Methods

The region and details of sampling has been dealt with elsewhere (Pillai *et al.*, 1973). Zooplankton samples collected at weekly intervals for a period of fifteen months (December, 1969 to February, 1971) were analysed and the cladoceran component of the samples sorted out, identified and counted up to the species. Measurements of temperature and salinity were made from the same station along with the zooplankton samples.

Hydrography

The annual rainfall in the Cochin Backwater is about 3.2 cm with fluctuations noticeable from year to year. The influence of the freshwater runoff on the hydrographical properties of the Cochin Backwater is considerable. Surface temperature evinced a bimodal distribution during the course of the period (Fig. 1). Temperature values decreased by the onset of monsoon and maximum temperature was recorded during pre-monsoon period. The range in temperature values was 27.6 - 31.3°C. (August and April respectively). Surface salinity showed maximum variation and fluctuated between 1.36 ‰ (July) to 34.53 ‰ (April) (Fig. 1). The commencement of the decreasing trend coincided with the onset of monsoon and during post-monsoon period a gradual rise in salinity values was observed. By the pre-monsoon months, maximum values were recorded.

Quantitative Distribution

Three species, *Evadne tergestina*, *Penilia avirostris* and *Podon* sp. were recorded during the present study, but the former two species make up the majority of the cladoceran component of the zooplankton and as such the seasonal fluctuations in their distribution has been dealt with separately in this report.

Evadne tergestina Claus (Figs. 1, 2*a*)

Members of this species were observed in the samples almost during all the seasons except the monsoon months of May and June (Fig. 1). They were common in the plankton collected during December, 1969. After a short diminution in January, 1970, they recorded a numerical increase during February since when a decline in their number was noted. They were absent in the plankton during May and June. This species reappeared in the samples in July and the period of their peak occurrence was the intermediate post-monsoon months. During September, maximum numbers (8187/m^3) were recorded and during this period females were observed to carry brood pouch with eggs. After October, 1970, their number dwindled in the plankton

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ECOLOGY OF THE CLADOCERANS OF THE PLANKTON COMMUNITY IN THE COCHIN BACKWATER

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ABSTRACT

Occurrence and seasonal changes in the distribution of two cladocerans in the Cochin Backwater, *Evadne tergestina* Claus and *Penilia avirostris* Dana have been considered. Fluctuations in temperature of the estuary are of the order of 5°C., while the changes in salinity are considerable. Seasonal variation in distribution of the two species has been correlated with temperature and salinity in T-S-P diagram for a period of fifteen months. Their numerical abundance month-wise has also been investigated. A comparative study of the distribution of cladocerans of the inshore waters of India with that of the Cochin Backwater has also been carried out.

Although various groups of zooplankters occurring in Cochin Backwater have been investigated in detail, comparatively little attention has been paid to study the species composition and ecology of cladocerans of this area. George (1958) in his pioneering studies on the plankton distribution in the canals and the connected estuarine waters around Cochin recorded the presence of *Evadne tergestina* Claus as the common cladoceran of the canal plankton. Nair and Tranter (1972) opined that cladocerans were present towards the mouth of the estuary and were conspicuous by their absence during the post-monsoon period. Menon *et al.* (1972) observed that the members of the genera *Evadne* and *Penilia* were 'the dominant representatives' of the cladocerans of the zooplankton of Cochin Backwater. The present investigation is aimed at understanding the species composition of cladocerans in the estuarine waters around Cochin, their seasonal distribution and succession in relation to hydrographic features and comparison of their quantitative distribution in the estuarine and neritic waters along the west cost of India.

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collections and in December only few specimens were observed. As recorded previously they were numerically high during February, 1971.

Penilia avirostris Dana (Figs. 1, 2*c*)

During December, 1969, this species was observed in the plankton and they were absent till August, 1970. Their reappearance in August was followed by their numerical peak during October, thus outlasting the peak occurrence of *E. tergestina* by a few weeks. They were quantitatively less during December, 1970 and few specimens were recorded during February, 1971. Most of the females recorded were parthenogenetic females although sexual females and males were also present in the collections.

