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Relationship between plankton and finfish and shellfish juveniles in Pichavaram mangrove waterways, south east coast of India

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ABSTRACT

Qualitative and quantitative assessments of phytoplankton in Pichavaram mangrove waterways were made monthly for a period of two years (1980-82) in order to investigate the relationship between phytoplankton abundance and that of the juveniles of commercially important finfishes and shrimps. Totally 84 species of phytoplankton comprising 74 species of diatoms, 5 species of dinoflagellates, 4 species of blue green algae and 1 species of green alga were recorded. The density of phytoplankton ranged from 12 to 50,11,872 cells/l during the period with peaks during summer and post-monsoon seasons. The positive relationship observed between the phytoplankton and the finfish and shrimp juveniles, indicates that phytoplankton could be one of the major factors influencing the temporal fluctuations of the populations of fish juveniles in this mangrove biotope.

Introduction

Mangroves all over the world are known for their importance as the best nursery grounds for many commercial species of marine finfishes. While many physico-chemical factors are contributed to the temporal and spatial distribution of young-ones of finfishes in mangrove biotope (Achuthan Kutty and Sreekumaran Nair, 1980), food seems to play a major role in their distribution (Macnae, 1974; Prince Jayaseelan and Krishnamurthy, 1980). Plankton being the link at the base of food chain have been observed to influence the distribution and abundance of fishes in the estuarine and coastal biotopes (Devasundaram and Roy, 1954; Rao and Gopalakrishnan, 1975; Saha *et. al.*, 1975). In this direction, an attempt has been made to evaluate the abundance of plankton, finfish juveniles and shrimp juveniles in Pichavaram mangrove and to determine the relationship between them.

Material and Methods

Fortnightly collections of water, plankton and juveniles of finfishes and shrimps were made during April 1980 – March 1982 in four sampling sites of Pichavaram mangrove (Fig. 1). For quantitative analysis of phytoplankton one litre of surface water was collected and allowed to settle for 24 hours after adding 5% neutralized formalin.

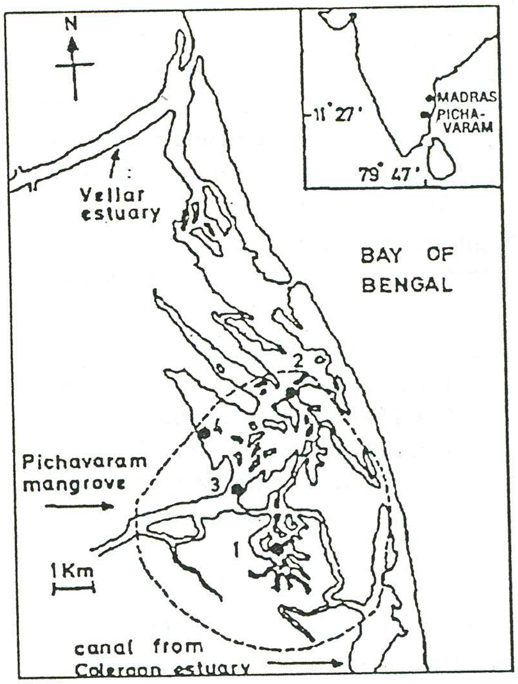

Fig. 1. *Map of study area showing the location of sampling sites*

For a qualitative analysis, No. 30 plankton net (bolting silk mesh size 48 µm) was used (Santhanam, 1976). Zooplankton were collected by filtering 200 litres of surface water through No. 10 bag type plankton net (mesh size 158 µm) for quantitative study (Thangaraj *et. al.*, 1979). The microzooplankton which may otherwise escape through No. 10 net, were collected in one litre polythene bottle and analyzed by sedimentation technique (Thangaraj *et. al.*, 1979) as employed for the quantitative study of phytoplankton. The phytoplankton was analysed using Utermohl's inverted microscope and the zooplankton by a Sedgwick rafter cell.

