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Ecology of Indian estuaries: Studies on the zooplankton ecology of Kadinamkulam Backwater

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Abstract. Ecology of the zooplankton of Kadinamkulam Backwater, a brackish water lake along the south-west coast of India, has been studied from February 1980–January 1981. Seasonal distribution of the zooplankton followed an uniform pattern throughout the backwater. Zooplankton in the Kadinamkulam Backwater is composed of foraminifers, coelenterates, nematodes, rotifers, chaetognaths, polychaetes, cladocerans, ostracods, amphipods, copepods, decapod larvae, insect larvae, bivalves, tunicates, and fish eggs and larvae. Among these, rotifers, copepods and copepod nauplii are the major components which form the bulk of the zooplankton (nearly 98%). A distinct regional variation is discernible in the dominance of zooplankton components. Copepods constitute the dominant group near the barmouth and middle portion of the backwater, while rotifers are dominant in the upper reaches, where freshwater influx was relatively high. Factors influencing seasonal variation and distribution have also been discussed.

Keywords. Zooplankton ecology; major components; numerical abundance; peak occurrence; seasonal distribution.

1. Introduction

In a broad sense plankton is considered as an index of fertility (Prasad 1969) and the landings of fish are directly proportionate to the quantity of plankton (Chidambaram and Menon 1945). Because of its importance, considerable work has been done on the plankton of Kerala backwaters. A review of earlier literature reveals that most of the studies are confined to the Cochin Backwaters (George 1958; Menon *et al* 1972; Nair and Tranter 1972; Haridas *et al* 1973; Wellershaus 1974; Silas and Pillay 1975; Madhupratap 1978). Attempts have also been made to study the plankton ecology of Kayamkulam Lake (Mary John 1958), Ashtamudi Estuary (Divakaran *et al* 1982), Edava-Nadayara-Paravur Backwaters (Azis 1978; Azis and Nair 1982) and Veli Lake (Arunachalam *et al* 1982). However, no attempt has hitherto been made to examine the zooplankton ecology of Kadinamkulam Backwater—a brackish water lake of southern Kerala. As part of an ecological study, the hydrography, primary productivity and fish fauna of this backwater have been investigated by Nair *et al* (1983a,b, 1984). The present paper deals with the seasonal distribution of zooplankton in relation to some ecological factors.

2. Environment

Kadinamkulam Lake (lat. 8°35′–8°40′N and long. 76°45′–76°52′E) (figure 1) opens into the sea at Perumathura by a temporary barmouth. The Vamanapuram River flows into

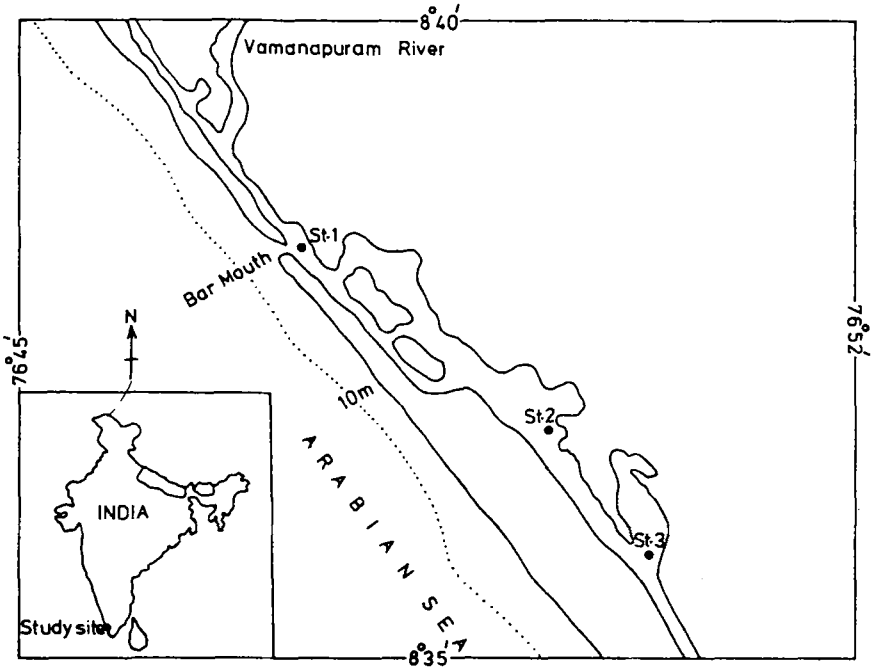

Figure 1. Map of Kadinamkulam Backwater.

