

ZOOPLANKTON STUDIES IN THE
COCHIN ENVIRONS

THESIS SUBMITTED TO THE COCHIN UNIVERSITY
IN PARTIAL FULFILMENT FOR THE DEGREE OF
DOCTOR OF PHILOSOPHY

By

P. HARIDAS M.Sc.



REGIONAL CENTRE
NATIONAL INSTITUTE OF OCEANOGRAPHY
COCHIN - 682 018

C E R T I F I C A T E

This is to certify that this thesis is an authentic record of the work carried out by Mr. P. Haridas, M.Sc. under my supervision at the Regional Centre of National Institute of Oceanography, Cochin and that no part thereof has been presented before for any other degree in any University.

T S S

(T.S.S. RAO)

HEAD
BIOLOGICAL OCEANOGRAPHY DIVISION
NATIONAL INSTITUTE OF OCEANOGRAPHY
GOA.

SUPERVISING TEACHER.

Dona Paula.

30-12-'82

C E R T I F I C A T E

This is to certify that this thesis is an authentic record of the work carried out by Mr. P. Haridas, M.Sc. under my joint supervision with Dr. T.S.S. Rao at the Regional Centre of National Institute of Oceanography, Cochin and that no part thereof has been presented before for any other degree in any University.

Mkr8888

(M. KRISHNANKUTTY)
SCIENTIST-IN-CHARGE,
NATIONAL INSTITUTE OF OCEANOGRAPHY,
REGIONAL CENTRE,
COCHIN - 682 018.

Cochin-18.

30.12.82



**ZOOPLANKTON STUDIES IN THE
COCHIN ENVIRONS**

C O N T E N T S

		Page
1.	INTRODUCTION	1
1.1.	Definitions and classifications of estuaries	4
1.2.	Review of the earlier works	7
2.	MATERIALS AND METHODS	12
2.1.	Areas of work	12
2.2.	Methods	18
2.2.1.	Sampling procedure	18
3.	HYDROGRAPHY	20
3.1.	Cochin backwaters	21
3.1.1.	Salinity	21
3.1.2.	Temperature	23
3.1.3.	Oxygen	25
3.2.	Comparison with other estuaries	26
3.2.1.	Comparison of Neendakara, Kallai, Beypore, Korapuzha and Mahe estuaries	28
3.2.2.	Comparison of Veli and Thottappilly Lakes	31

C O N T E N T S (Contd.)

					Page
4.	ZOOPLANKTON	..	..	..	36
4.1.	Zooplankton biomass and abundance	..	..	..	38
4.2.	Composition and distribution of zooplankton	..	..	..	41
4.2.1.	Hydromedusae	..	..	..	42
4.2.2.	Siphonophora	..	..	..	47
4.2.3.	Ctenophora	..	..	..	48
4.2.4.	Chaetognatha	..	..	..	49
4.2.5.	Cladocera	..	..	..	52
4.2.6.	Ostracoda	..	..	..	54
4.2.7.	Copepoda	..	..	..	55
4.2.8.	Amphipoda	..	..	..	72
4.2.9.	Sergestidae	..	..	..	73
4.2.10.	Mysidacea	..	..	..	74
4.2.11.	Cumacea	..	..	..	74
4.2.12.	Isopoda	..	..	..	75
4.2.13.	Invertebrate larvae	..	..	..	75
4.2.14.	Fish eggs and larvae	..	..	..	78
4.2.15.	Appendicularia	..	..	..	79
4.2.16.	Thaliacea	..	..	..	79
4.3.	General discussion	..	..	..	80

C O N T E N T S (Contd.)

					Page
5.	COMMUNITY STRUCTURE	..	..	..	89
6.	SPECIES DOMINANCE AND SUCCESSION	..			96
7.	SPECIES DIVERSITY	..	..	..	103
8.	ZOOPLANKTON ASSEMBLAGES		..	..	110
9.	SUMMARY	..	..	..	119
10.	BIBLIOGRAPHY	..	..	..	130
	TABLES 1 to 11	..	..	..	149
	FIGURES - 31 NOS.				
	APPENDIX - PUBLISHED PAPERS (9 NOS.)				

.....

1. INTRODUCTION.

Estuaries are important areas of human use for fisheries, transportation, food production and recreational pursuits. They form the nursery grounds for the larvae and young ones of numerous marine species, many of them commercially important. However, often they are turned into receptacles of human wastes and subject to pollution from industrial effluents.

Estuaries are highly productive areas and contribute substantially to the productivity of the coastal waters. With the depleting marine food resources and increasing population, the focus has now shifted to aquaculture. Estuaries because of their accessibility and semi enclosed nature, have emerged as ideal sites for these activities.

Various kinds of estuaries from coastal plain estuaries to steep sided fjords exist, all with the common feature of being areas where fresh water meet with sea water, thus forming buffer zones between the marine and limnetic counterparts. The most glaring environmental feature of the estuaries is the wide nature of fluctuations that occur in them. Understandably, estuaries have developed its own flora

and fauna which are capable of withstanding or adapting to these changes. A cursory look at any estuarine biota will show predominantly estuarine forms, mixed with some stragglers from the adjoining marine and fresh water environments.