The shrimps and finfish juveniles were collected using a velon screen drag net and a cast net. The velon screen drag net (2 x 0.75m) with a mesh size of 2 mm was used to collect the small sized post-larvae and early juveniles of finfishes and shrimps while the cast net measuring 4.5 m in diameter with a mesh size of 7 mm was used to collect relatively larger sized juveniles. Both the gears were operated at random in each sampling site and quantitative estimations were made based on the number of individuals (finfishes/shrimps) obtained per unit area (m^2). The finfish and shrimp samples were fixed in 6-10% neutral formalin for further analysis (Greeson *et. al.*, 1977).

Data on rainfall were obtained from the Meteorological Unit of the Institute. The surface water temperature was recorded *in situ* with a mercury Celsius thermometer marked to 0.1°C accuracy. Salinity, dissolved oxygen content, pH etc., were estimated following the standard methods of Strickland and Parsons (1972).

Results

(i) Phytoplankton

Totally, 84 species of phytoplankton were identified in the present study and it comprised 74 species of Bacillariophyceae (diatoms), 5 species of dinoflagellates, 4 species of Cyanophyceae and 1 species of Chlorophyceae. A check list of phytoplankton recorded from all the four sampling sites of Pichavaram mangrove is given in Table 1.

During the present investigation an analysis was also made on the native species (autochthonous) and migrants (allochthonous) of phytoplankton collected. For this analysis, species which occurred more than 90% were considered as autochthonous species and the rest of the occurrences related to allochthonous species. Such autochthonous species were *Biddulphia mobiliensis, Coscinodiscus jonesianus, Bacteriastrum delicatulum, Chaetoceros lorenzianus, Coscinodiscus centralis, C. eccentricus Gyrosigma balticum, Navicula rostellata, Pleurosigma elongatum* and *P. directum* (diatoms) and *Ceratium furca, Peridinium depressum* and *Provocentrum micans* (dinoflagellates).

The dominant allochthonous constituents were *Chaetoceros compressus, Eucampia zodiacus* and *Rhizosolenia setigera* among diatoms; and *Ceratium tripos* and *Dinophysis caudata* among dinoflagellates. Freshwater species such as *Anabaena, Nostoc, Oscillatoria, Spirogyra, Navicula* and *Synedra* were observed only during the freshwater influence in the biotope associated with monsoonal floods.

The phytoplankton population density ranged from 25 to 15,84,893 cells/l during 1980-81 and from 12 to 50,11,872 cells/l during 1981-82. Generally, the density was high during summer and post-monsoon seasons and low during monsoon periods (Fig. 2).

(ii) Zooplankton

Totally 47 species / groups of zooplankton were recorded in the present study. Calanoid and cyclopoid copepods were the main constituents of the macroplankton and the dominant species were *Acartia southwelli, Eucalanus elongatus, Oithona rigida, O. brevicornis* and *Pseudodiaptomus aurivilli.* The major components of microzooplankton were tintinnids represented by 10 species. Of these, *Dictyocysta seshaiyai, Tintinnopsis tubulosa, T. tocantinensis, T. cylindrica, T. minuta, T. uruguayensis, Tintinnidium primitivium* were most common numerically. The larval population consisted mainly of polychaete larvae, nauplii of copepods, prawn larvae, nauplii and cypris of cirripedes and veligers of gastropods and bivalves and fish larvae. Besides the above forms, rotifers, ctenophores, chaetognaths, siphonophores, hydrozoan medusae and pteropods were also recorded.

The population density of zooplankton varied from 11 to 22,13,094 organisms/l for the year 1980-81 and from 15 to 22,84,020 for the year 1981-82. Major peaks of abundance were recorded during post-monsoon and summer seasons and the lowest population density was noted during monsoon (October-December) (Fig.2).

(iii) Shrimp juveniles

Totally 14, 142 post-larvae and juveniles of seven species of penaeid shrimps, viz., *Penaeus indicus, P. merguiensis, P. monodon, P. semisulcatus, Metapenaeus monoceros, M. dobsoni* and *M. affinis* were collected. Three species, *P. indicus, M. dobsoni* and *M. monoceros* formed a major portion (99.44%) of the collections. Distribution of *P. merguinensis, P. monodon* and *P. semisulcatus* were sporadic. Juveniles of *M. affinis* were collected only in meagre numbers. Species-wise percentage contribution computed from the overall catch was : *M. dobsoni* (46.44%), *P. indicus* (36.78%), *M. monoceros* (11.23%), *P. monodon* (2.27%) and *M. affinis* (0.95%).