the sea through this opening. During the present study the barmouth was found closed on three occasions for varying durations. The backwater is connected to the Anchuthengu Backwater on the north and the Veli Lake on the south. Retting of coconut husks in shallow enclosures on the banks poses a major threat of pollution. Three stations were selected for routine samplings. Station 1 is situated close to the barmouth and is subjected to frequent changes through tidal waves and river discharge. Station 2 represents the middle portion and station 3 is located at the distal portion and receives freshwater discharge from the Parvathiputhanar Canal.

3. Materials and methods

Plankton was collected at fortnightly intervals from February 1980 to January 1981 by horizontal surface hauls (using a Nansen type plankton net made of fine bolting silk) (mesh size 75 μ). The total distance over which the hauls were made was kept constant at 200 m. The samples were preserved following the procedure of Currie (1963) and examined using standard methods (Tranter 1960). Data on temperature, salinity and dissolved oxygen published earlier (Nair *et al* 1984) were used for finding the relationship between these parameters and the distribution of zooplankton. Data on rainfall and river discharge were obtained from the Water Resources Division, Public Works Department, Government of Kerala.

4. Results and discussion

4.1 *Hydrographic conditions*

Data on rainfall and river discharge are shown in figure 2. The year is divided into 3 seasons *viz* pre-monsoon (February-May), monsoon (June–September) and post-monsoon (October–January) on the basis of rainfall brought to this coast by south-west monsoon. Maximum precipitation was observed during June followed by a decreasing trend thereafter. River discharge showed an increasing trend during the monsoon with a peak during August. Seasonal variations in temperature, salinity and dissolved oxygen are presented in figure 3. Temperature distribution followed an uniform pattern throughout the backwater and a distinct seasonal pattern was discernible. It varied from 25·4–31·5°C at stn. 1, 28·2–33·8°C at stn. 2 and 28·3–34·6°C at stn. 3. It was maximum during the pre-monsoon and minimum during the monsoon. Salinity ranged from 7·8–28·9 $\times 10^{-3}$ at stn. 1, 6·4–22·8 $\times 10^{-3}$ at stn. 2 and 3·6–19·9 $\times 10^{-3}$ at stn. 3. Maximum salinity value was recorded during the pre-monsoon. There was a diminishing trend from stn. 1 to stn. 3 in the backwater with regard to salinity values. During the present study, a steep decline observed during the pre-monsoon was due to the closure of the barmouth which prevented the entry of seawater into the lake. Dissolved oxygen varied from 2·7–7·2 ml/l at stn. 1, 1·4–8·03 ml/l at stn. 2 and 0·5–7·8 ml/l at stn. 3 with minimum values during June at stn. 1 and in October at stn. 2 and 3.

4.2 *Seasonal distribution of the zooplankton*

Monthly variation of the total zooplankton at all the three stations in the Kadinamkulam Backwater is presented in figure 4. Seasonal distribution followed an

