread of *Padina gymnospora* was very fast and by the end of March, they almost replaced all the *Chatomorpha media* which by then had attained a height of 5 cm. *Padina gymnospora* was seen all year round, but it was more dominant and luxuriant during the period February to April (Plate IV, Figs. 2 and 3). By the beginning of June, most of the plants were either eaten off by grazing animals or torn off their holdfasts. A second crop of *Padina gymnospora* was seen coming to prominence by the end of November, attaining a moderate sized population in December. This second crop was only of a short duration; by the middle of January most of the plants were washed off their hold. The cycle was again repeated by the end of February.

Early in March a fine growth of *Acetabularia mæbii* appeared on the coral surface, but before the plants could attain full growth they were eaten by nudibranchs which appeared during this season. A fresh crop again appeared by the middle of April, which was also eaten off by nudibranchs. By the end of May, all the plants of this species disappeared. *Neomeris annulata* formed a poor growth on the coral surface and it also had a short duration like *Acetabularia mæbii*.

By the beginning of April, a very complex community of green, brown and red algæ appeared on the coral surface, which persisted during May, June and even up to the middle of July, although there was always a tendency for *Padina gymnospora* to inhibit the growth of other algæ, particularly the greens, and even to replace them. In this competition, a very unsteady balance was attained among *Padina gymnospora*, *Sphacelaria tribuloides*, *Laurencia papillosa*, *Amphiroa fragilissima* and *Jania rubens*. By June, *Padina gymnospora* became few in number, and the other forms had almost started dwindling in population except *Laurencia papillosa*, which, though not very successful in the beginning in establishing itself along with the other algæ, was seen to have greater capacity to withstand the changing season; and it actually became luxuriant only when the other species became rare. From the close of September to the end of January, the boulder was mostly denuded except for a few forms; but during this period the coral surface was completely covered with *Lyngbya majuscula* harbouring a dense population of diatoms, particularly *Nitzschia closterium* and species of *Navicula*.

Table I shows the different species of algæ colonizing the coral surface of the boulder.

(ii) *Concrete faces*.—On the concrete faces, the colonization of the algæ was maximum on faces 2 and 4; lesser on face 3 and minimum on face 1. The seasonal fluctuation of the flora on the concrete faces was similar to that on the coral surface; but here, a greater number of species were represented. Remarkable among the forms observed on the concrete faces, as against the coral surface, were the members of Chlorophyta, particularly the species of *Caulerpa* and *Bærgesenia forbesii*. Unlike on the coral surface, *Acetabularia mæbii* were fewer on the concrete faces; but many of these plants on the concrete faces were spared by the nudibranchs. *Neomeris annulata* showed better growth at greater depth. Those plants found toward the top of the boulder on the concrete faces were almost half the size of the ones found toward the base of the concrete faces, indicating, probably, lesser preference to light. The other forms, *Dictyota bartayresiana*, *D. maxima*, *Sargassum myriocystum*, *Hypnea valentia*, *Gracilaria lichenoides*, *Ceramium transversale* and *Laurencia obtusa*, although present on the concrete surface, were either a few or rare and of very short duration. Thus from a comparison of the species on the coral and the concrete surfaces, it would appear that the two kinds of surfaces do not present any vastly varying factors as far as the growth of marine algæ that inhabit calcareous substrates is concerned and that substratum selectivity does not come into question. Table II shows the different species of algæ colonizing the concrete faces of the boulder.

(iii) *Palmyra beams*.—The flora on the palmyra beams was rather poor, represented mostly by greens and blue-greens. Further, it was very surprising, that among the greens, while *Caulerpa peltata* grew abundantly on the beams, the other two species of *Caulerpa* were very poorly represented on them. In the case of blue-greens, *Lyngbya majuscula* found in abundance on the beams during March had only a short duration, and it again came into prominence during December and January, a few plants having been seen in the month of October and November. *Symploca hydroides* was found in abundance early in April, and the plants continued their hold till late July; though, by the last week of May, the plants got reduced in population. During the month of March, when the blue-greens were in luxuriance on the beams, they harboured a very dense growth of *Climacosphænia elongata* and *Licmophora abbreviata*, and these diatoms were also found attached to *Hypnea valentia* growing on the beams. Table III shows the different species of algæ colonizing the palmyra beams.



