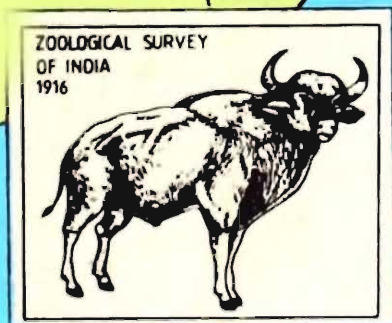


ESTUARINE ECOSYSTEM SERIES
PART-2

HUGLI MATLA ESTUARY

WEST BENGAL



ZOOLOGICAL SURVEY OF INDIA
1995

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Edited by
Director, Zoological Survey of India, Calcutta



सत्यमेव जयते

ZOOLOGICAL SURVEY OF INDIA
1995

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FOREWORD

The Hugli-Matla estuary was one of the earliest area of investigation by the founder-director of Zoological Survey of India, Dr. Thomas Nelson Annandale. The studies carried out in early part of this century has remained a pioneering work in this largest estuarine ecosystem in India. Scientists of ZSI have once again paid deserving attention to this unique productive and dynamic system which undoubtedly has undergone changes due to unprecedented human activities in the region. The results of this five year long study (1984-1989) updated and now presented in the present volume would provide a most comprehensive profile of biotic resources of this system, their diversity, changes. As many as 1498 species out of 1,26,000 species of plants and animals recorded from India find place in the estuarine system; some groups of aquatic fauna from the major components i.e. Crustacea (182 species), Insecta (162 species), fishes (156 species), Mollusca (130 species) dominate the system. It is well known that Hugli-Matla estuary plays a significant role in economy of Southern Bengal specially both for fin-fishes and shell fisheries activities. These resources particularly dealt in this present document would help the management authorities for designing an appropriate management strategy.

Calcutta
June, 1995

A.K. Ghosh
Director
Zoological Survey of India

Hugli Matla Estuary West Bengal

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A FAUNAL APPRAISAL OF HUGLI-MATLA ESTUARINE COMPLEX

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INTRODUCTION

India is gifted with a large coast line and vast stretches of coastal wetlands. Estuaries and back waters, which also include mangroves, mud flats, bays etc. extend over a large part of the coasts. There are fourteen major and a number of small and minor rivers opening either into Bay of Bengal or Arabian Sea. Except four all the major rivers open into the former and form estuaries at their confluences. It has been estimated that out of a total area of 19.25 lac sq. hectares of estuaries, 13.25 lac sq. hectares are on the east coast. The coast has the largest estuary formed by the rivers Ganges and Brahmaputra and criss-crossed by a number of small rivers. The Gangetic delta is the biggest of its kind in the world and stretches over an area of about 20,000 sq. km., the major part of which however, is in Bangladesh. The Ganges and its associated rivers open through several estuaries known as Hugli-Matla estuarine complex. Haribhanga, Matla, Thakuran, Saptamukhi, Muriganga etc. have a north-south course leading to the sea. Kalindi, Raimangal Baratala etc. travel through Sunderbans and join the complex. The silt and loam carried by these rivers were deposited on the salt marsh eventually leading to the unique mosaic of 104 islands, of which 54 are inhabited. Silation has been a continuous process which leads to the formation of new islands and New Moore island was one such recent addition. The uniqueness of the estuarine complex is the formation of Sunderbans with 5316 sq. km. of flat land and 4264 sq. km. of forest cover; the latter includes 2109 sq. km. of mangroves. The estuarine complex which is a culmination of the interaction of land, sea and freshwater offers diverse specialized habitats such as mangroves, non-vegetated mudflats, intertidal zone, reclaimed areas etc.

The Hugli-Matla estuaries, especially Sunderbans have been the focus of several investigations. A cursory glance into published literature revealed that there were a total of about-1300 titles dealing with various aspects of estuary (Nandi & Misra, 1987 listed 1191 references on the subject). The first publication was more than a century old and some of the reports of fauna were published at the end of the last century. Major part of the previous investigations had concentrated more on hydrological, physico-chemical and fishery characteristics of the Hugli estuary. Although there are a number of recent comprehensive reports (Mandal and Nandi, 1989. Anonymous, 1987) inventorying of biodiversity and monitoring of the changes were not very convincing. Taxonomic distinctiveness, endemism or rarity of invertebrate faunal components in the estuary were not much highlighted. Even the sampling was carried out at selected or easily accessible localities. In order to collect data on some of these aspects not covered hitherto and to draw attention to lesser known taxa the Zoological Survey of India carried out faunistic surveys in different parts of estuarine complex, from 1984 to 1989. The findings of various subject specialists are presented in separate papers. Since these papers do not cover all the known taxonomic groups a brief resume on the zoology of estuaries is given incorporating the available data on the biodiversity. A brief account of the estuarine environment based on the published data also is given to make the picture complete.

Ecosystem Characteristics

The Hugli-Matla estuary is a tide-dominated delta, which has a funnel shape. Tides facilitate transportation of sediment, replenishment of nutrients, flushing out of wastes and mixing of fresh and salt waters. The tides are semidiurnal with two high and two low tides in a day. The tides are unequal, varying in time and range depending on the location of a place in the estuary.