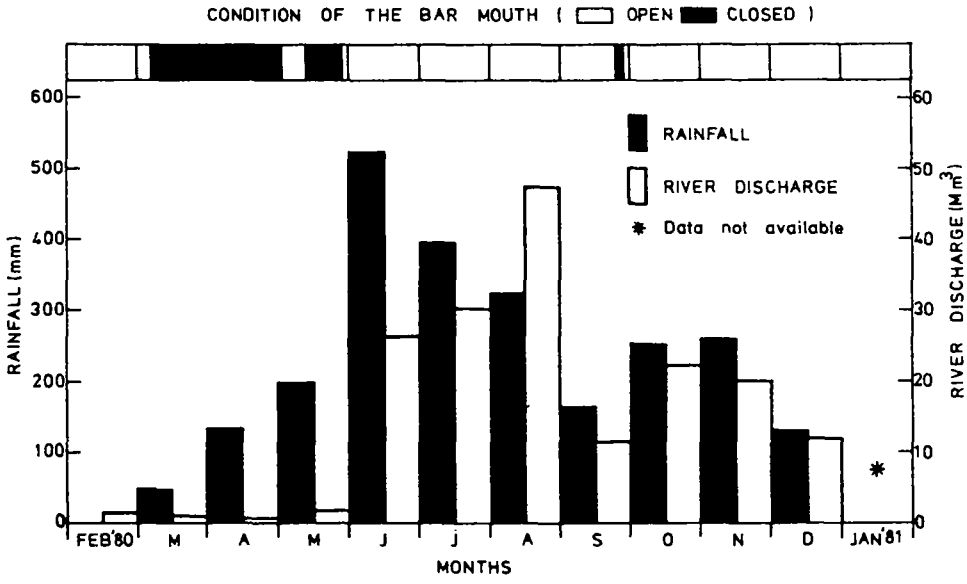

Figure 2. Monthly variations of rainfall and river discharge, and nature of the barmouth.

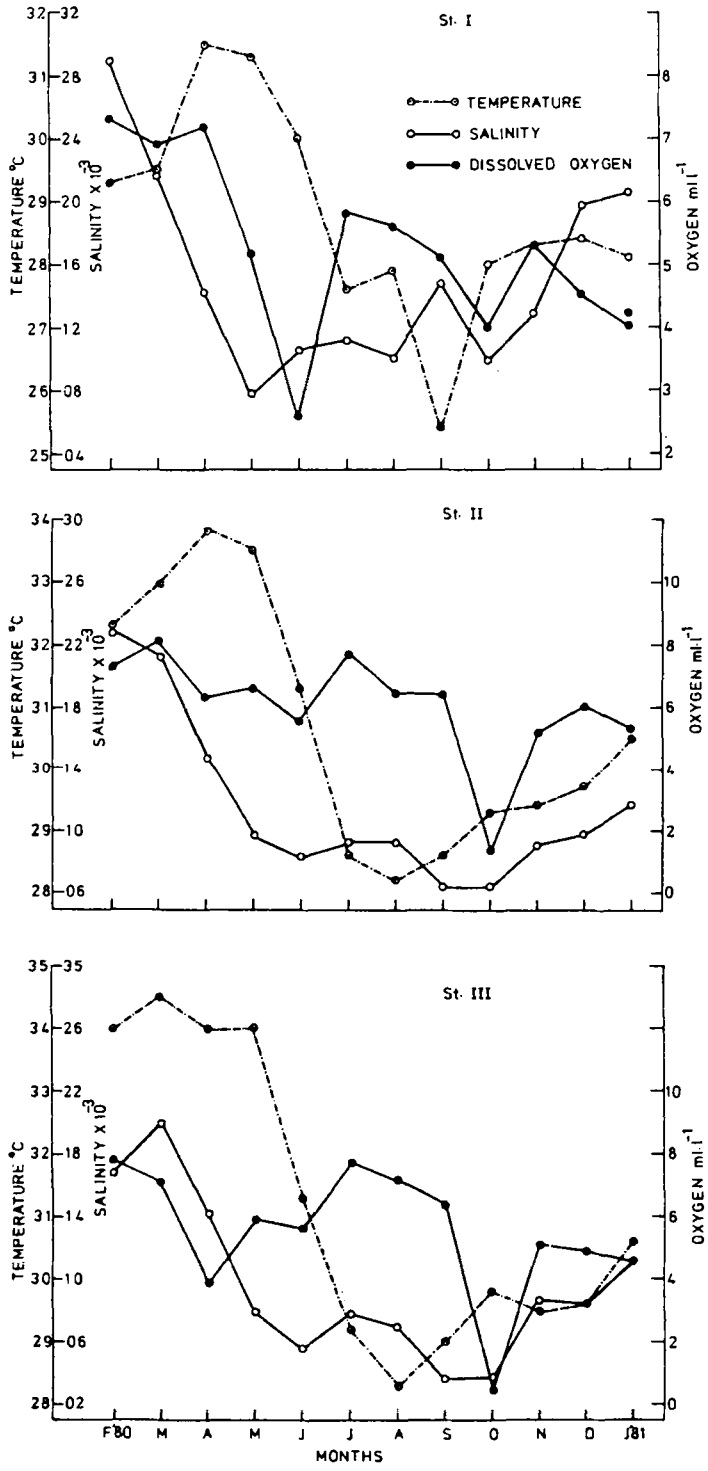

Figure 3. Monthly variations in surface water temperature, salinity and dissolved oxygen at stn. 1,2 and 3.

