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# THE ROLE OF GAMETES AND ASEXUAL PRODUCTS OF ALGAE IN THE FOOD CHAIN OF AQUATIC MEDIUM

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## Abstract

Experiments conducted by keeping mussel larvae in filtered sea water along with fragments of *Ulva* sp., *Chaetomorpha* sp. and *Cladophora* sp. capable of readily releasing gametes in the medium showed that the larvae could metamorphose to settling stage with in 15 to 18 days by actively feeding on the gametes released by these algae. It is also noticed that the breeding cycle of the above algae along with the other algae in the locality coincides with the peak breeding period of mussel in Vizhinjam and in other mussel bed areas. The asexual reproductive products of these algae have also been observed to play in similar role as diet of the larvae and adult mussels.

The study shows that gametes and other reproductive cells released by algae form a microleval food chain in the aquatic medium enriching the ecosystem. The paper emphasises a new line of investigation to find out the impact of this micro level food chain to improve the fish and shellfish production in coastal brackish water and fresh water ecosystems by comparing the role of other algal groups on a global basis.

Eventhough considerable work has been done on a global on the reproduction and propagation of algae, the biologists throughout the world have been concentrating mostly on the biology of reproduction in these groups. However, the role of the gametes and other asexually released products in the aquatic medium other than their natural process of propagation has not been studied.

Among a few important works on algae the reviews on the reproduction of algae made by Bold and Wynne(1978) Fritsch (1977) and Bhatia (1975) are worth mentioning and they give a broad picture on the alternation of generations and the reproductive behaviour of the marine,

**KEY WORD** : Algal reproductive products as mussel larval feed-Role in food chain.

brackish water and fresh water species of algae in detail. The Indian works on algae are innumerable but no attempt seems to have been made to study their impact in the ecosystem other than the fouling and settlement of certain species and their biological associates.

The Central Marine Fisheries Research Institute has initiated a new project "The investigations on biocoenosis" in April 1986 at Vizhinjam to evolve procedures for system management in aquaculture. It has been a puzzling problem that, how the food chain in the marine environment could compensate the needs of the bivalve larvae released at the intertidal and subtidal area as well as the shallow waters especially when millions of larvae of bivalve molluscs are released during certain specific seasons.

As part of this product this has been investigated during the period of study. It is also found that mussels spawn during May to September along the South west coast of India and during this season the conventional planktonic biomass available and the dietary requirements of the larvae has no correlation in the ecosystem as far the larvae are concerned considering the size of the larvae and size of the diatoms. It is under this situation that the large scale settlement of *Ulva* spp., *Enteromorpha* sp. and *Chaetomorpha* sp. and many of the major algae noticed in the same environment has given an idea that these algae might also influence the ecosystem. On these bearings further investigations are made and it has been observed that the bivalve larvae feed on the gametes of these algae land the results are presented here.

## OBSERVATIONS ON BIVALVE LARVAE FEEDING ON GAMETES OF ALGAE

The behaviour of the bivalve larvae and their feeding activities on gametes of algae are made by laboratory observations. The larvae are kept in cavity blocks along with fragments of algae capable of readily releasing gametes in the medium. It is well known that during specific periods of their reproductive phase, if the portions of algae are kept in containers, they liberate the gametes and other reproductive bodies to the surrounding areas which can be watched through the microscope. It has been observed that the larvae are very actively feeding on the gametes (Plate-I). The 'Propagula' which are also released by the epiphytic algae in the same medium are found to be rejected by the larvae because of their larger size when compared with the size of gametes. The planktonic mussel larvae measuring 80 to 200 $\mu$ are taken from the Vizhinjam Bay plankton are given the "gamete diet" as described earlier, could survive well in the condition and are found quite healthy and active throughout the period of observation. The survival rate of mussel larvae and the details of the experiment using the gamete diet are presented in Table -

I. The larvae took 15 to 18 days for complete metamorphosis and these larvae at the settling stage also actively feeds up on the gametes. To avoid interference of other food item; filtered seawater is used for the experiments and fresh bits of algae releasing the gametes are substituted periodically for continuous feeding of the larvae. During the experiments gametes released by *Ulva* sp., *Cladophora* sp. and *Chaetomorpha* sp. are used and are found highly successful as food item for the larvae and the results show that in natural habitat the gametes of these algae play an important role as food of filter feeding animals.