<i>Padina gymnospora</i>	..	..	F	A	D	A	M	F	F	R	R	R	R	M
<i>Sargassum myriocystum</i>	..	..	..	..	..	..	..	..	..	..	..	..	..	..
<i>Liagora farinosa</i>	..	..	..	..	..	..	..	..	..	R	..	..	..	..
<i>Gelidium micropterum</i>	..	..	..	..	..	..	..	..	R	..	..	..	..	..
<i>Amphiroa fragilissima</i>	..	..	..	..	..	A	D	M	M	R	R	..	..	..
<i>Jania rubens</i>	..	..	..	..	..	A	D	M	M	R	..	..	..	..
<i>Lithophyllum</i> sp.	..	..	..	R	R	R	R	..	..	..	..	..	..	..
<i>Hypnea esperi</i>	..	..	..	..	..	F	..	M	..	..	..	R	..	..
<i>Hypnea valentiae</i>	..	..	..	..	..	..	..	..	..	..	..	..	..	..
<i>Gracilaria lichenoides</i>	..	..	..	..	..	..	..	..	..	..	..	..	..	..
<i>Champia globulifera</i>	..	..	..	..	..	M	M	R	..	..	..	..	..	..
<i>Champia parvula</i>	..	..	..	..	..	..	..	M	R	R	R	..	..	..
<i>Chondrococcus hornemanni</i>	..	..	..	..	..	..	..	..	..	..	R	..	..	..
<i>Ceramium transversale</i>	..	..	..	..	..	..	..	..	..	..	..	..	..	..
<i>Spyridia fusiformis</i>	..	..	..	..	..	..	..	..	..	R	..	..	..	..
<i>Roschera glomerulata</i>	..	..	..	..	..	..	..	..	..	..	F	F	R	..
<i>Acanthophora spicifera</i>	..	..	..	..	F	..	..	..	..	R	..	..	..	..
<i>Laurencia obtusa</i>	..	..	..	..	..	..	..	..	..	..	..	..	..	..
<i>Laurencia papillosa</i>	..	..	..	F	V	F	F	R	M	A	A	M	R	R
<i>Leveillea jungermannioides</i>	..	..	..	..	..	..	..	F	..	..	..	..	..	..
<i>Lyngbya majuscula</i>	..	..	..	D	F	R	..	M	..	..	..	..	M	V
<i>Symploca hydroides</i>	..	..	..	..	..	..	..	..	..	..	..	..	..	..

D = Dominant; V = Very abundant; A = Abundant; M = Moderate; F = Few; R = Rare (less than 5 plants).

TABLE.

Showing the different species of algae colonizing the concrete faces of the boulder

Algae taking part in the colonization	Month of occurrence											
	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
<i>Ulva reticulata</i>	..	..	..	F	R	..	..	..	..	..	..	..
<i>Cladophora</i> sp.	..	..	..	F	M	..	..	..	F	..	..	..
<i>Chaetomorpha media</i>	..	..	..	R	..	..	..	..	F	..	..	..
<i>Caulerpa peltata</i>	..	..	..	A	F	A	A	R	..	..	..	..
<i>Caulerpa racemosa</i>	..	..	..	F	M	..	..	..	..	..	..	..
<i>Caulerpa taxifolia</i>	..	..	..	F	..	..	..	..	..	..	..	..
<i>Acetabularia mæbii</i>	..	..	..	F	F	R	..	..	..	..	..	..
<i>Neomeris annulata</i>	..	..	..	M	M	F	..	..	..	..	..	..
<i>Bergesenia forbesii</i>	..	..	..	F	F	F	..	..	..	..	..	..
<i>Liemophora abbreviata</i>	..	..	..	A	A	..	..	..	..	..	..	..
<i>Climacosphania elongata</i>	..	..	..	A	A	..	..	..	..	..	..	..
<i>Cocconeis</i> sp.	..	..	..	..	..	..	..	..	..	..	..	..
<i>Navicula</i> spp.	..	..	..	..	..	..	..	..	..	..	..	..
<i>Nitzschia closterium</i>	..	..	..	M	..	..	..	..	..	..	..	..
<i>Sphacelaria tribuloides</i>	..	..	..	R	M	M	M	R	..	..	..	..
<i>Dictyota bartayresiana</i>	..	..	F	R	..	M	..	..	..	..	..	..
<i>Dictyota maxima</i>	..	..	..	..	..	R	R	..	..	..	..	..