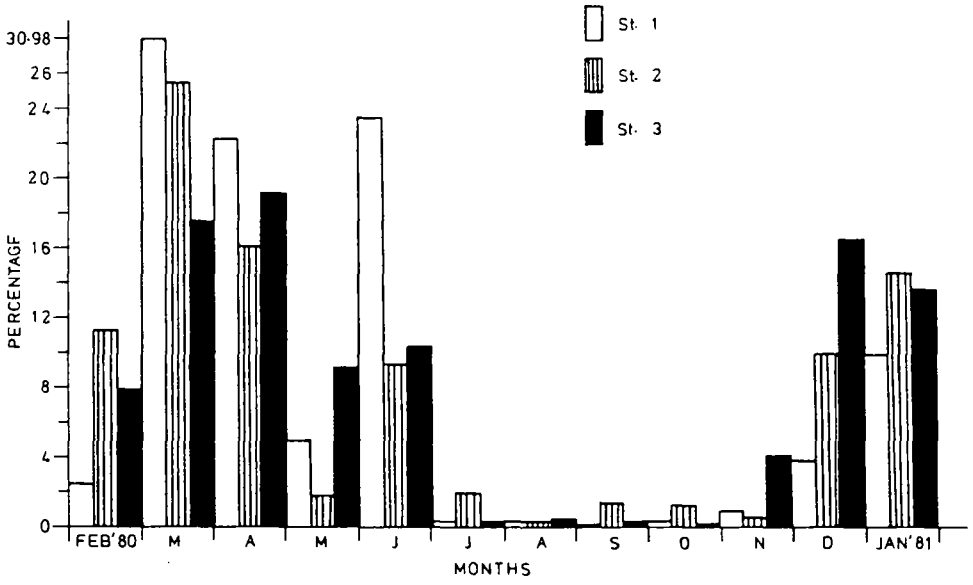

Figure 4. Monthly variations of total zooplankton at the three different stations in Kadinamkulam Backwater.

uniform pattern throughout the backwater. In general, a higher numerical abundance was observed during December–June and it was low during July–November. The highest number was recorded during March at stn. 1 and 2 and in April at stn. 3. There are two distinct peaks, a major peak during the pre-monsoon and a minor peak during post-monsoon. Studies by several authors have revealed that plankton differs considerably both in quality and quantity from place to place and from time to time. The present zooplankton distribution was very similar to that of Cochin Backwater with regard to its numerical abundance during the high saline pre-monsoon period (Silas and Pillay 1975; Madhupratap 1978). But in the Ashtamudi Estuary a major peak was observed during the monsoon and a minor peak during the post-monsoon (Divakaran *et al* 1982). However in the Veli Lake, a backwater adjacent to the Kadinamkulam, peak incidence was observed during the monsoon at the barmouth, while it was during the pre- and post-monsoon periods in the upper reaches (Arunachalam *et al* 1982).

4.3 *Zooplankton composition*

Different physico-chemical factors have their varying influence in the estuaries and convert them into specialised, dynamic environments. The zooplankton community occurring in these habitats consists of estuarine, marine and freshwater forms. Zooplankton in the Kadinamkulam Backwater is composed of foraminifers, coelenterates, nematodes, rotifers, chaetognaths, polychaetes, cladocerans, ostracods, amphipods, copepods, decapod larvae, insect larvae, bivalves, tunicates and fish eggs and larvae. Among these, rotifers, copepods and copepod nauplii are the major components which constitute the bulk of the zooplankton (nearly 98 %). A distinct regional variation was

discernible in the dominance of zooplankton components. Copepods constituted the dominant group at stn. 1 and 2 (52·89% and 55·75% respectively), while rotifers were dominant at stn. 3 (75·93%).

Dominant component of zooplankton has been reported to vary widely in different waters (Madhupratap 1978). However, copepods occupied the dominant position in Cochin backwaters (Madhupratap 1978), Edava-Nadayara backwaters (Azis 1978), Ashtamudi estuary (Divakaran *et al* 1982) and Veli lake (Arunachalam *et al* 1982). In Vellar estuary, Porto Novo, copepods constituted 91% of the zooplankton (Subbaraju and Krishnamurthy 1972). Recent studies in Nethravati-Gurupur estuary also revealed that copepods and copepodites together formed the bulk of the zooplankton (Bhat and Gupta 1983).