The estuary is characterised by strong tides (5 to 7 m amplitude) during summer season from February to May and during prewinter season, and relatively weaker tides during the winter months. This corresponds to the rising of mean sea level at the Hugli mouth in February, reaching a peak by September and falling down by winter months. Tidal influence is seen in the estuary up to 290 km. from the sea face. The tides create an important intertidal zone, which harbours characteristic biota. The intertidal zone has silt flats often mixed with mud to varying degrees.

Tides have strong influence on water quality parameters. In addition to tides, water movement is caused by surface and bottom currents. The latter carry plankton upstream and also maintain salinity gradients. The circulation of water is of importance in maintaining populations of sessile or sedentary benthic organisms, majority of which have planktonic dispersal stages. Tides also help in transporting some of the euryhaline marine organisms from the sea into the estuary.

Salinity is an important factor which influences the distribution and biology of living organisms. It is very much influenced by tides and is highly variable, ranging from 3.6 ‰ to 32.77‰ depending on the place and season. It was observed that there was no well defined saline water at the bottom. In comparison the fluctuations in temperature (between 21.7° c and 32.2° c) and pH (7.9 and 8.3) of water are modest. The latest investigations had recorded 14.0° c and 34.0° c as the average minimum and maximum temperatures of water respectively. The range of pH varied from 7.35 to 8.40 in the region between Budge Budge and Bakkhali. There had been a fall in temperature and increase in pH in the downstream direction (Sen *et al.*, 1994).

The depth and width of the estuary also varied with the place and season, depending on the influx of freshwater and distance from the sea. The maximum breadth and depth recorded at Diamond Harbour were 4.65 km and 28.0 m (during monsoon) respectively, while the same measurements were reduced to 0.75 km and 16.0 m respectively at Calcutta (Kidderpore). The most upstream area coming under saline influence is Barrackpore and here the breadth and depth were 0.54 km. and 18.0 m respectively (Bose, 1956). The average depth of the estuary measures about 2.8 m (at 200 km. up stream) and 8.3 m at sea face (Sen *et al.*, 1994).

The turbidity was very high during monsoon months (25.00 ppm) but very low (25 ppm) during winter season. The estuarine ecosystem with its variable physico-chemical and hydrological characteristics is constantly under a flux. These variable factors restrict the movement of organisms and only those which could adapt to these conditions can survive in the estuary. A somewhat near stable conditions prevail during the period from February to June in the Hugli estuary. In the Matla estuary the fluctuations in physico-chemical characters are less pronounced. About a hundred years ago Matla was connected to the Hugli river by Bidhyadhari, which is totally dried up now leaving the former as a tidal river.

Regions of the Estuary

As mentioned above the conditions in the Hugli-Matla estuarine complex are not uniform throughout. Based on the physico-chemical and hydrological parameters the estuary has been divided into five zones as given below:

Zone I : Upper Zone-Nabadwip to Konnagar

Zone II : Middle Zone or Gradient Zone-Konnagar to Diamond Harbour.

Table I
Species Richness of Different Organisms in the Estuary

Name of the Kingdom/ Phylum	No. of families	No. of species	Remarks
Bacteria	...	22	
Algae	...	16	
Fungi	...	184	
Plants	31	69	
Protista	...	43+11	Parasitic + freeliving
Animalia			
Porifera	1	1	
Cnidaria	15	24	5 species based on old records
Ctenophora	2	2	
Platyhelminthes		13	Parasitic
Nemathelminthes	...	67	Freeliving
Nemerteans	...	2	
Annelida	20	78	6 spp oligochaetes + 3 spp of leeches
Rotifera	2	4	
Mollusca	57	130	
Echiura	1	4	
Sipuncula	1	1	
Ectoprocta	1	3	
Arthropoda			
Crustacea	31	182	
Insecta	—	162	Majority terrestrial, a few freshwater and estuarine
Merostomota	1	2	
Arachnida		...	33
Chaetognatha	...	4	
Echinodermata	10	20	6 from the estuary, rest from sandheads.
Hemichordata			
Chordata	...	1	Endemic
Pisces	55	156	42 intertidal benthic
Amphibia	...	5	None from the river-
Reptilia	...	56	23 Aquatic Mostly based on old records.
Aves	62	163	30 species in the lower reaches
Mammalia	...	40	11 Aquatic + terrestrial
Total for the estuary		1498	

Zone III : Lower or Marine Zone—Diamond Harbour to the mouth of the estuary, entire lower Sunderban

Zone IV : River Rupnarayan a tributary of Hugli

Zone V : River Matla

Taxonomic Diversity

Biodiversity of the estuary consists of terrestrial, freshwater and marine communities. The islands and reclaimed areas have been colonized by terrestrial insects, spiders, oligochaets and vertebrates. The freshwater forms include molluscs, insects, crustaceans and amphibians. Seventeen animal phyla have their representatives in the estuary. Some of the phyla are dealt in the subsequent papers. After going through the available literature (Anonymous, 1987; Mandal and Nandi, 1989) and the papers by subject specialists in this volume an analysis of the numerical abundance of species in the estuary is presented in the table.