The comparative size of the gametes and the size of cultured plankton feed like *Isochrysis* sp. and *Pavlova* sp. etc used for mass culture of bivalve larvae are presented in Fig-2. It is worthwhile to notice that the size of the gametes are comparatively smaller than the size of such cultured feeds (7 to 8 $\mu$) used in bivalve hatcheries. A careful microscopical examination of the water samples from different localities during the peak spawning period of the bivalve molluscs of this area has also shown that no other ultraplankton which can effectively support the bulk larval requirement in the environment is available and naturally they have to solely depend upon these algal gametes (Table III) which are the dominant constituent of ultraplankton available for the larvae to feed upon. Another advantage of depending on these algal diet is that the food is naturally available at the sources. Immediately after settlement also the surrounding water area is highly enriched with the gametes released by the algae. It is also possible that the reproductive phase of the algae might trigger the adult animals by supplementing their diet to help the process of their "fattening" prior to spawning and the easy accessibility of food for the larvae also may stimulate the parent animals to spawn which is a phenomena further to be investigated. It was also observed in the laboratory that even while the primary film is formed over the substratum gamete release is common in certain cases and this process enriches the environment attracting the larvae of the sedentary species to settle at such localities. Further studies on the preference. if any, of the larvae for particular algal gametes, as well as the impact of the gametes on different larval groups will be communicated subsequently.

However, the biocoenotic impact of the sexual and asexual reproductive phase of the algae in the biosystem is highly significant and is an important field in which the biologists have to concentrate for evaluating the productivity of the coastal and shallow water areas.