4.4 *Abundance and diversity*

Seasonal distribution of the different zooplankton components in the Kadinamkulam backwater is presented in figures 5–7 and station-wise distribution of copepod species is presented in table 1. Foraminifers appeared during January–April, June, August and November only at stn. 1. The highest number was recorded during August. It was represented mainly by *Nonion* sp. coelenterates, represented by hydromedusae, also appeared only at stn. 1 during January. Though chaetognaths were reported as abundant throughout the year in Cochin Backwaters (Vijayalakshmi Nair 1975) they appeared in Kadinamkulam backwater only on one occasion during the pre-monsoon period. Nematodes and polychaetes showed periodic incidence.

Rotifers formed a common group among the zooplankton components in Kadinamkulam Backwater. It constituted 34·15% of the total plankton at stn. 1, 39·82% at stn. 2 and 75·93% at stn. 3. They made their presence throughout the year at stn. 2 and 3 except during February, August and September at stn. 1. Like other major components, a declining trend in rotifers was noticed during the monsoon period. Their peak occurrence varied regionally with maximum numerical abundance during March at stn. 1, and with two peaks at stn. 2 (one during June and the other during December–January). At stn. 3, it occupied the dominant position througout the year and showed two peaks, one in April and the other in December.

Cladocera represented by *Evadne* sp and *Diaphanosoma* sp exhibited an irregular distribution. They were more frequent at stn. 1 with highest number during March. Ostracods and amphipods were sparsely observed and the latter appeared only at stn. 3 during the pre-monsoon period.

Copepods dominated at stations 1 and 2 and contributed to 52·89% at stn. 1, 55·75% at stn. 2 and 22·08% at stn. 3 of the total zooplankton. From the results a definite seasonal pattern is discernible in copepod distribution with more abundance during the high saline pre-monsoon period and lesser abundance during the low saline monsoon period. Their peak occurrence varied regionally, in April at stn. 1 and in March at stn. 2 and 3, resulting from the swarming of *Oithona* sp. calanoids, cyclopoids and harpacticoids formed the major groups. Of these, calanoids dominated in diversity and were represented by *Eucalanus* sp, *Acrocalanus gibber*, *A. gracilis*, *Centropages elongatus*, *C. alcocki*, *Pseudodiaptomus aurivilli*, *Paradiaptomus* sp and *Phyllodiaptomus* sp while *Oithona* sp and *Mesocyclops* sp represented cyclopoids, *Euterpina* sp and *Canthocamptus* sp were the harpacticoid representatives. *A. gracilis*, *C. elongatus*,