<i>Padina gymnospora</i> ..	..	..	F	A	A	A	M	F	F	R	R	R	R	R
<i>Sargassum myriocystum</i>	..	..	..	..	..	..	..	..	R	R	R	..	..	..
<i>Liagora farinosa</i> ..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
<i>Gelidium micropterum</i>	..	..	..	..	..	..	..	..	..	..	..	..	..	..
<i>Amphiroa fragilissima</i>	..	..	..	..	..	A	V	M	..	..	..	..	..	..
<i>Jania rubens</i> ..	..	..	..	..	..	A	V	M	..	..	..	..	..	..
<i>Lithophyllum</i> sp.	..	..	..	..	..	..	..	..	..	..	..	..	..	..
<i>Hypnea esperi</i> ..	..	..	..	F	F	..	F	..	..	..	..	..	..	..
<i>Hypnea valentia</i> ..	..	..	..	F	F	..	F	..	R	..	..	..	..	..
<i>Gracilaria lichenoides</i> ..	..	..	..	..	..	..	R	R	R	..	..	R	..	..
<i>Champia globulifera</i> ..	..	..	..	..	F	F	R	..	..	..	..	..	..	..
<i>Champia parvula</i> ..	..	..	..	..	..	..	M	M	R	M	..	..	..	..
<i>Chondrococcus hornemanni</i>	..	..	..	..	..	..	..	..	..	R	..	..	..	..
<i>Ceramium transversale</i>	..	..	..	..	..	..	..	..	..	R	R	..	..	..
<i>Spyridia fusiformis</i> ..	..	..	..	..	..	..	F	..	F	..	..	..	..	..
<i>Roschera glomerulata</i>	..	..	..	..	..	..	..	..	..	F	F	R	..	..
<i>Acanthophora spicifera</i>	..	..	..	A	..	..	..	..	R	..	..	..	..	..
<i>Laurencia obtusa</i> ..	..	..	..	..	..	..	..	R	R	..	..	..	..	..
<i>Laurencia papillosa</i> ..	..	..	..	..	F	F	M	M	R	R	..	..	..	..
<i>Leveillea jungermannioides</i>	..	..	..	..	..	..	F	..	..	..	..	..	..	..
<i>Lyngbya majuscula</i> ..	..	..	V	F	..	..	A	..	..	..	..	M	V	V
<i>Symploca hydnoides</i> ..	..	..	..	..	..	..	..	..	..	..	..	..	..	..

D = Dominant; V = Very abundant; A = Abundant; M = Moderate; F = Few; R = Rare (less than 5 plants).

TABLE III

Showing the different species of algæ colonizing the palmyra beams

Algæ taking part in the colonization	Month of occurrence											
	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
<i>Ulva reticulata</i> .. ..	..	..	..	..	..	..	..	..	..	..	..	..
<i>Cladophora</i> sp. .. ..	..	..	..	..	F	..	..	..	..	..	..	..
<i>Chaetomorpha media</i> .. ..	..	..	..	..	..	..	..	..	F	..	..	..
<i>Caulerpa peltata</i> .. ..	..	..	..	V	F	A	A	F	..	..	..	..
<i>Caulerpa racemosa</i> .. ..	..	..	..	F	F	..	..	..	..	..	..	..
<i>Caulerpa taxifolia</i> .. ..	..	..	..	F	F	..	..	..	..	..	..	..
<i>Acetabularia mæbii</i> .. ..	..	..	..	..	..	..	..	..	..	..	..	..
<i>Neomeris annulata</i> .. ..	..	..	..	..	..	..	..	..	..	..	..	..
<i>Bergesenia forbesii</i> .. ..	..	..	..	..	..	..	..	..	..	..	..	..
<i>Licmophora abbreviata</i> .. ..	..	..	..	..	..	..	..	..	..	..	..	..
<i>Climacosphania elongata</i> .. ..	..	..	..	..	..	A	..	..	..	..	..	..
<i>Cocconeis</i> sp. .. ..	..	..	..	..	..	A	..	..	..	..	..	F
<i>Navicula</i> spp. .. ..	..	..	..	..	..	..	..	..	..	..	..	F
<i>Nitzschia closterium</i> .. ..	..	..	..	..	..	..	..	..	..	..	..	..
<i>Sphaecelaria tribuloides</i> .. ..	..	..	..	..	..	..	..	..	..	..	..	..
<i>Dictyota bartayresiana</i> .. ..	..	..	..	..	..	..	..	..	..	..	..	..
<i>Dictyota maxima</i> .. ..	..	..	..	..	..	F	..	..	..	..	..	..