A proper understanding of the environmental parameters and their effects on the biota is a must in the management of any ecosystem. Zooplankton form a vital link in the trophic chain of any aquatic ecosystem. Their production and abundance can be directly linked with the potential of an area both for capture and culture fisheries. Apart from this, their composition and distribution provides interesting insights into many ecological concepts like community structure, species diversity, species coexistence and evolution. In the ensuing account it will be shown that the estuarine zooplankton have its own distinctive assemblages - different from the adjoining marine or fresh water environments - able to withstand the peculiarities nature has imposed on them.

India has several major riverine/estuarine systems (Fig. 1). Along the east coast are the Hoogly, Mahanadi, Godavari, Krishna and Cauvery. On the west coast we

have the Narmada and Tapi of the Gujarat and Mandovi-Zuari estuaries of Goa. The Pulicat and Chilka lakes of the east coast and the Vembanad lake of the west coast form large bodies of brackish water. Apart from these, many medium and minor rivers (about 100) also contribute to the estuarine wealth of India. The rivers together have a catchment area of more than 3 million sq. km and a runoff of 1,600 million cu. m (Khosla, 1951; Rao, 1975). The total runoff of the major riverine systems of the east and west coasts of India is given in Table 1. Of this, the discharge from the rivers of the Kerala coast is estimated at 2.56×10^4 million cu. ft/year (Karunakaran, 1982).

The State of Kerala has many estuarine systems, the hydrobiology of which are greatly influenced by the monsoons. Of the tropical monsoonal estuaries of Kerala, the Cochin backwaters have received most of the attention of the scientific community. The present work on zooplankton of brackish water environs of Cochin was made more broad-based as data from seven other estuaries located along a 500 km stretch of the coast also came on hand. Thus this is the first attempt of its kind to study and compare the estuarine zooplankton of a coast receiving the full impact of both the monsoons. However, in carrying out sampling programme covering such a wide area several logistic problems arose and the observations had to be limited to one station each near

the mouth in the estuaries, except Cochin backwaters. In the following account, the distribution and other aspects of zooplankton from Cochin backwaters will be used as the spring board to evaluate the similarities and variations in the ecology of estuarine zooplankton in the other areas of study.

1.1. Definitions and classifications of estuaries.

Various definitions have been put forward by different authors for estuaries. Ketchum (1951) defined an estuary "as a body of water in which the river water mixes with and measurably dilutes sea water". Emery and Stevenson (1957) described it as the mouth of a river or an arm of the sea where the tides meet the river currents. They differentiated two types based on salinity and tidal characteristics.

1. 'Normal' type where due to river discharge salinities are reduced as one goes upstream.
2. 'Hypersaline' or negative estuary where exchange is poor and salinities are much higher than neighbouring sea. Various classifications are also put forward by Day (1951) and Rochford (1951).

Pritchard (1952a) defined estuary as a semi-enclosed coastal body of water having a free connection with the open sea and containing a measurable quantity of sea salt. He classified the estuaries in terms of fresh water inflow and evaporation into (1) 'Positive' estuaries, where there is a measurable dilution of sea water by land drainage, (2) 'Inverse' estuaries where evaporation exceeds precipitation and (3) 'Neutral' estuaries where neither fresh water inflow nor evaporation dominates. But Pritchard later (1967) modified his original definition for estuaries as "a semienclosed coastal body of water which has a free connection with the open sea and within which sea water is measurably diluted with fresh water derived from land drainage". He prefers to reserve the term 'estuary' without any qualifying adjective to those bodies which he previously called 'positive estuaries'. This is probably the most recent and commonly recognised definition for estuaries.

A classification based on topography has been presented by Pritchard (1952b). He divides the estuaries into four groups: Drowned river valleys or coastal plain estuaries, fjords, bar built estuaries and estuaries produced by tectonic processes.

1. Drowned river valleys or coastal plain estuaries are those which have been formed by drowning of former river valleys either from a subsidence of land or from a rise in sea level. They are usually an elongated indenture of the coastline with the river flowing into the upper end.
2. Fjords are generally 'U' shaped in cross-section most of them having a river entering at the head and exhibiting estuarine features in the upper layers.
3. Bar built estuaries result from the development of an offshore bar on the shoreline and have a relatively small channel connecting the estuary with the ocean. They are shallow within, and run parallel to the coastline with frequently more than one river entering the estuary.
4. Coastal indentures formed by tectonic processes like faulting or local subsidence having an excess supply of fresh water form another group.

The original definition of Pritchard is further refined by Caspers (1967) who feels that it would include both estuaries and lagoons. He differentiates lagoons

as those having a stable body of brackish water whereas in estuaries the mixing of fresh and marine waters is not stable but shows periodic changes.

1.2. Review of the earlier works.

Considerable amount of work on the physical, chemical, biological and other related aspects of various estuaries have come out in the last 50 years. These studies have contributed to a better understanding of the physical and biological processes taking place in the estuarine systems.