The overall estimation of shrimp juveniles from all the four sampling sites showed unimodal peak during late monsoon to early post-monsoon period (December-February) contributing 39.43% of the total catch of the first year. However, in the second year, three peaks, one during summer (April-June; 33.44% of the total catch), the second during mid and late pre-monsoon (August-September; 20.69%) and the third one during early post-monsoon (January, 12.30%) were observed.

(iv) Finfish juveniles

A total of 10,287 finfish juveniles belonging to 42 species were collected during the study period. Ninety per cent of the total catch was contributed by 14 most dominant species. Among these, *Liza* spp., *Mugil cephalus, Chanos chanos, Elops machnata, Etroplus suratensis, Megalops cyprinoides* and *Lates calcarifer* were commercially important ones. The fishes

Table 1. *Checklist of phytoplankton collected during the study period at Pichavaram mangrove.*

Diatoms

Achnanthes brevipes
Ampniprora gigantea
Asterionella japonica
Bacteriastrum comosum
B. delicatulum
B. varians
Bellarochea malleus
Biddulphia dubia
B. heteroceros
B. mobiliensis
B. sinensis

Biddulphia sp.
Cerataulina bergonii
Chaetoceros affinis
C. compressus
C. indicus
C. lorenzianus

C. peruvianus
C. socialis
Climacosphaenia moniligera
Cocconeis disculoides
Coscinodiscus centralis
C. concinnus
C. eccentricus
C. gigas
C. jonesianus
C. lineatus
C. marginatus
C. oculusiridis
C. thorii
Diploneis bombus
Ditylum brightwellii
D. sol
Eucampia cornuta
E. zodiacus

Fragilaria intermedia
Frustulia rhomboides
Guinardia flaccida
Gyrosigma balticum
G. hippocampus
Gyrosigma sp.
Hemiaulus sinensis
Hemidiscus hardmannianus
Lauderia annulata
Leptocylindrus danicus
Lithodesmium undulatum

Melosira sulcata
Navicula longa
N./ lyra
N. pygmaea
N. rostellata
N. salinarum

Nitzschia closterium
N. longissima
N. obtusa
N. paradoxa
N. seriata
N. sigmoidea
Pleurosigma directum
P. elongatum
Rhizosolenia alata f. gracillima
R. setigera
R. stolterforthii
R. styliformis
Schroedrella delicatula
Skeletonema costatus
Stephanoplixis palmeriana
Surirella ovalis
Synedra ulna
Thalassiothrix frauenfeldii

Triceratium favus
T. reticulum

Dinoflagellates

Ceratium furca
C. tripos
Dinophysis caudata
Peridinium depressum
Provocentrum micans

Blue greens (Cyanophyceae)

Anabaena sp.
Nostoc sp.
Oscillatoria sp.
Trichodesmium erythraeum

Greens (Chlorophyceae)

Spirogyra sp.