<i>Padina gymnospora</i>	..	..	..	..	..	..	..	..	..	..	..	..	..	..
<i>Sargassum myriocystum</i>	..	..	..	..	..	..	..	..	..	..	..	..	..	..
<i>Liagora farinosa</i>	..	..	..	..	..	..	..	..	..	..	..	..	..	..
<i>Golidium micropterum</i>	..	..	..	..	..	..	..	..	..	..	..	..	..	..
<i>Amphiroa fragilissima</i>	..	..	..	..	..	..	..	..	..	..	..	..	..	..
<i>Jania rubens</i>	..	..	..	..	..	..	..	..	..	..	..	..	..	..
<i>Lithophyllum</i> sp.	..	..	..	..	..	..	..	..	..	..	..	..	..	..
<i>Hypnea esperi</i>	..	..	..	..	..	..	..	..	..	..	..	..	..	..
<i>Hypnea valentiae</i>	..	..	..	..	..	..	F	..	..	..	..	..	..	..
<i>Gracilaria lichenoides</i>	..	..	..	..	..	..	..	..	..	..	..	..	..	..
<i>Champia globulifera</i>	..	..	..	..	..	..	..	..	..	..	..	..	..	..
<i>Champia parvula</i>	..	..	..	..	..	..	..	..	..	..	..	..	..	..
<i>Chondrococcus hornemanni</i>	..	..	..	..	..	..	..	..	..	..	..	..	..	..
<i>Ceramium transversale</i>	..	..	..	..	..	..	..	..	..	..	..	..	..	..
<i>Spyridia fusiformis</i>	..	..	..	..	..	..	..	..	..	..	..	..	..	..
<i>Roschera glomerulata</i>	..	..	..	..	..	..	..	..	..	..	..	..	..	..
<i>Acanthophora spicifera</i>	..	..	..	..	..	..	..	..	..	..	..	..	..	..
<i>Laurencia obtusa</i>	..	..	..	..	..	..	..	..	..	..	..	..	..	..
<i>Laurencia papillosa</i>	..	..	..	..	F	F	M	R	..	..	..	..	..	..
<i>Leveillea jungermanniioides</i>	..	..	..	..	..	..	..	..	..	..	..	..	..	..
<i>Lyngbya majuscula</i>	..	..	A	..	..	..	A	..	..	..	..	F	F	M
<i>Symploca hydroides</i>	..	..	..	..	..	A	V	F	F	..	..	..	..	..

D = Dominant; V = Very abundant; A = Abundant; M = Moderate; F = Few; R = Rare (less than 5 plants).

## BIOTIC FACTORS

During the above studies, the boulder was found to be harbouring gastropods, nudibranchs, crabs, hydroid colonies and sponges. The hydroid colonies and sponges were found to be abundant on the palmyra beams and in fact they were the pioneer colonizers, the algæ having appeared much later. Gastropods were found all through the season; while nudibranchs were only of a short duration when there was a good growth of green algæ on the coral surface, particularly *Acetabularia mæbii*. Crabs were very often present in large numbers when *Padina gymnospora* plants were in full growth. Most of these organisms were hand-picked and removed from the boulder and palmyra beams during periodic inspections of the boulder.