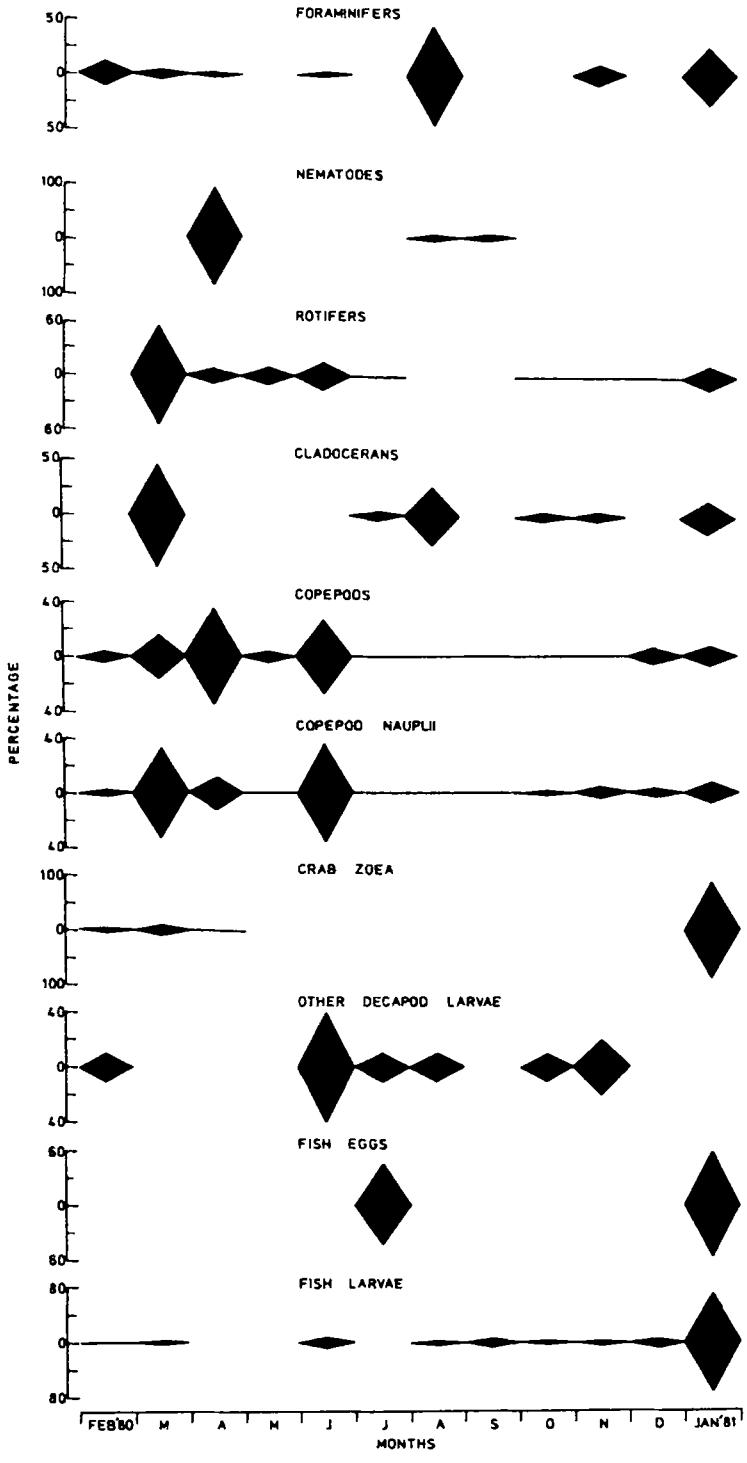

Figure 5. Seasonal distribution of different zooplankton components at stn. 1.