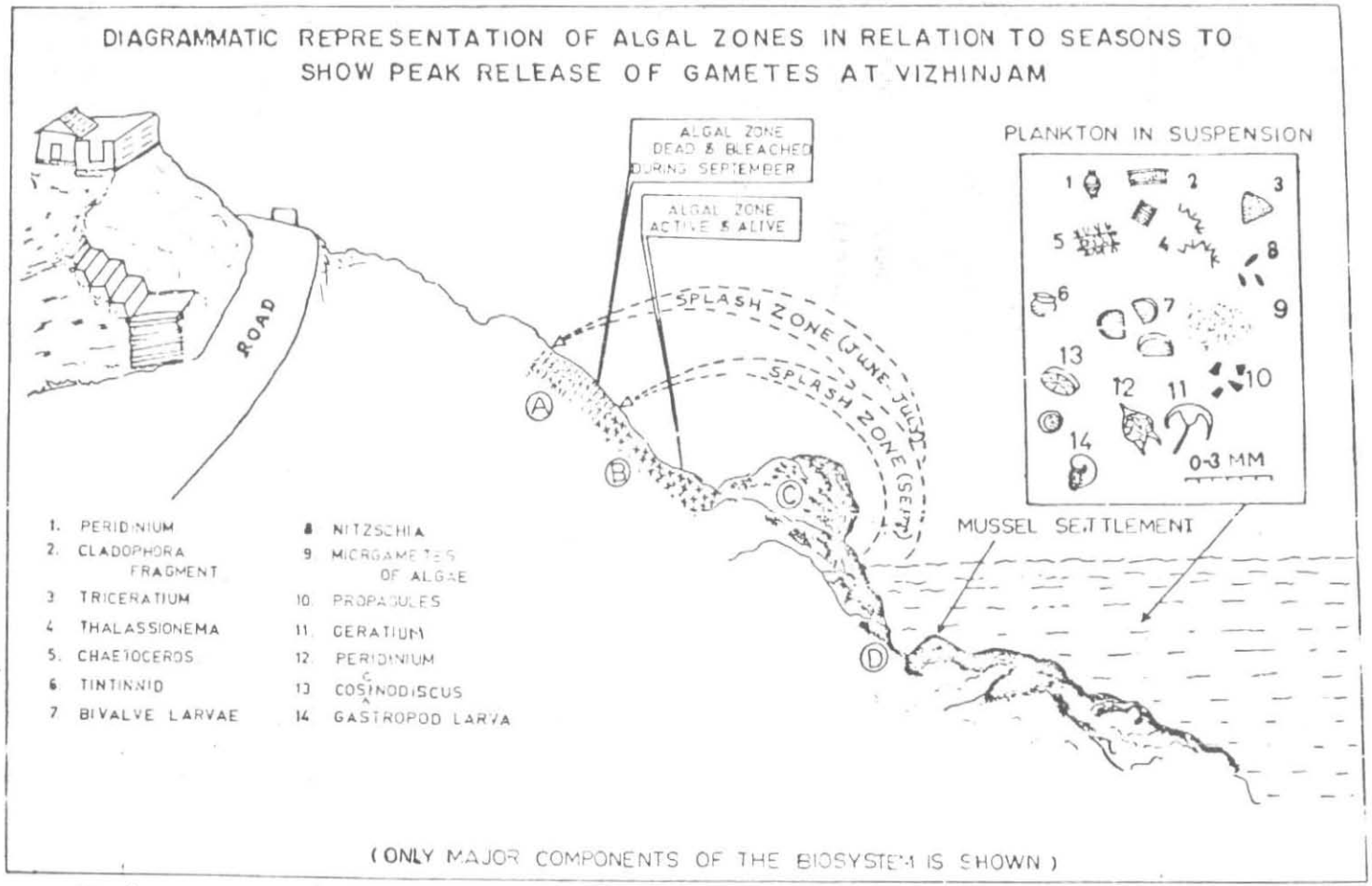

DIAGRAMMATIC REPRESENTATION OF ALGAL ZONES IN RELATION TO SEASONS TO SHOW PEAK RELEASE OF GAMETES AT VIZHINJAM
ALGAL ZONE DEAD & BLEACHED DURING SEPTEMBER
ALGAL ZONE ACTIVE & ALIVE
PLANKTON IN SUSPENSION
ROAD
SPLASH ZONE (JUNE-JULY)
SPLASH ZONE (SEPT.)
A
B
C
D
MUSSEL SETTLEMENT
0-3 MM
1. PERIDINIUM
2. CLADOPHORA FRAGMENT
3. TRICERATIUM
4. THALASSIONEMA
5. CHAETOCEROS
6. TINTINNID
7. BIVALVE LARVAE
8. NITZSCHIA
9. MICROGAMETES OF ALGAE
10. PROPAGULES
11. CERATIUM
12. PERIDINIUM
13. COSCINODISCUS
14. GASTROPOD LARVA
(ONLY MAJOR COMPONENTS OF THE BIOSYSTEM IS SHOWN)