Earlier reports on estuaries include studies on the South African estuaries by Day (1951, 1967); Day et al. (1952, 1954, 1956); Australian estuaries by Rochford (1951) and Chesapeake Bay by Fritchard (1952a, b; 1954, 1956). Contributions on estuarine hydrography, circulation, fauna and their ecology have come from Bowden (1960, 1963); Emery and Stevenson (1957), Hedgepeth (1957), Jeffries (1962a, b, c, d), Ketchum (1951, 1954) and Odum (1971). A treatise on various aspects of estuarine research and management by outstanding authors is presented in "Estuaries" (Lauff, 1967).

Pioneering studies on the estuaries in India date back to the beginning of this century. The fauna of the Ganges delta was described by Annandale (1907), Alcock (1911) and Kemp (1917). Excellent studies on systematics and taxonomy have come from the Chilka Lake (Annandale and Kemp, 1915; Sewell, 1924). Some interesting work was carried out on the brackish water fauna of Madras area by Panikkar and Aiyer (1937) and Panikkar (1951) reviewed the physiological adaptations of animals. Godavari estuary has been studied in detail in 1964 (ICAR Report) by Chandra Mohan (1963) and Chandra Mohan and Rao (1972). Vellar estuary of Porto Novo has been studied by Seshaiya (1959), Rangarajan (1959), Krishna Moorthy (1961), Ramamoorthy et al. (1965), Subbaraju and Krishna Moorthy (1972), Krishna Moorthy and Sundar Raj (1973), Devendran et al. (1974). Various aspects like hydrography, circulation, chemistry, phytoplankton, benthos etc. from Mandovi-Zuari estuarine system of Goa have been studied by Das et al. (1972), Singhal (1973), Parulekar et al. (1973, 1980), Cheriyan et al. (1974, 1975), Bhargava and Dwivedi (1974), Goswami and Singhal (1974), Goswami and Selvakumar (1977), Rao (1974), Varma et al. (1975). Compiled information on the more recent works on the various aspects of estuarine biology has come from Natarajan (1973) and Kurian (1977).

The backwaters of Cochin is one of the better studied estuaries in India. General hydrography of the estuary was studied by Ramamirtham and Jayaraman (1963), Darbishire (1967), Wellershaus (1972), Haridas et al. (1973) and Shynamma and Balakrishnan (1973). The tidal fluctuations were reported by George and Krishna Kartha (1963) and Qasim and Gopinathan (1969); Solar radiation by Qasim et al. (1968); nutrient distribution by Sankaranarayanan and Qasim (1969); Joseph (1974) and Manikoth and Salih (1974); silting by Gopinathan and Qasim (1971); sediments by Murty and Veerayya (1972 a, b) and Veerayya and Murty (1974); phosphate regeneration by Reddy and Sankaranarayanan (1972) and nanoplankton by Qasim et al. (1974). The organic production and phytoplankton ecology and related aspects have been studied by Qasim and Reddy (1967), Qasim et al. (1969), Qasim (1970) and Devassy and Bhattathiri (1974). Some work on the pollution problem in the estuary has been reported by Unnithan et al. (1975), Saraladevi et al. (1979), Remani et al. (1980 a, b; 1981) and Venugopal et al. (1980). The changes in the ecology of the system brought about by man-made changes were reviewed by Qasim and Madhupratap (1979).

The general composition of the zooplankton of Cochin backwaters was published by George (1958). Some aspects of seasonal changes in zooplankton have been studied by Nair and Tranter (1971), Wellershaus (1974) and Menon et al. (1971). Distribution and ecology of some of the groups of zooplankton has been studied by various authors, such as hydromedusae by Santhakumari and Vannucci (1971); chaetognaths by Vijayalakshmi Nair (1971, 1973) and Sreenivasan (1971); copepods by Pillai (1971), Pillai and Pillai (1973), Pillai et al. (1973) and species of the family A cartiidae by Tranter and Abraham (1971). An account of the taxonomy of copepods in the estuary is given by Wellershaus (1969, 1970), species composition and their seasonal fluctuations in the estuary by Madhupratap and Haridas (1975) and Rao et al. (1975). Studies on the tidal influence on the estuarine zooplankton, community structure and ecology of some species of copepods have come from Madhupratap (1978, 1979, 1980). Magnitude of secondary production in the Cochin backwaters has been studied by Madhupratap et al. (1977).

Studies on the other estuarine systems along the Kerala coast are scanty and discontinuous. Some preliminary hydrobiological and planktonological investi-

gations in the river mouth at Korapusha estuary were made by ~~Rao~~ ^{Suryanarayana Rao} and George (1959), George (1953 a, b) and Varkey John (1971); at Beypore by ~~Varkey~~ John and Alexander (1968). Recently Murugan et al. (1980) have studied the benthic fauna of Veli Lake. Mathew and Balakrishnan Nair (1980) have studied the phytoplankton of Ashtamudi (Neendakara) estuary. The numerous other estuaries of Kerala coast have received little attention.

.....