A study of the literature revealed that sampling has not been uniform for all the groups. Further some of the data has not been critically analysed. The data on parasitic groups, Arthropoda, Reptilia and mammals have to be reinforced with more sampling and needs critical evaluation by concerned specialists. The available data indicates that a total of (of all living organisms) 1498 species were reported from different parts of the estuary. Fauna with a total of 1267 species has the maximum component, and by excluding terrestrial and freshwater species (about 300 Nos.) it is seen that aquatic fauna of the estuary constitute 76.3 per cent of the total faunal species known.

The fauna is not uniformly distributed throughout the estuary. From the data presented in this volume it is seen that maximum number of species prefer Zones III and V. Out of a total of 69 species of polychaetes 53 species were reported from Zone III. About 83 species of the total (130 Nos.) molluscan species occur in Zones III (58 spp) and V (74 spp). Some of the groups represented by benthic forms, such as Echiura, Sipuncula, Echinodermata, intertidal benthic fishes are restricted to those two Zones of the estuary

Faunistic Profile of the Estuary

Estuarine fauna fall under two broad categories, resident and non-resident. The former include mainly a number of invertebrates such as molluscs, polychaets, crustaceans and a few vertebrates. Majority of them are detritus feeders and many have significant roles in the process of detritus formation. Meiofauna, peanut worms, crabs etc. assist in the formation of detritus. As detritus feeders these animals are conditioned by the availability of suitable substrate and hence these are abundant where the conditions are favourable. Non-resident forms are mostly planktonic or nektonic. Some of these animals spend their lives in the estuary either as adults or as juveniles. Biological and physiological adaptations of many species in the estuary are worth investigating.

The document is mainly aimed at presenting an inventory of the less known groups of animals. There are papers on the ecology and pollution in the Hugli estuary (Khan), on groups such as Cnidaria, Mollusca, Annelida (Polychaeta), Crustacea, Echinodermata, intertidal fishes, Amphibia and Reptilia. Some are exhaustive treatments, at least those on Mollusca and Polychaeta, while others are useful inventories. In order to present a total faunistic profile information has been culled from other published data and no claim is made to its originality.

Vertebrates : In general there are only a few aquatic species which have adapted to estuarine life. There are certain euryhaline species which migrate into the estuary.

Eleven species of mammals were recorded from the estuary (Agrawal, 1991). Out of the three species of fishing cats, two, namely *Lutra perspicillata* and *Aonyx cinerea* were recorded from Salt lakes, near Calcutta and the former also from Sundarbans. The Irawaddy dolphin, *Orcaella brevirostris*, the Black finless porpoise, *Neophocaena phocaenoides* and the Indian pilot whale, *Globicephalus indicus* (= *G. macrorhyncha*) were reported to ascend the river along with

the tides. These reports were more than a century old and were not substantiated by recent records. Annandale (1922) mentioned *O. brevirostris* as the only euryhaline mammal of the gangetic delta.

Gangetic dolphin, *Platanista gangetica*, the relict fauna of the Ganges often wanders into the estuary. Jones (1982) estimated a population of about 3000 to 3500 in the Gangetic delta network above the region of saline influence. Gangetic dolphin was sighted in the upper reaches near Balykhal and locally more at Nabadwip. The stretch of Hugli river near Nabadwip is an important area from the conservation point of view of species. The latest reports put the population of Gangetic dolphin around 1500 below Brijghat and up to the estuary.

The rest of the species were whales and were reported a century ago. A total of 29 species of terrestrial mammals, including Bengal tiger, were reported from the area. These were reported from the reclaimed part of the estuary and a few from sunderbans (Mukherjee, 1975).

Estuary is dominated by invertebrate communities. These form a rich source of food material for birds. A total of about 163 species of birds have been listed (Mandal and Nandi, 1989), of which there are 110 residents and 53 migratory birds. A number of birds which nest in colonies, such as herons, egrets, storks, ibises, cormorants etc. find Sunderbans an ideal place for living and breeding. A natural bird sanctuary, Pakhirala at Saznakhali is a significant biodiversity spot (Mukherjee 1975).

The table shows the occurrence of 56 species of reptiles. The aquatic component consists of 23 species of turtles, snakes and a species of crocodile. *Batagur baska*, common batagur and *Crocodyles porosus*, estuarine crocodile are two important species of the estuary. Among aquatic forms there are more freshwater species. There are no estuarine amphibians and the species reported are common species enjoying wide distribution.

Fish fauna and fisheries of the estuary have been extensively and intensively studied. The fishes of the delta include freshwater, estuarine and marine species, contributing to important fisheries. There is no 'resident' species which contribute to commercial fishery. Many of the marine species migrate to the estuary. There are a few species (gobiids, blennids and eels) which are typical to the estuary. Eels live as adults in the estuary and migrate to sea for breeding. Some of the gobiids have almost adapted to terrestrial life, e.g. *Periophthalmidan schlosseri*.

Talwar (1991) listed 31 species of rays sharks etc. from the Gangetic delta. Thread fins and cat fishes seasonally ascend the river for spawning in the freshwater zone of the estuary. There used to be viable fishery in the estuary till two decades ago. Sunderbans account for about 70-80 per cent of the total estimated landing (Gopalakrishnan, 1973). *Hilsa* occupies a prominent place in estuary. A complete failure of Hilsa fishery had been reported during 1959-1960 (Gopalakrishnan, 1973). As per the available fish data Hilsa catch has gone down by 50 % within last 15 years. Once the river stretch between Kalyani and Tribeni yielded good catches of Hilsa (Bilgrami, 1994)

The most significant discovery from the estuary has been the occurrence of *Sacoglossus* sp.