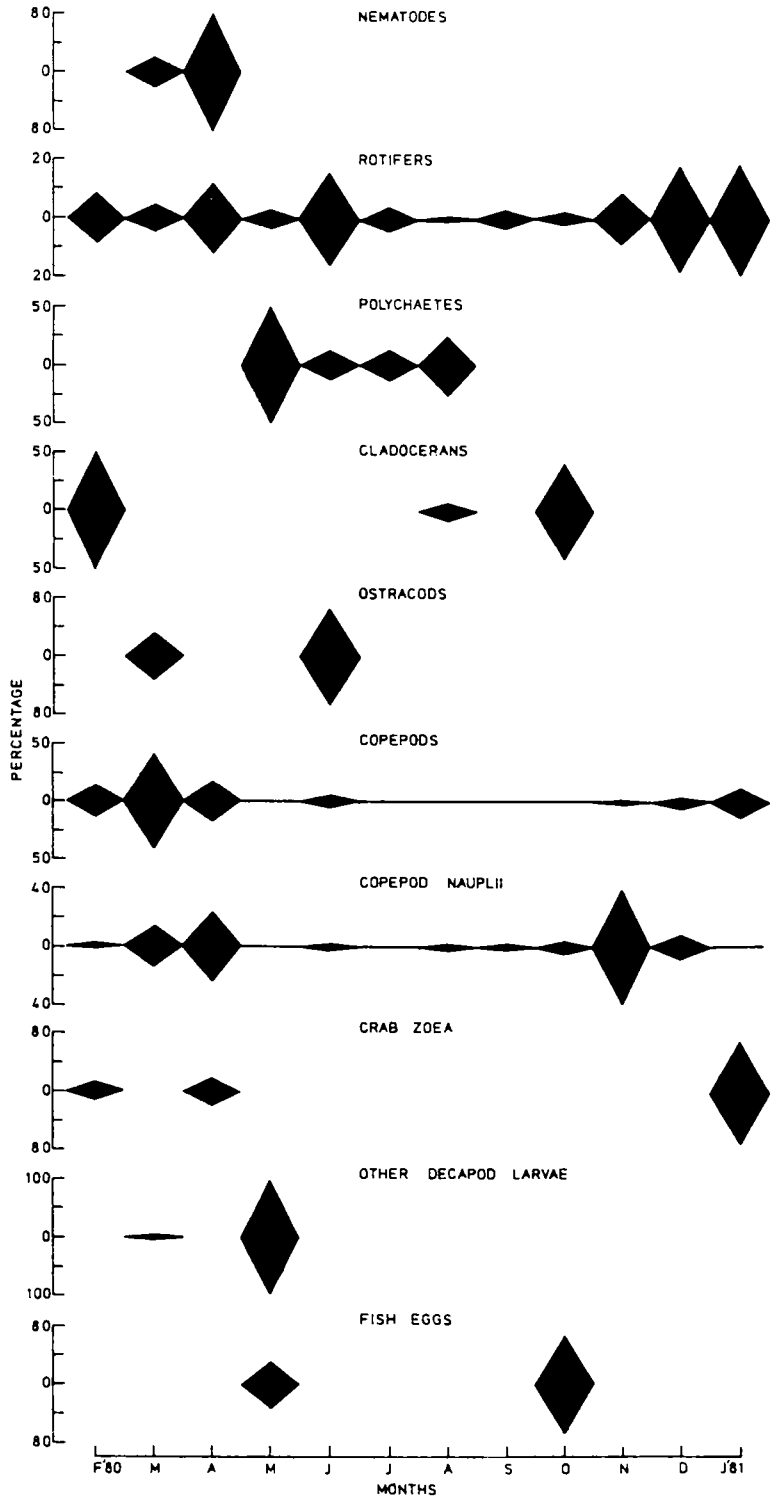

Figure 6. Seasonal distribution of different zooplankton components at stn. 2.

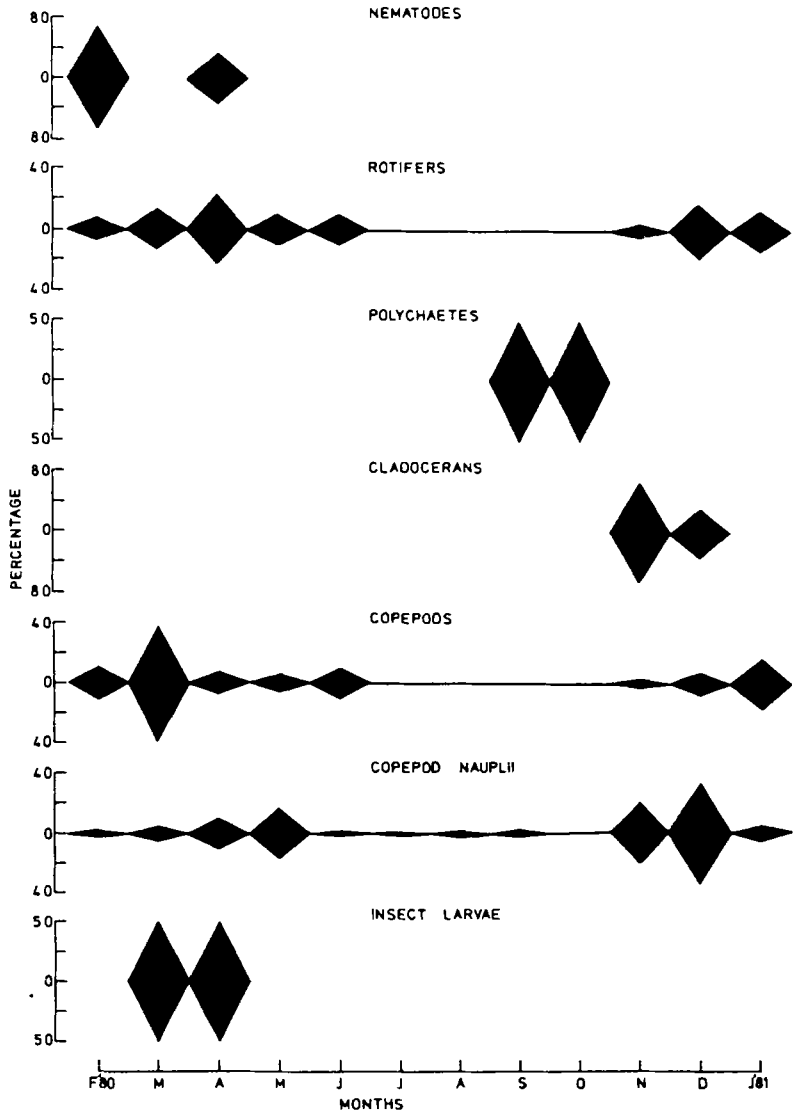

Figure 7. Seasonal distribution of different zooplankton components at stn. 3.