Fig.1

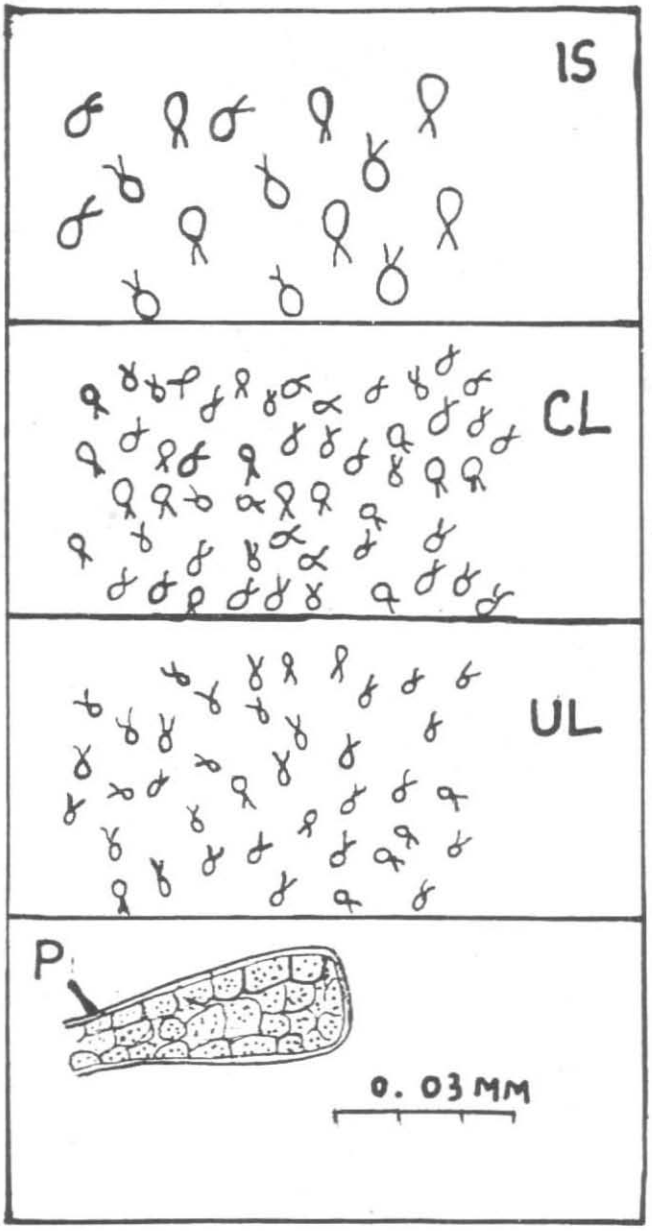



**Fig. 2**

Diagram to illustrate the proportionate size of gametes of algae and laboratory cultured bivalve feed, *Isochrysis*.

CL. Gametes of Cladophorales IS. *Isochrysis*, P. Propagula, UL. Gametes of Ulvaceae.

**Plate - I** A. Fragments of *Chaetomorpha* releasing gametes.
B. Epiphytes releasing propagula
C & D Mussel larvae feeding on the gametes.

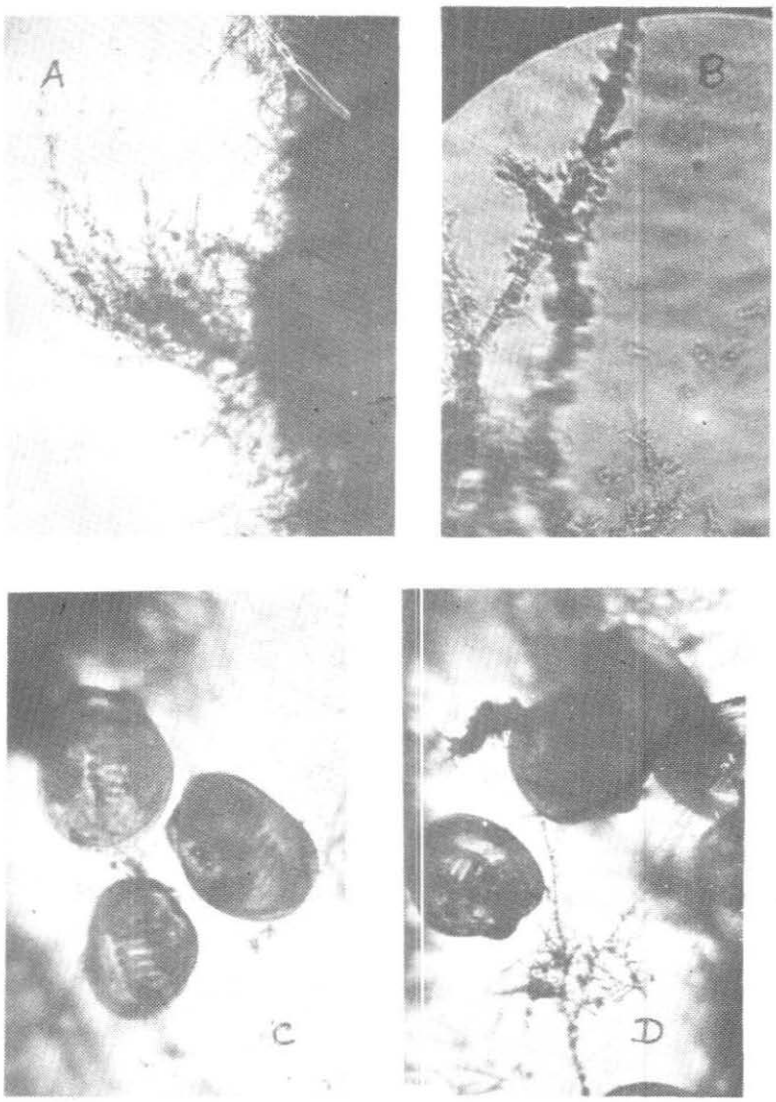



**PLATE - I**

Gametes and asexual products of Algae and their role in the food chain of Aquatic medium G.P.K.Achary *et al.*

**Plate - II** A & B Stages of gamete formation in *Codium* sp.
C. Gamete formation in *Chaetomorpha* sp.
D. Gamete formation in *Rhyzoclonium* sp.