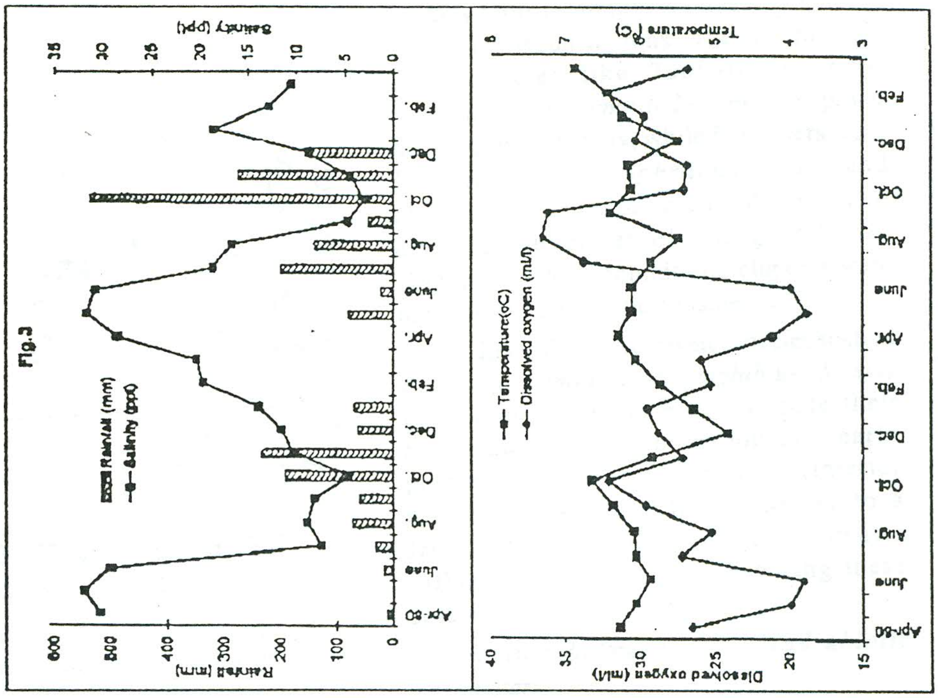

Fig. 3. Environmental parameters of the study area

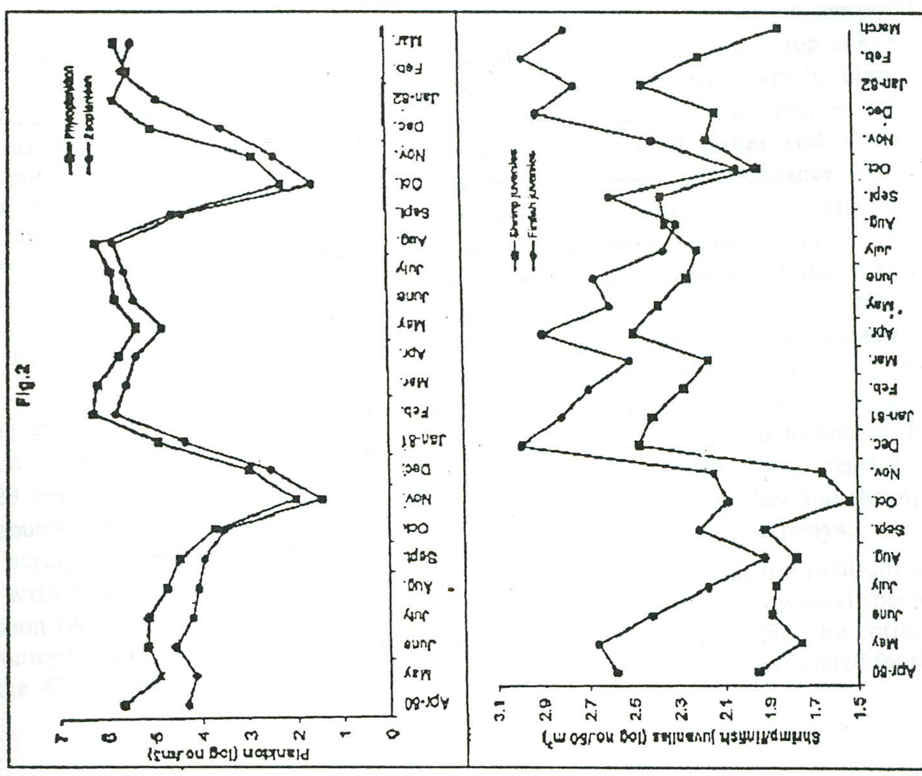

Fig. 2. Seasonal variations in the abundance of phytoplankton, zooplankton, shrimp and finfish juveniles in Pichavaram mangrove during April, 1980 - March, 1982.