Discussion

Seasonal cycle and quantitative distribution

George (1958) recorded *E. tergestina* in considerable numbers in the Cochin Backwater during July, August and September and less numerically in October. He also commented that they were absent during the high salinity period from November and according to him the entry of these forms from the neighbouring coastal waters to the estuarine area may either be due to their abundance in the inshore waters during the post-monsoon period or due to their active breeding habits. Nair and Tranter (1972) recorded cladocerans from the mouth of the estuary and stated that 'they were conspicuous by their absence towards the head of the estuary during the pre-monsoon periods'. However, Menon *et al.* (1972) observed cladocerans at Aroor, a typically estuarine habitat during both high and low salinity periods. Present observations show that the distribution of cladocerans, especially *E. tergestina* is more or less year round and their peak occurrence coincided with the post-monsoon months of September to October (Fig. 1), which are in concurrence with the observation of Menon *et al.* (1972).

Out of the four species of cladocerans recorded from the Indian Ocean, *viz. Evadne tergestina*, *E. spinifera*, *Podon polyphemoides* and *Penilia avirostris*, *E. tergestina* is widely distributed in both the coastal and oceanic waters and the other species are restricted mostly to the coastal waters. Further, Nair *et al.* (1973) reported that the peak abundance of cladocerans was noticed (900/haul) off Cochin, Goa, Gulf of Cambay and Karachi Coast. According to Della Croce and Venugopal (1972) *E. tergestina* is present discontinuously throughout the year in costal waters of Arabian Sea where it reaches high density populations in some areas in November. During March to May this species was observed in offshore waters indicating of seaward transport during the monsoon transitional period. From the Madras Coast Rajagopal (1962) recorded the maxima of *E. tergestina* during March to

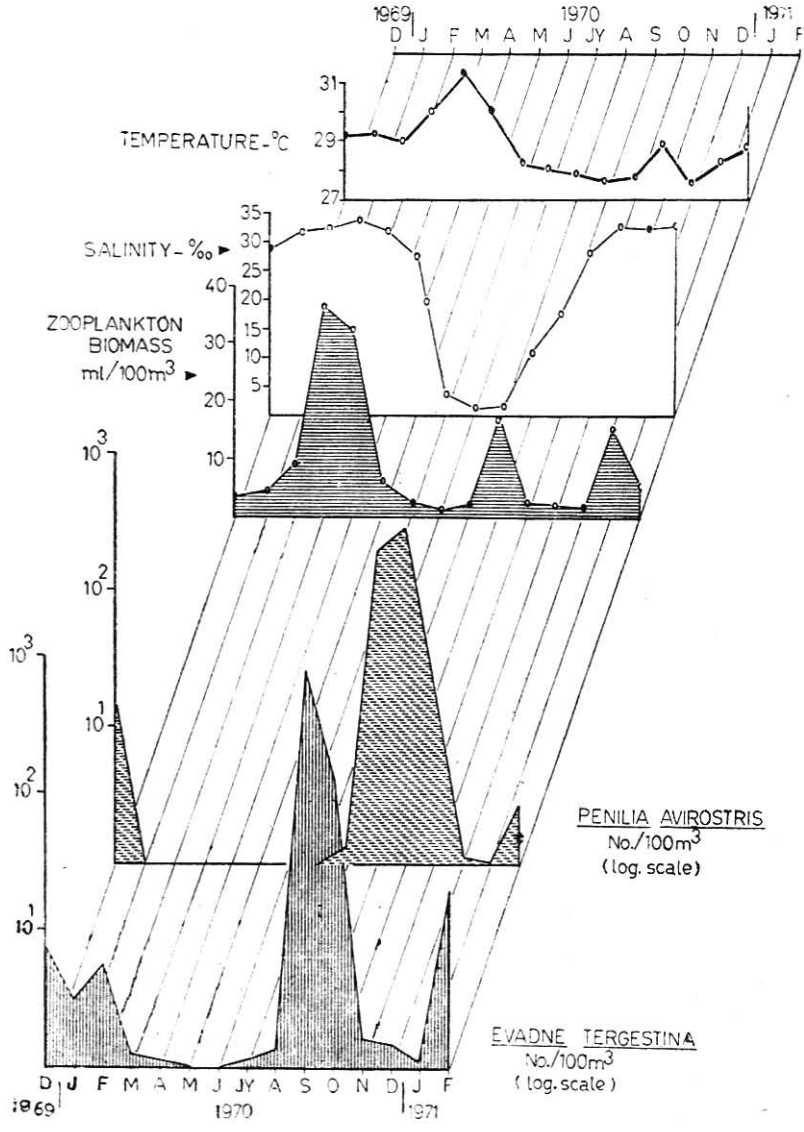

Fig. 1. Monthly distribution of Temperature, Salinity, zooplankton biomass and mean (monthly) numbers of *Evadne tergestina* and *Penilia avirostris* in the Cochin Backwater during December, 1969 to February 1971.