Oithona sp and *Mesocyclops* sp were common. Among these, *Oithona* sp was the most common and occurred throughout the year. *Mesocyclops* sp, a typical freshwater copepod, was abundant at the lesser saline stn. 3 while *C. elongatus*, an exclusively marine species was more common at the high saline stn. 1.

Copepod nauplii formed a significant part and recorded 11.5% at stn. 1, 4·30% at stn. 2 and 1·98% at stn. 3. Their highest number was noticed during the pre-monsoon period.

Decapod larvae were restricted only to stations 1 and 2. Among these, zoeae of Brachyura were well represented and occupied the dominant position. Their numerical

Table 1. Station-wise distribution of copepod species in Kadinamkulam backwater.

Species	Stn. 1	Stn. 2	Stn. 3
Eucalanus sp.	+	+	−
Acrocalanus gibber	+	+	−
A. gracilis	+	+	+
Centropages elongatus	+	+	+
C. alcocki	+	−	−
Pseudodiaptomus aurivilli	+	−	−
Paradiaptomus sp.	+	−	+
Phyllodiaptomus sp.	−	+	+
Oithona sp.	+	+	+
Mesocyclops sp.	+	−	+
Euterpina sp.	+	+	+
Canthocamptus sp.	−	+	−

(+: present; −: absent)

abundance was comparatively higher at stn. 1 with a peak during January. Penaeid larvae showed an irregular distribution.

Represented by *Pentaneura* sp, insect larvae appeared at stations 1 and 3 during the pre-monsoon and at stn. 2 during the monsoon period. In the Veli Lake, it formed an important component of the zooplankton at the interior region with a peak during the pre-monsoon (Arunachalam *et al* 1982).

Larval stages of *Villorita* sp, and tunicates represented by *Oikopleura* sp were recorded from stn. 1 during February.

Fish eggs were limited to stn. 1 and 2. Fish larvae appeared only at stn. 1 throughout the year except during April, May and July with a preponderance during January.

4.5 *Factors influencing distribution*

Although most zooplankton species survive under a wide range of environmental conditions their growth and density depend on a number of physical, chemical and biological factors (Swar and Fernando 1980). Hutchinson (1967) cited numerous studies which indicated that temperature regulated the birth rate, longevity and other population characteristics of zooplankton. The availability of food (Comita and Anderson 1959; Patalas 1972) and predation by planktivorous fishes and invertebrates (Swar and Fernando 1980) have also noticeable effects on the zooplankton community.

Kadinamkulam Lake, being a brackish water environment, undergoes frequent variation in the physico-chemical features. Among the ecological factors salinity is by far the most varied physical factor with a range of $3{\cdot}6$–$28{\cdot}9 \times 10^{-3}$. The extent of salt intrusion depends on a number of factors such as tidal regime, quantity of rainfall and freshwater influx. As Kadinamkulam Backwater is periodically exposed to the sea, the condition of the barmouth (closed or open) has a crucial role. In the present study salinity was low during the monsoon period. Zooplankton distribution in the backwater was well associated with salinity distribution, with a higher numerical

abundance during the high saline pre-monsoon months and a lower abundance during the low saline monsoon months. The effect of salinity in the distribution of plankton has been discussed by Madhupratap (1978) and Pillai *et al* (1973) in the Cochin Backwater. Apart from salinity, strong currents downstream and turbidity may be rendering the environment severe for many organisms during the monsoon (Madhupratap 1978).

Net primary production in the backwater varied from 0–378·79 mg $C/m^3/hr$ and gross primary production from 0–664·65 mg $C/m^3/hr$ with respective annual average of 84·28 and 152·33 mg $C/m^3/hr$ (Nair *et al* 1983a). The backwater is most productive during the monsoon period. Swar and Fernando (1980) discussed that the amount of food available to zooplankton is proportional to gross primary production of the particular water body. In Kadinamkulam Backwater zooplankton was least abundant during the monsoon indicating an inverse relationship with primary production. The intrusion of planktonic organisms from the sea and their existence in the lake depending on the hydrographic features, especially salinity and temperature and the ability of the estuarine and freshwater species to survive under the widely fluctuating conditions of the environment seem to determine among other factors, the nature of the plankton in these habitats.

Acknowledgement

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