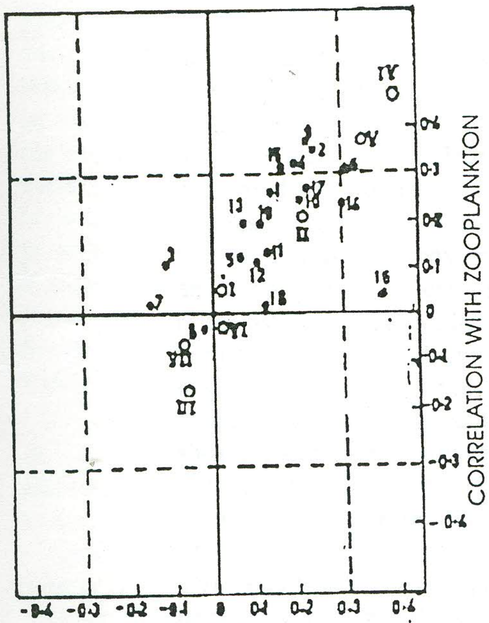

Fig. 4. *Ordination of 19 species of finfishes (•) and 7 species of shrimps (o) with phyto and zooplankton (interrupted lines indicate the significance at P > 10% level).*

1. *Oryzias melanostigma;* 2. *Ambassis sp.;* 3. *Cyprinus sp.;* 4. *Liza spp.;* 5. *Mugil cephalus;* 6. *Pomadasys hasta;* 7.*Chanos chanos;* 8. *Thryssa sp.*; 9. *Etroplus suratensis;* 10. *Elops machnata;* 11. *Scatophagus argus;* 12. *Etroplus maculatus;* 13. *Lates calcarifer;* 14. *Megalops cyprinoides;* 15. *Gobiids;* 16. *Siganus javus;* 17. *Cynoglossus sp.*; 18. *Hemiramphus sp.;* 19. *Sillago sihama;*

I. *Penaeus indicus;* II. *P. merguiensis;* III. *P. monodon;* IV. *P. semisulcatus;* V. *Metapenaeus monoceros;* VI. *M. affinis;* VII. *M. dobsoni*

numbering less than 150 (<1.49%) were considered as less dominant. Out of 42 species, 29 belonged to this category. The peaks of abundance of finfish juveniles were observed during summer and post-monsoon seasons with the lowest values during pre-monsoon (August) in the first year and during monsoon (October) in the second year. Out of the 42 species of finfish juveniles studied, 18 species exhibited maximum abundance during summer and post-monsoon seasons with minimum numbers occurring during monsoon months. The juveniles of some species like *Tachysurus arius, Hemirhamphus gaimardi, Leiognathus* sp. and *Ilisha* sp. were patchy, while few others, viz., *Lutjanus johni, Sphraena jello* and *Dussumieria acuta* occurred only occasionally. The juveniles of *Sillago sihama, Therapon jarbua,* gobiids and clupeids were numerically poor to be considered.

Juveniles of freshwater species such as *Puntius conchonius, P. amphibius, Mystus gulio* and *Cirrhinus mirgala* made their appearance during monsoon and early post-monsoon periods at site I (interior mangrove) and at site III (nearer to a freshwater channel), where freshwater influence was always high during these seasons.

Interaction between biotic and abiotic parameters

A comparison between the temporal variations of phytoplankton, zooplankton, shrimp juveniles and finfish juveniles clearly shows that the four biological entities were much related to each other and almost uniform in their patterns of abundance (Fig.2). Among the environmental parameters, such as water temperature, rainfall, salinity and dissolved oxygen content of the water, monitored throughout the study period, an inverse relationship could be observed between rainfall and salinity (Fig. 3). The seasonal fluctuations of both salinity and temperature were also similar to that of the temporal changes of biotic components, i.e., plankton, juveniles of finfishes and shrimps in Pichavaram mangrove waterways.

In order to find out the relationship between the abundance of individual species of finfish/shrimp and plankton, the correlation coefficient values were calculated for the abundance of each of 19 species of finfishes and 7 species of shrimps with the temporal variations of phytoplankton and zooplankton. The correlation coefficient values were ordinated as shown in Fig. 4. Out of 19 species of finfishes ordinated, 16 of them showed positive relationships with both phyto and zooplankton, 2 species showed negative relationship with phytoplankton but positive with zooplankton and one species showed negative relationship with both phyto and zooplankton. Similarly, out of 7 species of shrimps, 4 of them positively correlated with both phyto and zooplankton, 2 of them indicated negative relationships with both phyto and zooplankton and 1 species correlated positively with phytoplankton but negatively with zooplankton. Thus most of the species of finfishes and shrimps had positive correlation with plankton.