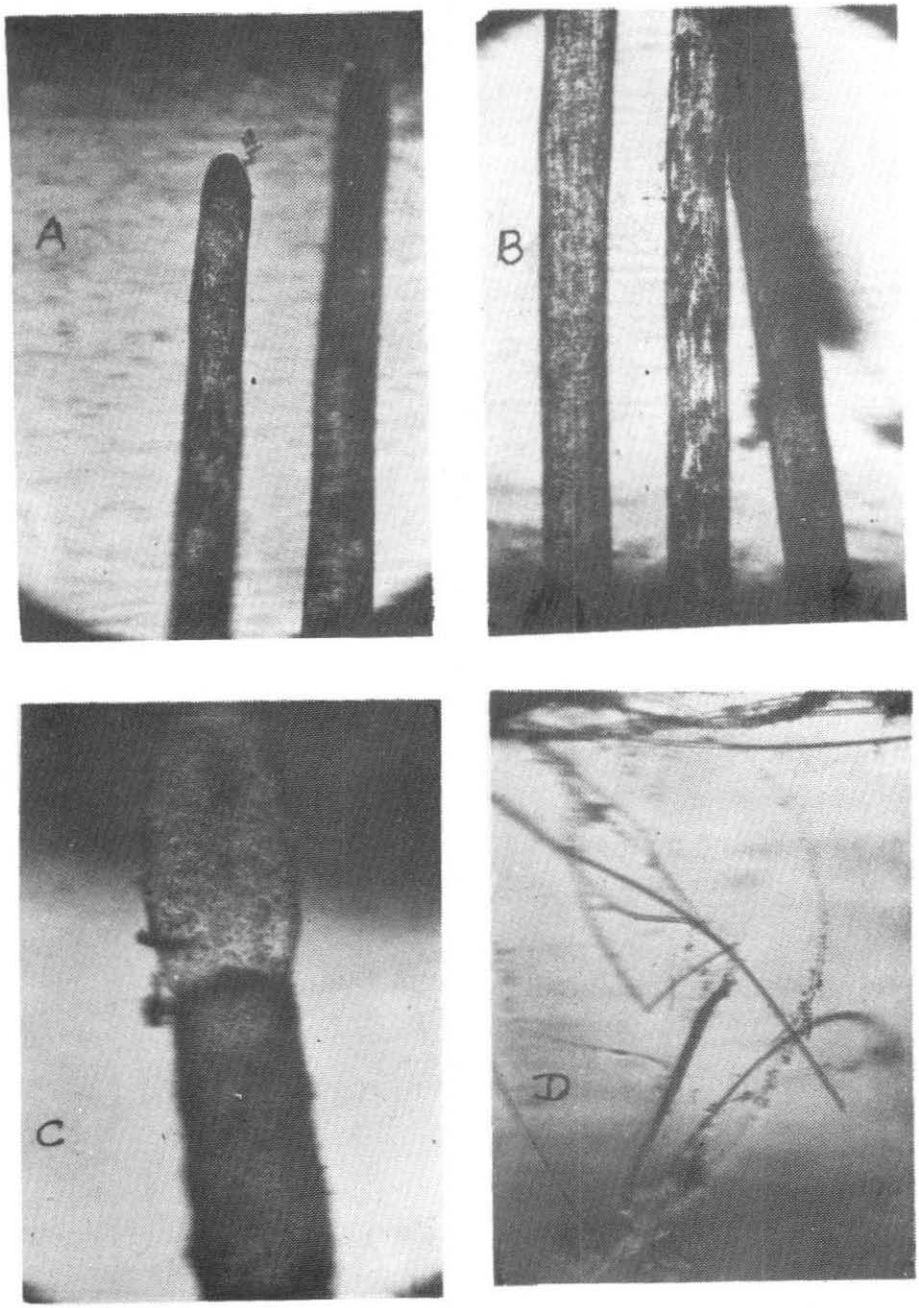


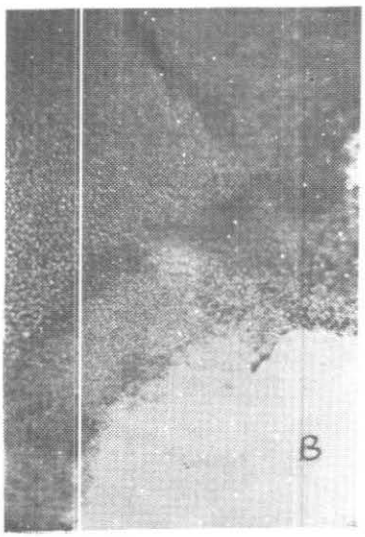

**PLATE - II**

Gametes and asexual products of Algae and their role in the food chain of Aquatic medium G.P.K.Achary *et al.*

**Plate - III** A & B. Gamete formation in *Ulva*

C. Gamete cells in plankton

D. Stages of gamete formation in primary film. —



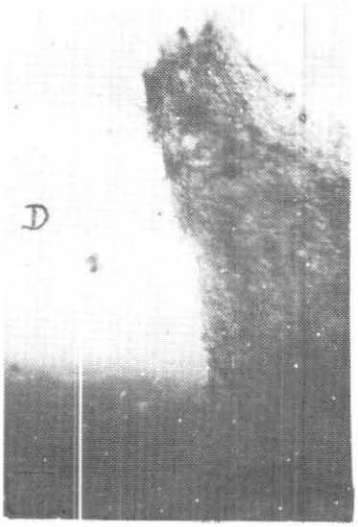



**PLATE - III**

Gametes and asexual products of Algae and their role in the food chain of Aquatic medium G.P.K.Achary *et al.*

**Table - I**

Experimental results of the mussel larvae feeding on gametes released by algae.

| Sl.No. | Number of mussel larvae in cavity blocks | Gamete releasing algal fragments used | Number of larvae survived after metamorphosis | Percentage (%) |
|---|---|---|---|---|
| 1. | 10 | *Cladophora* sp. | 8 | 80 |
| 2. | 10 | *Ulva* sp. | 9 | 90 |