May. Vijayalakshmi and Venugopalan (1972) observed *Penilia avirostris* during a single season (March to April) with a peak occurrence in April.

One characteristic feature observed during the present study on the distribution patterns of cladocerans is that the commencement of their swarming is as abrupt as their tapering off. This may be due to the fact that they reproduce in successive generations quickly, by active and efficient parthenogenesis in addition to amphimetic reproduction. According to Wickstead (1965) 'for the greater part of the year they will be absent. Then, when the resting eggs hatch one or two will be caught. After this the numbers will increase rapidly. Within six months or so *Penilia* can range from being completely absent to being present in numbers like 2500/m^3 forming over fifty percent of the plankton in number'. According to Vijayalakshmi and Venugopalan (1972) maximum of *P. avirostris* was recorded in the Porto Novo waters during April, which coincide with the month of diatom abundance (diatoms 528 x 10^3 cells/m^3). The population lasted for a period of only three months. Parthenogenetic females were common than males and sexual females which constituted only 3% and 0.4% of the total *Penilia* population suggesting that cyclical parthenogenesis occurs at the Porto Novo waters. Such rapid numerical increase and waning out has been reported to be more or less regular at different areas in the coastal waters along the west coast of India (George, 1953; Ramamurthy, 1965; Mukundan, 1971).

T - S - P relationship (Fig. 2 *b, d*)

E. tergestina and *P. avirostris* exhibit distribution patterns which seem to depend on the local hydrographical conditions. Earlier records on the occurrence of cladocerans in the Cochin Backwater in relation to salinity show that they are recorded in a wide range of salinity (George, 1958: 2.00 to 11.00 ‰; Menon *et al.*, 1972: 0.6 to 32.8 ‰). Present study on the temperature-salinity relationship of the two species of cladocerans shows that *P, avirostris* is more restricted in distribution, while *E. tergestina* occurs in a wide range of salinity, both the species showing abundance during the period when the salinity and temperature values are relatively low (Fig. 2 *b, d*). *P. avirostris* was observed to prefer low temperature of the environment and they were recorded within a temperature range of 26.5 - 30.0°C. Ramamurthy (1965) recorded the occurrence and abundance of cladocerans in the coastal plankton of the North Kanara waters and according to him *E. tergestina* would appear to prefer a lower salinity (16.17 - 30.94 ‰) than *Penilia* (29.00 – 33.56 ‰). Della Croce and Venugopal (1972) reported the occurrence of *P. avirostris* off Bombay Coast at a surface temperature of 30.18°C and 8.7°C. remaining the lower limit. Vijayalakshmi and Venugopalan (1972)

observed that *Penilia* occurred in the plankton within the salinity range of 31.8 - 33.9 ‰ and temperature range of 29.0 - 31.0°C. According to Dutta *et al.* (1954), for freshwater cladocerans temperature between 21 - 22°C. accompanied with low turbidity, is presumably most favourable for their occurrence. During the present observation we have noted the occurrence of *P. avirostris* and *E. tergestina* in lower salinities as low as 11.09 ‰. This difference in observation may be due to the fact that in the estuarine environment extensive fluctuations in salinity values were observed while in coastal waters such extreme values are seldom met with. However, no decisive conclusion could be drawn on the tolerence of these species to different salinity gradients as only limited data is available.