Invertebrates

Cnidaria : It includes mainly marine species, a few of which may be carried into the estuary. The report in this volume includes 15 species, of which five are on the basis of old collections. There are seven new records *Moerisia gangetica* was endemic to the estuary but its present occurrence in the estuary is not confirmed by any fresh collections. According to old reports (Annandale, 1922), *Eirene menoni* (mentioned as *Campanulina ceylonensis* Browne) occurred in large numbers in April in the outskirts of Calcutta. Their abundance continued till monsoon. Although not in abundance the species occurs even at present as evidenced by collections from Ballykhal at Uttarpara, near Calcutta.

Annandale (1922) mentioned the occurrence of three species of sea anemones and all of them figure in the recent reports also. *Edwardsia jonesi* Seshiya and Cuttress (Mandal & Nandi, 1989)

was an addition. *Phytocoetes gangeticus* (Annandale) is endemic in Gangetic delta, while *Pelocoetes exul* (Annandale) is restricted to east coast of India. *Diadumene schilleriana* is common to Gangetic and Irawaddy deltas.

Annandale (1922) further reported three genera of Hydrozoa, namely *Dicycloecoryne filamentosa*, *Annulella gemmata* and a medusoid form *Asenathia* sp. Although the position of these three species in the estuary at present is not known there has been an addition of one species to the list, *Halammhydra sagarensis* Rao and Misra.

Mollusca : It is abundantly represented in the estuary. A very detailed analysis of distribution of species in the estuary, comparison with other Indian estuaries and other relevant data are presented by Subba Rao *et al.* (in this volume).

Molluscs were observed to have high rate of endemism (about 40%) in the Indian estuaries. There are a few species restricted to Hugli - Matla estuary. These are: *Neritina smithi*, *Larina burmana*, *Scaphula deltae*, *Novaculina gangetica*, *Tanysiphon rivalis*. The species *Larina burmana*, and *Tanysiphon rivalis* were reported from the Irawaddy delta beside this estuary.

Annandale (1922) categorised two genera, *Novaculina* and *Scaphula* as the relict fauna of the river Ganga and mentioned their occurrence in the middle reaches of the river. He had also reported only one caryhaline species, *Cuthona annandalei*, an opisthobranch from the estuary. But our observations had shown that at present the two bivalve genera *Scaphula* and *Novaculina* are restricted to the lower estuary and opisthobranchs are fairly common. The most significant part of our study has been the collection of cephalopods in the Matla river. These species are definitely recent additions to the fauna of the estuary.

At the family level it is seen that at least 12 families have their representation in this estuary and do not occur in other estuaries of the Indo Pacific. Many of the bivalve species are typical to the estuary and do not occur in other Indian estuaries. One notable absence in this estuary is *Terebralia palustris*, which occurs in other estuaries. In general, the malaco fauna of the Gangetic delta has certain similarities to that of Irawaddy delta.

Annelida : These are primarily represented by polychaetes, which are abundant in the estuary. A few species of oligochaetes were reported from the upper reaches. An exhaustive account of the polychaete fauna in the estuary is given separately by Misra (in this volume). A significant aspect of the polychaete fauna is the presence of 18 species (out of a total 69 species) which are endemic in India. Two species, namely *Asychis gangeticus* and *Sabellaria pectinata* are restricted endemic in the estuary. The former species, however, could not be collected in the recent surveys. *Pseudopolydora kempfi*, another endemic species, is not represented by fresh collections. On the contrary some of the species, whose type locality was outskirts of Calcutta, were collected during recent surveys from other parts of the estuary. *Namalycastis indica* and *Neanthus chingrighattensis*, a species endemic in India are of common occurrence in the estuary. *Eteone barantocla*, another endemic species is now reported from Ganga Sagar.

Capitella capitata, *Ceratonereis* sp. *Minuspio cirrifera* reported from the zone 1, between Bally to Bandel, are potential bioindicator species. *Mastobrarchus cf indias* which is abundant in the areas with sewage pollution is another possible bioindicator species. Besides, three species of oligochaetes, namely *Tubifex* sp, *Aulodrilus* sp and *Branchiura sowerbyi* were also identified to be bioindicators (Datta 1991).

Crustacea : Species richness of Crustacea in the estuary is very much in evidence as these occupy all possible habitats. Of the total species reported, about 44 percent are planktonic forms. Among benthic forms crabs are abundant in the estuary and are represented by about 77 species. Six species of the family Portunidae are commercially important and provide livelihood for a number of fishermen in the Sunderbans (Nandi & Pramanik, 1994). About 21 species of shrimps and prawns are reported from the estuary. *Penaeus monodon*, tiger prawn and *Penaeus indica*,

Indian white shrimp are commercially important and the juveniles are found abundantly in the estuary with peak periods during March to June.

The following species are endemic in the estuary. *Tympanomerus stapletoni* de Mann, *Tympanomerus gangeticus* and *Carionosquilla multicarinata* (White).