| 3. | 10 | *Ulva* sp. | 10 | 100 |
| 4. | 25 | *Ulva* sp. | 15 | 60 |
| 5. | 10 | *Chaetomorpha* sp. | 9 | 90 |
| 6. | 15 | *Ulva* sp. | 12 | 80 |
| 7. | 10 | *Cladophora* sp. | 10 | 100 |
| 8. | 25 | *Chaetomorpha* sp. | 20 | 80 |
| 9. | 10 | *Ulva* sp. | 10 | 100 |
| 10. | 10 | *Ulva* sp. | 9 | 90 |
| Total | 135 | | 112 | 82.9 |

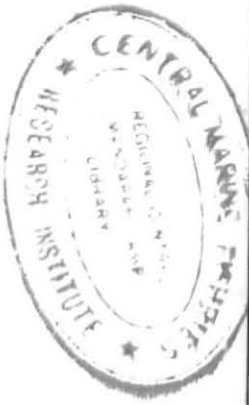



**TABLE - II**

The growth of *Ulva* sp. at the different zones of observations in September 1986 at Vizhinjam.

| Zone + | Length of fronds in cm | Algal biomass per $m^2$ | Peak period of settlement | Remarks. |
|---|---|---|---|---|
| A | 2.1 to 14.2 | 2.87 Kg | June-July | Bleached by sun |
| B | 4.3 to 18.10 | 3.12 Kg | June-July | Partially bleached |
| C | 3.2 to 34.5 | 4.43 Kg | June-September | Healthy growth subtidal level |

+ Zones are shown in Fig.1.