## GROWTH RATE

Among the algæ found common on the coral and the concrete surfaces, the ones on the latter had more luxuriant growth except *Amphiroa fragilissima* and *Jania rubens* which were more abundant and luxuriant on the coral surface. Further, in general, the early growth of all the forms was more marked on the coral face than on the concrete faces; but, after a particular stage, all the forms on the concrete faces developed faster and became more robust. This applies to those found growing even on concrete face 1, although here the number of species represented was much limited compared to the other faces. At the height of the growing season, the limits of size achieved before reproduction took place were still further extended. Thus, on the coral surface, in the case of *Padina gymnospora*, many plants with fronds less than 3 cm., were seen with mature tetrasporangia; while, on the concrete faces the plants generally produced tetrasporangia after attaining a height of 5 cm., or more. Again, on concrete face 1, *Padina gymnospora* plants were seen to be much better developed with greater number of fronds from the same base; while on the other concrete faces and on the coral surface, plants with one or two fronds were met with more often. In other words, for a luxuriant growth, *Padina gymnospora* prefers a sheltered place rather than regions exposed to wave action. During the unfavourable season, from the end of July to November, only few *Padina gymnospora* plants were recorded; and all of them, without any exception, were subsequent growths from older plants which were broken off from the holdfasts or eaten off by grazing animals. In this vegetative growth it has been observed that the fronds were very coarse and smaller compared to fronds produced by sporelings. In the case of *Sphacelaria tribuloides*, *Amphiroa fragilissima* and *Jania rubens*, in the initial stage, the plants were very fast growing, extending over a period of two to three weeks, after which, the growth was seen only

in the lateral spread of the plants resulting in a bushy nature. In *Sphacelaria tribuloides*, the maximum height recorded was 1.8 cm., in plants which were about ten weeks old. In the course of six weeks, *Amphiroa fragilissima* and *Jania rubens* attained a maximum height of 4.3 cm. and 2.7 cm., respectively. The growth of *Laurencia papillosa* was rather difficult to follow, because of the fact that the plants were fast growing ones; and in four weeks time, from sporelings, they attained a height of more than 8 cm. But in the majority of cases, it was observed that when the plants attained a height of about 4-6 cm., most of the branches broke off at the places of origin and even the main thallus broke off leaving small stumps with few broken branches. Fresh branches were seen to arise from these stumps resulting in a denser growth. Stumps which had put forth branches two or three times were observed to be stunted and the subsequent branches produced by them were very small with profuse fruit bodies.

In general, most of the growth activities of the algæ were over in three to ten weeks, except in the case of *Caulerpa*, *Dictyota*, *Sargassum*, *Lithophyllum*, *Gracilaria* and *Acanthophora*. In *Caulerpa*, the growth was a continuous process all through the favourable season; and as the plants continued growth and spread on the substratum, the older regions became yellowish and rotted. When such rotting was of a high order, it was observed that these rotten regions were soon colonized by hydroid colonies and sponges. All the other forms of algæ above-mentioned were ill-represented on the boulder and hence no proper growth rate measurements could be taken; and in the case of *Sargassum myriocystum* almost all the plants got detached from their hold even when they were less than 15 cm. tall. This is partly because plants of *Sargassum myriocystum* were seen to make their appearance on the boulder during the rough season, and probably also because the concrete surfaces were not the proper substrata for their firm anchorage.

It has been observed earlier, that there is not much of substratum selectivity exhibited by the algæ where concrete and coral substrata are in question. Therefore the growth rate observations indicate that the algæ in general prefer a vertical to a horizontal substratum; position perhaps acting along with the microclimate. However, this is applicable only to the smaller forms and not to the larger ones like *Gracilaria* and *Sargassum*.

#### REPRODUCTIVE PHASE

In the case of *Cladophora* sp., early in the month of April, almost all the plants showed the presence of empty apical cells with apical openings indicating the possibility of having produced swarmers, although such

swarmers were not actually met with. *Sphacelaria tribuloides* propagated only vegetatively by means of the propagules, and sporangia were not observed. In the case of *Padina gymnospora* only tetrasporic plants were observed on the boulder; the production of tetraspores were very much earlier on the coral surface than on the concrete faces. The tetraspores were produced at very regular intervals of about two weeks, but the tetrasporic zones were better developed only during the months of March, April and May. There was practically very little spore production during August to November. In both *Amphiroa fragilissima* and *Jania rubens*, mature conceptacles were seen in abundance during late April and late June. *Hypnea valentiae* produced only tetrasporic plants, and tetrasporangia were seen in plants of all age-group, they being produced more often in a regular sequence from the base of the plant upward, except in few cases where the nemathecium were seen scattered even at the terminal parts of the plants. *Laurencia papillosa* also appears to reproduce by spores, although sporelings or spores were not met with in the water samples collected from the small crevices on the coral surface; but, cystocarps were seen in abundance during the middle of June and during the last week of November.