Echinodermata : these are strictly marine animals, but some of the species may develop tissue tolerance and may penetrate into estuaries. It is interesting to note that except crinoids all the other classes have been equally represented in the estuary. It is perhaps the first authentic report on the status of echinoderms in the estuary. Five species of echinoids were collected from near the mouth of the river in 1885 and 1908, but there were no subsequent records. Out of six species of brittle stars three were from the Sand Heads and the rest were from Matla. One of the species, *Ophiactis delagoa* occurs also in the Hugli. Of the five species of holothuroids supposed to occur in the estuary three were based on old reports and not substantiated by any recent collections. Two of these species, namely *Stolus rapax* and *Thorsonia investigatoris* are endemic in Bengal coast and the latter is common on Digha coast. Two species, which may be considered euryhaline are *Synaptula recta* and *Labidoplax* sp. The former, which is abundant in Matla and Thakuran rivers, has a Indo-West Pacific distribution. Four species of star fishes were reported. Only *Astropecten indicus*, a common star fish was collected from Kishori Mohanpur and Prentice Island and the rest were from Sand Heads.

Echiura and Sipuncula : Three species, which are endemic in India, occur in the estuary. *Anelassorhynchus branchiorynchus* was hitherto known from two localities in Sunderbans. Haldar (in this volume) collected it from a number of localities and the species seems to be common in the estuary. The only species of Sipuncula is a Indo-West Pacific species and occurs in Zones III & V of the estuary.

Chaetognatha : Another typically marine group is represented by two species in the estuary. During premonsoon the species of chaetognatha penetrate up to middle reaches of Zones III and V as the salinity was high at that time.

Pollution :

There have been several studies on the pollution in the estuary. The estuary has a thickly populated urban and highly industrialized centres of hinterland, such as Calcutta metropolis and Haldia Complex. These centres generate domestic/municipal sewage and industrial effluents, which find their way into the sea. The agricultural run off also add to the pollution load. The existence of port and shipping through the estuary further complicates the situation in the Hugli-Matla estuarine complex. There are a number of small and large industries on the banks of the river Hugli. The number of industries varied between 40 and 215 (Pl. see Khan in this publication). The industries, which may cause pollution from point sources include paper, textiles, chemicals, pharmaceuticals, plastics, shellac, food, leather, jute, pesticides, oil etc. The studies have revealed that domestic/municipal sewage contribute maximum (68.95%) pollution to the estuary. The impact of pollution on biota was seen at short distance below the outfall but overall there has been a poor biological quality of the estuary near industries indicating a general deterioration in the ecological conditions. Zone III and IV of Hugli-Matla estuarine complex was found to be relatively free from pollution stress. Khan (in three papers) presents the pollution scenario in the estuary.

Heavy metals are the normal constituents in the marine and estuarine environment. Pollution of Hugli estuary with trace metals has been on the rise (Mitra *et al*, 1994). Sedentary organisms are adversely affected by the trace metal pollution. Bio-accumulation of trace metals in the tissues of benthic molluscs has been investigated (Mitra and Choudhury, 1993). Some of these organisms (*Nerita articulata*, *Littorina undulata*, *Cymia lacera*, *Columbella* sp. and *Crassostrea cucullata* investigated and other species of molluscs) may turn out to be indicator species, which

may be useful in biological monitoring of the estuary. The authors (Mitra and Choudhury, 1993) have suggested *Crassostrea cucullata* and *Balanus* sp as useful organisms in monitoring the ecological conditions of the estuary. The former occurs in saline zone of the estuary, whereas the latter can survive under fluctuating physico-chemical conditions. It survives even in the upper reaches of the estuary where the salinity falls to 0.8‰ during monsoon and in the mouth of the estuary with salinity ranging 28‰ during premonsoon period. Overall it was observed that *Cymia lacera* and *Crassostrea cucullata* contained higher concentrations of Zn, Cu, Mn in their tissues than other molluscs during monsoon period.