The linear relationships were statistically significant in the case of finfish species, viz., *Siganus javus, Megalops cyprinoides, Pomadasys hasta, Ambassis* sp., *Etroplus suratensis, Liza* spp. and gobiids and the shrimps *Penaeus semisulcatus* and *Metapenaeus monoceros.*

Discussion

An overall picture of the plankton populations of Pichavaram mangrove area reveals that among phytoplankton, the diatoms formed the bulk of the pelagic autotrophs followed by dinoflagellates. Copepods formed the major portion of zooplankton. Similar dominance was also observed earlier by Santhanam (1976) in Pichavaram mangrove waters and by Sivakumar (1982) and Chandran (1982) in the adjoining Vellar estuary.

Bimodal peaks in seasonal abundance of phyto and zooplankton have been also reported earlier in this area (Santhanam, 1976; Chandran, 1982; Sivakumar, 1982). A decrease in phytoplankton and zooplankton populations during monsoon as observed now could be probably due to the heavy freshwater flow associated with increase in suspended matter. Inshore waters also seem to influence the abundance of phytoplankton and zooplankton during summer. Similar increase in plankton populations during post-monsoon season was observed when estuarine conditions were restored with optimal concentration of nutrients and favourable salinities (Sivakumar, 1982).

Wellershaus (1974) found that the diversity and abundance of microzooplankton were positively correlated with salinity in Cochin backwaters. He also reported on stability of the environment and higher salinity conditions only during the post and pre-monsoonal months which coincided with a rich and diverse zooplankton population.. Rao (1977) opined that the poor density of zooplankton during monsoon could be attributed to the low salinity, high turbidity and strong water currents in the backwaters. Two peaks of zooplankton i.e., one in summer and the other during pre-monsoon observed immediately after phytoplankton peaks indicate the existence of a possible trophic relationship between the primary and secondary producers.

Continuous recruitment of fish larvae and post-larvae, their growth and the short term residential phase as observed in the mangrove biotopes seemed to be controlled by many abiotic and biotic (breeding sequence) factors. The seasonal variations observed in the phytoplankton, zooplankton and juvenile fishes in Pichavaram mangrove waterways for a continuous two year period shows a standard pattern of abundance of these organisms during summer and post-monsoon periods with minimum population densities during monsoon seasons. The drastic reduction in salinity exerted a pronounced influence on the species composition and abundance of finfishes and shrimps in Pichavaram mangrove. A decrease in number of individuals of fishes in correlation with plankton was evident during north-east monsoon (October-December). A bimodal trend in the abundance of shrimp juveniles and finfishes was observed earlier in many Indian coastal areas (Jhingran and Natarajan, 1969; Achuthankutty and Sreekumaran Nair, 1980; Suseelan and Kathirvel, 1982).

De Sylva (1975) attributed variations in estuarine nekton to substrate characteristics and related their distribution to the associated prey organisms. Rao and Gopalakrishnan (1975) indicated that many species of finfishes in brackishwater bodies feed upon phyto and zooplankton during their early life stages and upon detritus as they grow into adult. Devasundaram and Roy (1954) and Saha *et. al.,* (1975) also observed a direct relationship between finfish abundance and plankton in Chilka lake and Hooghly estuarine systems.

Although both abiotic factors and biotic factors seem to influence the spatial and temporal distribution of shrimps and finfishes in coastal waters, it is difficult to identify the major factors as the interactions of these parameters are complex in any dynamic aquatic system. Moreover, the abundance of finfish and shellfish juveniles in mangrove waterways is invariably related to the spawning intensity of the adult populations of the adjacent areas and the process of recruitment of these young-ones into the mangrove. A thorough study on the gut content analysis of the fishes in relation to the qualitative and quantitative spectrum of plankton community may, therefore, be needed to confirm the link between the abundance of plankton and that of shrimps / finfishes.

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