**TABLE - ■**

Relative abundance of phytoplankters in Vizhinjam during June-Sept.1986 (Values represent numbers/litre)

| Phytoplankters | June | July | August | September |
|---|---|---|---|---|
| *Bellerochea malleus* | 1777 | - | - | - |
| *Biddulphia* sp. | 154 | 753 | 10 | - |
| *Chaetoceros* spp. | 60270 | 110507 | - | - |
| *Cerataulina* sp. | 6 | - | - | - |
| *Coscinodiscus* spp. | 7417 | 11040 | 446 | 50 |
| *Fragilaria oceanica* | 27675 | 1545017 | 327666 | 6300 |
| *Nitzschia* spp. | 154 | 6057 | 28 | 6599 |
| *Pleurosigma* sp. | 44 | - | - | - |
| *Planktoniella* sp. | 44 | - | - | - |
| *Rhizosolenia* spp. | 173 | 40 | - | 18 |
| *Thalassionema* spp. | 3690 | 812 | 579 | - |
| *Thalassiosira* sp. | - | - | 9494 | - |
| *Thalassiothrix* sp. | - | 50956 | 89 | 344 |
| *Triceratium* sp. | 173 | 184 | - | 33 |
| Other diatoms | - | 7729 | - | - |
| Fragments of Cladophorales (less than 1 mm) | 17528 | 12 | 37 | 444 |
| Microgametes of algae | 14467 | 72583 | 88000 | 64933 |
| Microgametes (coagulated) | 580 | 2162 | 2547 | 2712 |
| Propagules (vegetative reproductive bodies) | - | - | - | 382 |
| *Ceratium* spp. | - | - | 214 | 52 |
| *Peridinium* spp. | - | - | - | 52 |

## ALGAL ZONES IN RELATION TO SEASON TO SHOW PEAK RELEASE OF GAMETES

The monsoon conditions of the West coast of India especially at the southern region raises the water level to a very great extent because of the rough weather conditions and the splash zone reaches upto more than 5 to 10 metre from the normal water level in certain localities. This situation has enabled to observe new colonisation and settlement of flora and fauna at this zone during this period. A cross sectional view of the Vishinjam area is given in Fig.-1 showing the major components of the ecosystem involved in this study during the south west monsoon and postmonsoon period. Similar zonation and settlement patterns are observed at colachel, Enayam and Kovalam area having more or less same ecological features, with rich mussel beds.

It has been observed that in Zone 'A' heavy settlement of *Ulva* sp. *Chaetomorpha* sp. and *Cladophora* sp. occurred along with other algae during June-July period which is continued upto August. Large quantities of gametes of these algae are noticed in the plankton during this period which is more or less coinciding with the enormous release of larvae of almost all invertebrate groups in this area. Zone 'A' is found to be a very active area as far as the bioactivity is concerned, right from the formation of the primary film to this settlement of sedentary groups and this is found to be an annual cyclic phenomenon in this zone. For a comparison of the biological process during this period at zone 'A' with the other zones, the details are presented in Table - II. It is noted that the production of 2.87 kg/m$^2$ at this zone is the product of settlement during June and July and comparatively when the monsoon subsides, the splash zone recedes and this area is more exposed to sun affecting further settlement and survival of the gametes. Because of this condition, the mussel larval settlement also is limited at this area. In Zone 'B' also similar situation prevails during August and September and hence the productivity is low compared with the subtidal zone.

The conditions of the plankton biomass is also represented in Fig.1 for a comparison of the size of various diatoms and larvae available during this period. The algal gametes in suspension is found to highly enrich the water and the process of settlement of almost all the algal groups in this locality is continued at the lower zones during this period of study.

RELATIVE ABUNDANCE OF GAMETE CELLS IN THE PLANKTON

To observe the occurrence of the gamete cells in the plankton, samples are regularly taken at a frequency of two samples per week by filtering about 500 to 700 litres of water from the locality. Bolting silk (30 mesh size) is used for filtering the water and it is observed that when few litres of water passes through the fine meshes, the mesh gets clogged due to the presence of coagulated cells in suspension. This has helped to entrap the gamete cells also. The samples were observed in live condition and was used for the laboratory reared invertebrate groups like sponges, corals, bivalves and gastropods. Subsamples were prepared for further qualitative and numerical estimation of the standing crop, at least to give a relative picture of the availability of these cells in the ecosystem. The results of the study are given in Table - III. The study has revealed that *Fragilaria oceanica, Chactorceros* spp. *Coscinodiscus* spp., *Thalassionema* spp. and *Thalassiothrix* sp. were the dominant species of phytoplankton occurring during June to September. Fragments of Cladophorales were also noticed during this period. the minute free cells occurring in the samples in enormous numbers were found to be microgametes of algae and in addition coagulated mass of microgametes were also found to be in high concentration during the period of observation. However,microgametes might have been unnoticed by earlier workers because of their very minute size.