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MEDUSAE : CNIDARIA

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INTRODUCTION

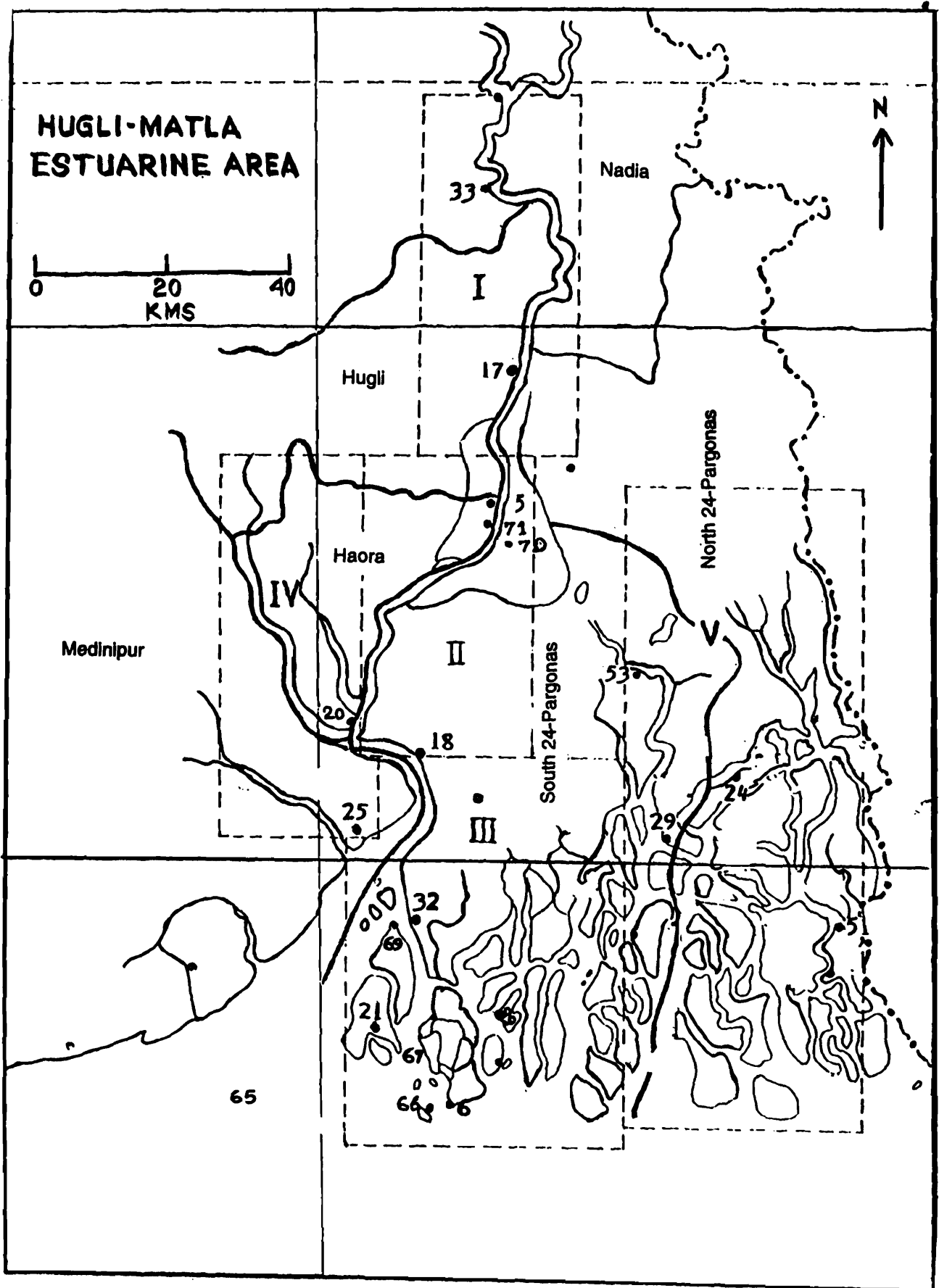
Medusae, commonly known as jelly fish, are the inhabitants of marine and estuarine waters and even found in freshwater bodies like rivers, lakes and ponds. They possess a feeble power of movement and as a result they are easily drifted by watermasses.

Medusae of the Indian coast have received a considerable attention over few decades and as a result 125 species under 82 genera have been recorded so far. Comparatively little is known about the estuarine forms. Previous knowledge of the medusoid fauna of the Ganges estuary largely based on small collections which appeared in the works of Annandale (1907, 1915), Rao (1931) and Kramp (1958). As a result 8 species under 8 genera are so far reported from this estuary. The present work, pursued in connection with zooplankton study, contributes knowledge on the distribution of the medusae and further records of the rarer species. Out of the 16 species under 15 genera 7 species under 7 genera are reported for the first time from this estuary. The paper deals with the diagnostic characters of the genus and species and their distribution. In short, morphology and terminology of the group are described.

MORPHOLOGY AND TERMINOLOGY

The basic structure of the medusa may be summarised as follows, the terms in italics are used in the description of the species.

- Umbrella* : The main body of the medusa consists of gelatinous part
- Exumbrellar surface* : Outer convex surface of the umbrella
- Subumbrellar surface* : Inner concave surface of the umbrella
- Subumbrellar cavity* : The cavity bounded by the subumbrellar surface
- Umbrellar margin* : The marginal edge of the umbrella



Distribution of medusae in the Hugli-Matla estuarine area

1. *Bougainvillia fulva*—67 (mouth of Mooriganga river), 66 (Jambudweep) ;
2. *Obelia* sp.—66 (Jambudweep), 29 (Jharkhali), 24 (Gosaba) ;
3. *Blackfordia virginica*—70 (Salt Lake near Calcutta) ;
4. *Octophyllucium indicum*—67 (month of Mooriganga river), 66 (Off Jambudweep) ;
5. *Eirene ceylonensis*—29 (Jharkhali) ;
6. *E. menoni*—71 (Shyambazar khal), 69 (Kachuberia), 25 (Patikhali, Haldia), 24 (Gosaba), 20 (Sibgang, Gadiwara), 18 (Diamond Harbour), 5 (Baallykhal) ;
7. *Aequorea pensilis*—21 (Gangasagar) ;
8. *Meoerisia gangetica*—71 (Shyambazar khal near Calcutta) ;
9. *Limnognathia indica*—33 (Kaalna, Bardhaman), 17 (Bandel near Chunchura) ;
10. *Liquiope Tetraaphylla*—69 (Kachuberia), 29 (Jharkhali), 24 (Gosaba) ;
11. *Taamoya gargantua*—65 (Sandheads) ;
12. *Atolla wyvillei*—65 (Off Gangetic delta) ;
13. *Cassiopea andromeda*—65 (Sandheads) ;
14. *Netrostoma typhlodendrium*—68 (Prentice Island), 53 (Port Canning), 32 (Maynapara khal near Kakdwip).