In all the above cases, it has been observed that during the reproductive season, both fertile and sterile plants of the same size-group existed side by side. Such a co-existence of fertile and sterile plants suggests that the formation of reproductive bodies is not entirely dependent on environmental factors, but is essentially controlled by an internal factor of the individual plant which factor interacting with the environmental conditions results in the reproductive processes following a period of growth.

#### CHEMICAL FACTORS

An attempt at a correlation of the chemical factors of the environment with the growth and reproduction of the algæ is apparently far-fetched. Some investigators as Klebs (1896), hold the view that environmental factors are of primary importance in inducing the formation of reproductive bodies, but when taken as a whole, investigations of this type are mostly contradictory. Broadly speaking, maximum vegetation and growth are seen during the months when the salinity of the sea-water is moderate. From August, the flora gets depopulated with practically very few species occurring during the months of November to January and even early February, when the salinity fall is too rapid with, probably, marked fluctuations. Exception to this is the blue-green algæ, *Lyngbya majuscula* and *Symploca hydroides* which appear to tolerate and prefer a steep fluctuation in salinity.

Considering total nitrogen of the water, most of the forms appeared during the peak period, between February and March, but as they became luxuriant, the total nitrogen content of the water indicated a fall; and it was mostly during the low period that the reproductive structures were seen to develop. The rhythmic fluctuation in total nitrogen seems to correspond with the periodic vegetative and reproductive phases of the algæ in general.

Consideration of the temperature as a contributory factor has a very limited scope, since the temperature range is very small. But, here again, in general, the majority of forms were seen to flourish well during the warmer months and the frequency of sporulation was faster and of shorter duration during these seasons.

#### OTHER DYNAMIC FACTORS

Apart from the fact that the turbulence of the water acting in an indirect manner in modifying the physical and chemical quality of the water, it was observed that when the sea was rough and turbulent, most of the smaller and delicate algæ got completely detached from their hold or got torn off the base. In the above studies, an exception seen was in the case of *Lyngbya majuscula*, which was seen to withstand the turbulence of the sea.

#### RELATION OF THE SURROUNDING FLORA ON THE COLONIZATION

From periodic observations of the immediate vicinity of the experimental boulder, it has been observed that the majority of the algæ found on the boulder were seen growing in the immediate vicinity also. But *Acanthophora spicifera*, *Hypnea valentia*, *Ulva reticulata* and *Gracilaria lichenoides*, abundant all around in Palk Bay, were very poorly represented on the boulder. The same is applicable in the case of *Liagora farinosa*, although this alga was not in such abundance in the immediate vicinity. On the contrary, *Padina gymnospora* was not found to any appreciable level in the surrounding area, but was seen all year round on the boulder. This is applicable in the case of the blue-green algæ also, which were never in abundance in the immediate vicinity. It was also observed that during certain seasons, Palk Bay had a dense growth of sea-grasses, particularly *Cymodocea* spp., and *Halophila* spp., on which plenty of *Chatomorpha linum* (Müller) Kützing, were seen growing entangled. But at no time, on the boulder, were sea-grasses or *Chatomorpha linum* seen.