As the present investigation has been oriented to find out the micro feed available in the environment, much are is taken during the time of collection to entrap these microcellur products. The gamete cells from the plankton is compared with the gamete cells released from the algae in laboratory and is found that these microcells are nothing but the gametes released by the algae in this locality. It is also observed that the biosystem is highly enriched by periodic release of these gametes in the surrounding water and it has an important role in supporting the invertebrate larval groups as well as minute fish larvae which require ultra microscopic diet.

## Discussion

The basic investigations on available food item in natural system, especially when larvae are released in bulk, is an important tool for triggering natural settlement of culturable bivalve species. The size of food particle available in the environment and the size of the larvae which can feed upon the food particle also is of considerable importance and as such the conventional diatoms or their blooms have found of little importance at this context because of the larger size of the diatoms.

In the laboratory conditions even though cultured feed like *Pavlova* sp. or *Isochrysis* sp. are found to be successful in large scale culture of mussel and pearl oyster larvae it is evident that such species do not occur in the Indian Coast to supplement the dietary requirements of the large number of larvae released in the ecosystem. This situation naturally lead to new thinking to find out what might be the link in the food chain in the aquatic environment when such large scale liberation of larvae occur during a particular season. Because of the minute size of the gametes and the other asexual products released by the algae it is not possible to get them in the regular plankton collection and even isolated microcells when entrapped in the plankton become unnoticed and unidentifiable for the investigators. The present study has enabled to directly link these gametes with the larval diet in the laboratory experiments and this has become possible because, from the thorough investigations of this locality, the biosystem has given a clue that June to August is the peak period for the settlement of species like *Ulva, Chaetomorpha* and *Cladophora* as well as many of the major algae in this area at the spray zone and supralittoral zone extending even upto the subtidal levels with characteristic zonation. This directly shows that these algae also might influence the system during this period. The enormous release of the gametes as well as the zoospores and zygotes of these algal forms together with the asexual phase of certain algae in the form of "propagula" enrich the biosystem at the coastal areas and forms microcellular food for all the invertebrate groups based on the observations made in the laboratory as presented in this paper.

## Summary and Recommendations

1. The study shows that there is a micro level food chain in the aquatic medium which is constituted by the reproductive cells both sexual as well as asexual products released by algae.

2. The larvae of mussels feed on micro-gametes of algae like *Ulva, Chaetomorpha* and *Cladophora* based on the observations made in the laboratory and it is found that the mass reproduction of these algae and mussels in the Southwest coast of India has got direct significance. When the gametes of the algae are liberated in bulk during certain seasons it adds to the biomass in suspension forming the food of other larval forms also.

3. The coagulated unconsumed products liberated by these algae which could not successfully settle at the substratum to forms new colonies of algae can improve the dietary value of the detritus feeders also and can directly influence the bottom

communities.

4. The study also revealed that the indiscriminate exploitation of the different species of algae for commercial purpose may also affect the biosystem since it may affect the gamete food chain in the environment which has to support a great majority of the invertebrate larvae, their adults as well as fish larvae which may feed upon these microfeed.

5. In addition to the commercial exploitation; the man made changes in the environment also might affect the algal population and conservation measures also are to be adopted to balance the ecosystem.

6. Further studies are to be intensified on these lines to assess the standing crop by the release of sexual and asexual products of the algae and their correlation with the fishery and benthic biomass. This will also give certain important results as far as the production of commercial bivalve and gastropod molluscs, fish production and production of other invertebrate groups and also evolve procedures for artificial enrichment of the environment to increase production.

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## References

Bhatia, K.N. 1975. A treatise on algae, pp. 1-475 ,Chand & Co. Delhi .

Bold, H.C. & M.J. Wynne. 1978. Introduction to the algae,pp.1-706 Printice-Hall India, New Delhi. 1

Fritsch, F.E.1977. The structure and reproduction of algae,pp. 1-791, Reprint Edition New Delhi.