- Stomach* : Hanging hollow structure from the centre of the subumbrellar surface
- Mouth* : Distal terminal opening of stomach
- Radial canals* : From the stomach just beneath the subumbrellar surface four hollow canals running along the radii to join another hollow canal
- Ring canal* : A continuous hollow circular canal running round the marginal edge of the subumbrella and receiving the radial canals
- Marginal tentacle* : Contractile in nature, placed on the umbrellar margin, at each of the four points where a radial canal joining the ring canal and used for capture of prey
- Cirri* : Small tentacular-like organs situated on the umbrellar margin between the true marginal tentacles but much smaller and solid in contrast to former
- Velum* : The opening of the subumbrellar cavity can be partially closed by a continuous horizontal shelf situated just inside the umbrellar margin
- Gonads* : Situated on the walls of the stomach or on the radial canals and of considerable value as classificatory characters. When situated on stomach the form and its position are valuable characters for purpose of classification
- Ocelli* : A kind of sense organ situated on the basal bulb of marginal tentacles and acting as organs of light receptor
- Statocysts* : Situated in the velum just where former joining margin of the umbrella, possibly organs of orientation and of great value for classificatory purposes

COLLECTION AND PRESERVATION

The most usual method of collecting medusae is with the ordinary plankton net, a conical net like that of a butterfly net, which is towed through water and filters off the planktonic organisms. Medusae are delicate organisms and in order to collect them with least damage it is always advisable to use a tow-net which has an enamelled or galvanised bucket at its end. The medusae will be still in water when the net be lifted from water. Then the medusae are required to be placed in finger bowl of clean water. It is not usually necessary to use any narcotising reagents to preserve the specimens in a fully expanded condition. Strong formalin may be squirted in by a pipette in the bowl containing actively swimming medusae and it is essential to keep the water and the medusae moving well stirred. The process should be continued until the medusae show no spontaneous movements. Alcohol as a preservative should not be used as it causes shrinkage and

contraction of specimens and further it renders the tissue of the medusae extremely brittle. For final preservation 5% formalin is recommended.

LIST OF SPECIES KNOWN FROM THE STUDY AREA

SYSTEMATIC ACCOUNT

- Phylum : CNIDARIA
 Class : HYDROZOA
 Order A : ANTHOMEDUSAE
 Family I : BOUGAINVILLIIDAE
 Genus 1. : *Bougainvillia* Lesson, 1836
- * 1. *Bougainvillia fulva* Agassiz & Mayer, 1899
- Order B : LEPTOMEDUSAE
 Family II : CAMPANULARIIDAE
 Genus 2. : *Obelia* Peron & Lesueur, 1809
- * 2. *Obelia* sp.
- Family III : EUCOPIIDAE
 Genus 3. : *Blackfordia* Mayer, 1910
3. *Blackfordia virginica* Mayer, 1910
- Family IV : PHIALUCIIDAE
 Genus 4. : *Octophialucium* Kramp, 1955
- * 4. *Octophialucium indicum* Kramp, 1958
- Family V : EIRENIDAE
 Genus 5. : *Eirene* Eschscholtz, 1829
- * 5. *Eirene ceylonensis* Browne, 1905
6. *Eirene menoni* Kramp, 1953
- Family VI : AEQUOREIDAE
 Genus 6. : *Aequorea* Peron & Lesueur, 1809
7. *Aequorea pensilis* (Eschscholtz, 1829)
- Order C : LIMNOMEDUSAE

Family VII : MOERISIIDAE

Genus 7. : *Moerisia* Boulenger, 1908

8. *Moerisia gangetica* Kramp, 1958

Family VIII : LIMNOCNIDIDAE

Genus 8. : *Limnocrnida* Gunther, 1893

* 9. *Limnocrnida indica* Annandale, 1912

Order D : TRACHYMEDUSAE

Family IX : GERYONIDAE

Genus 9. : *Liriope* Lesson, 1843

* 10. *Liriope tetraphylla* (Chamisso & Eysenhardt, 1821) .

Order E : CUBOMEDUSAE

Family X : CARYBDEIDAE

Genus 10. : *Tamoya* Muller, 1859

11. *Tamoya gargantua* Haeckel, 1880

Order F : CORONATAE

Family XI : ATOLLIDAE

Genus 11. : *Atolla* Haeckel, 1880

12. *Atolla wyvillei* Haeckel, 1880

Order G : RHIZOSTOMEAE

Family XII : CASSIOPEIDAE

Genus 12. : *Cassiopea* Peron & Lesueur, 1809

* 13. *Cassiopea andromeda* (Forsk., 1775)

Family XIII : CEPHEIDAE

Genus 13. : *Netrostoma* L. S. Schultze, 1898

14. *Netrostoma typhlodendrium* Schultz, 1898

Family XIV : CATOSTYLIDAE

Genus 14. : *Acromitus* Light, 1914

15. *Acromitus flagellatus* (Maas, 1903)

Family XV : VERSURIGIDAE

Genus 15. : *Versuriga* Kramp, 1961

16. *Versuriga anadyomene* (Maas, 1903)

*denotes new record from the study area

SYSTEMATIC ACCOUNT

Order A : ANTHOMEDUSAE

Family I : BOUGAINVILLIIDAE

Genus 1. : *Bougainvillia* Lesson, 1836

1836. *Bougainvillia* Lesson, *Ann. Sci. nat. (Zool.)*, (2) 5 : 262.