#### SUMMARY

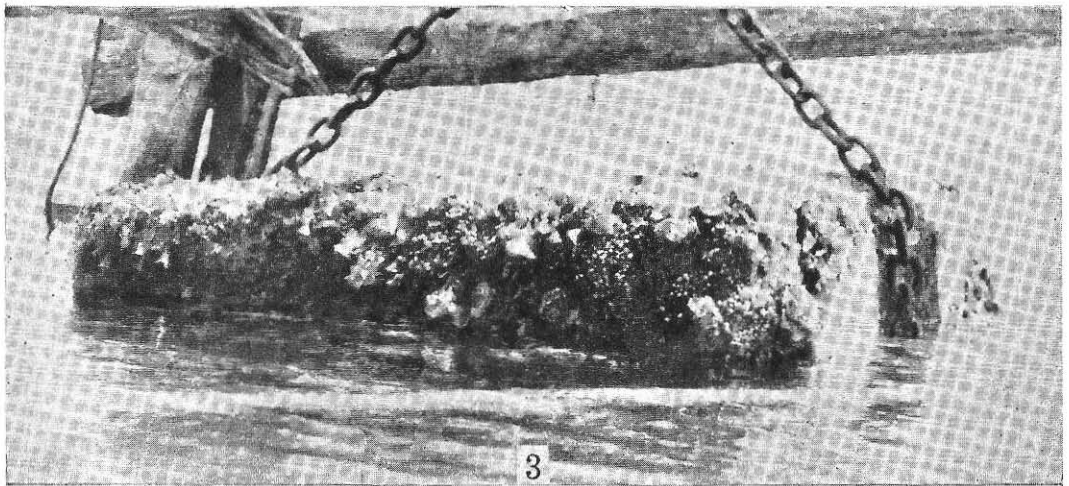
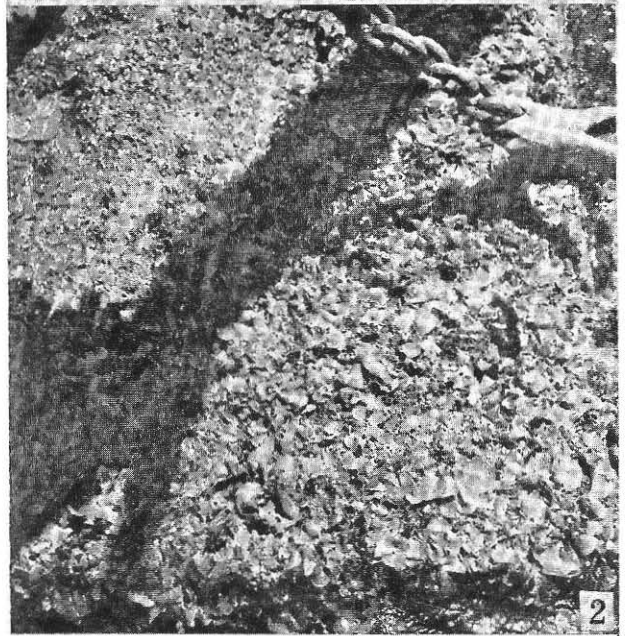
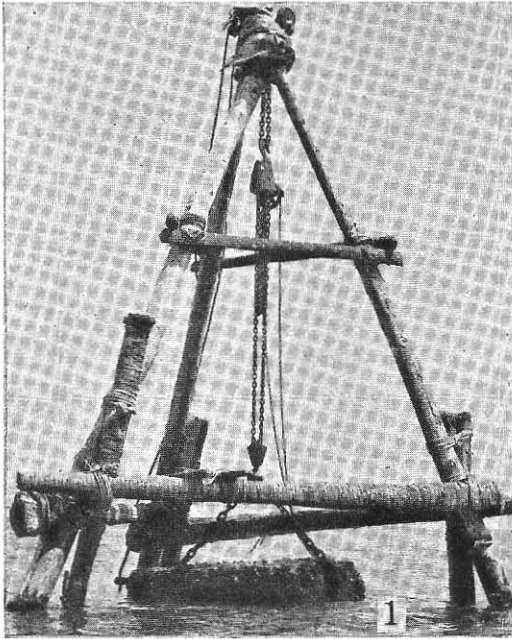
Succession of marine algæ on a fresh substratum—a concrete boulder with the top surface paved with coral stones—was studied. The algæ

colonizing the boulder were identified; the pioneer communities, succession, biotic factors, growth rate and reproductive phases of some of the forms, chemical factors, other dynamic factors and relation of the surrounding flora on the colonization over a period of 18 months were noted.

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FIGS. 1-3

*Succession of Marine Algæ on Fresh Substratum in Palk Bay* 263

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EXPLANATION OF PLATE IV

FIG. 1. Showing the leverage-tripod in position around the boulder which is partly lifted up by chain blocks.

FIGS. 2 and 3. Showing the luxuriant growth of *Padina gymnospora* on the coral surface during February to April.