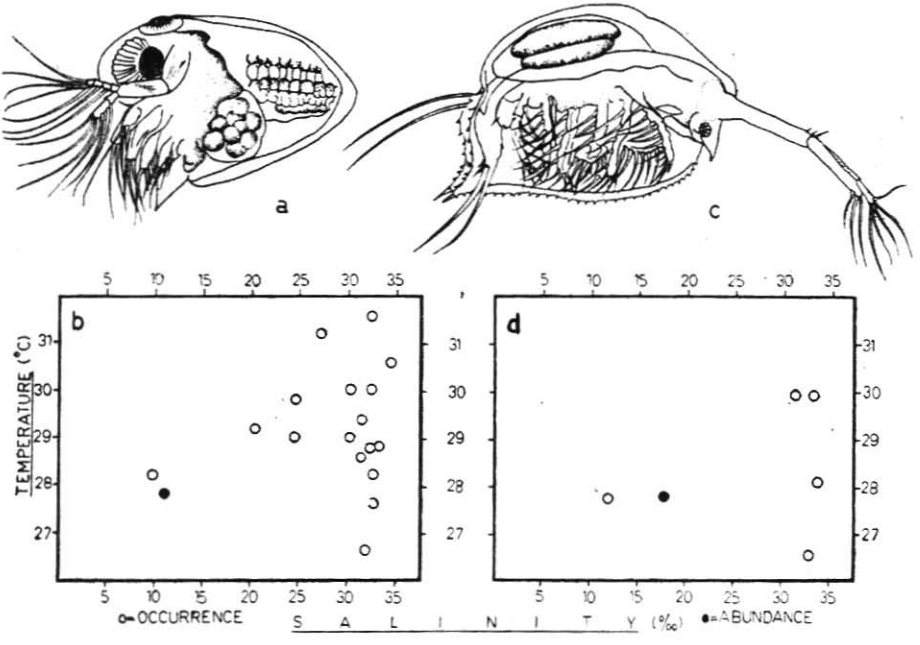

Fig. 2. *a. Evadne tergestina* Claus, lateral view; *b.* T - S - P relation of *E. tergestina*; *c. Penilia avirostris* Dana, lateral view; *d.* T - S - P relation of *P. avirostris* (open circles indicate their occurrence and closed circles their abundance).

An interesting parallel could be observed in the quantitative distribution of cladocerans in the neritic waters and in the estuaries. Pillai and Pillai (1973) while studying the tidal influence on the diel variations of zooplankton in the Cochin Backwater observed that a clear relationship is evident between the abundance of cladocerans and tidal variations in the

estuarine area. A comparative study of the previous records of the distribution patterns of cladocerans in the inshore waters of the west coast of India reveals that they attain maximum occurrence and abundance both in the sea and in the backwater at more or less the same time. The period of their abundance previously recorded at various centres along the coastal waters of the west coast of India is during the post-monsoon months of September - November (Table 1). Pillai (1970) observed that cladocerans were fairly abundant in the plankton of Bombay Coast during May and according to him 'in no other samples they occur in noticeable numbers'. The significance of such an early attainment of their abundance is not apparent in the light of the hydrographic data, the values of which were maximum during May (Temperature: 30·0°C; Salinity: 36.20‰). However, Bhargava *et al.* (1973) observed cladocerans along Panaji - Bombay Coast during September to January and Della Croce and Venugopal (1972) recorded their abundance at Bombay during November - December period. It is also apparent that there is a south to north movement of cladocerans along the west coast of India which is evident from the reports of their distribution and abundance during different months of the year from various centres along the coast.

Table 1. *Periods of peak occurrence of cladocerans at different centres along the coastal waters of India*

Location	*Author* (s)	*Peak period* (s)
Madras Coast	Rajagopal (1962)	March - May
Porto Novo waters	Vijayalakshmi and Venugopalan (1972)	March - April
Trivandrum Coast	Menon (1945)	July, October
Cochin Backwater	George (1958)	August - September
	Menon *et al.* (1972)	September
	Present study	September - October
Calicut Coast	George (1953)	September - October
	Mukundan (1971)	July, October
North Kanara Coast	Ramamurthy (1965)	September - October
Panaji to Bombay Coast	Bhargava *et al.* (1973)	September - January
Bombay Coast	Pillai (1970)	May
	Della Croce and Venugopal (1972)	November - December
Coastal waters of Arabian Sea	Della Croce and Venugopal (1972)	November

The coincidence of the cladoceran maximum with that of the other groups of the zooplankton community was also observed in the Cochin Backwater. After the monsoonal decline in population, copepods in the Cochin Backwater evince a gradual rise in number and biomass during the months of September - November when their secondary maximum was noticed (Pillai *et al.*, 1973). During this period fish eggs and larvae were recorded in maximum numbers indicative of active breeding of fishes. The relationship of mackerel fishery of the west coast of India to the abundance of cladocerans has been reviewed by Selvakumar (1970) and according to him, the movement of cladocerans is followed by mackerel shoals from south to north during late monsoon. With the avilable information it is difficult to ascertain the exact nature of the migratory behaviour of mackerels in relation to the abundance of cladocerans since the former involves various environmental factors as well. However, the coincidence of the abundance of cladocerans during this period is noteworthy as similar abundance has been reported from the Calicut Coast (George, 1953; Mukundan, 1971), and as opined by George (1953) 'cladoceran maximum also coincides with the peak fishery along the Calicut Coast and the cladocerans have been observed to form the important food of the shoaling fishes'.

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