1973. *Bougainvillia* : Kramp, *J. mar. biol. Ass. U. K.*, 40 : 74.

Diagnosis : Marginal tentacles grouped in clusters placed on four radii, tentacles of each cluster being all of one kind and similar in structure; perradials four and dichotomously branched.

* 1. *Bougainvillia fulva* Agassiz & Mayer, 1899

1899. *Bougainvillia fulva* Agassiz & Mayer, *Bull. Mus. comp. Zool. Harvard*, 32 (9) : 162.

1973. *Bougainvillia fulva* : Fagetti, *Revista Biol. mar.* 15(1) : 38

Material examined : 1 ex., mouth of Mooriganga river, 27. ii. 1981; 1 ex., on way to Jambudweep from Sagar Island, 3. iii. 1981.

Diagnosis : Bell 8-10 mm high, thick vertical sides and flatly rounded top; four radially placed marginal tentacles with about 15-20 tentacles in each cluster and these tentacles not half as long as bell height; radial canals four, straight and wide near the junction with stomach; manubrium half as long as bell height, wide at base but lacking peduncle; oral tentacles branch dichotomously; gonads eight, two upon each interradial side.

Remarks : Common medusa in the coastal waters of India. It is for the first time reported from this estuary. Material came in the catch during high salinity period.

Distribution : In India : West Bengal : Sagar Island (present record); Orissa (Kramp, 1958); Visakhapatnam (Ganapati & Nagabhusanam, 1958) Tamil Nadu – Madras (Menon, 1932); Andamans (Kramp, 1958); Kerala – Trivandrum coast (Nair, 1951). *Elsewhere* : *Indian Ocean* :

East Africa; Seychelles; Chagos Archipelago; Mergui; Malay Archipel; Philippines; Sunda Strait; China; Palao Island.

Order B. LEPTOMEDUSAE

Family II. CAMPANULARIIDAE

Genus 2. *Obelia* Peron & Lesueur, 1809

1809. *Obelia* Peron & Lesueur, *Annu. Mus. Hist. nat.*, **14** : 312.

1961. *Obelia* : Kramp, *J. mar. biol. Ass. U. K.*, **40** : 162.

Diagnosis : Velum reduced; marginal tentacles solid; persence of eight lithocysts (marginal vesicles).

Remarks : Identification of species of this genus is very difficult and the species so far described under the genus are of confusing characters.

* 2. *Obelia* sp.

Material examined : 1 ex., Vidya river near Gosaba Kheya ghat, 15. ix. 1984; 4 exs., Matla river near Jharkhali, 22.ix.1984; 2 exs., Mooriganga river on way to Jambudweep, 17.xii.1987.

Diagnosis : Umbrella 2.5–4 mm wide, flat, jelly thin; velum very much reduced; stomach short with quadrangular base and mouth with four short simple perradial lips; gonad round or oval sac-like placed at middle of radial canals; tentacles numerous, solid, short and marginal, each tentacle provided with basal swelling; lithocysts eight in number, adradial in position, placed underside of basal bulb of marginal tentacles.

Remarks : The specific identification is difficult. Specimens of this genus though collected few in numbers are found in the early part of post-monsoon in the Matla and in Vidya while in the Mooriganga during late post-monsoon and totally absent during monsoon months. *Obelia* sp. is so far not reported from this estuary.

Family III. EUCOPIDAE

Genus 3. *Blackfordia* Mayer, 1910

1910. *Blackfordia* Mayer, *Medusae of the world : Hydromedusae*, **I** : 277.

1961. *Blackfordia* : Kramp, *J. mar. biol. Ass. U. K.*, **40** : 180.

Diagnosis : Radial canals four in numbers; gastric peduncle absent; gonads completely surrounded the radial canals; marginal tentacles numerous, hollow; marginal vesicles numerous and closed type.

3. *Blackfordia virginica* Mayer, 1910

1910. *Blackfordia virginica* Mayer, *Medusae of the world : Hydromedusae*, 1 : 277, pl. 36, figs. 3-5; pl. 37, fig. 6.

1987. *Blackfordia virginica* : Kramp, Moore, *J. mar. biol. Ass. U. K.*, 67(2) : 287-291

Material examined : 2 exs., Salt Lake, near Calcutta, 8.v.1926.

Diagnosis : Umbrella diameter varies from 4 to 11 mm and with rounded apex; tentacles 72-88 in number, finger-shaped, diverticula from the tentacle bulbs present at base of all the tentacles; marginal vesicle present between each successive pair of tentacles; black pigment granules adjacent to statocyst absent; stomach half as long as bell cavity and with four long lips; gonads surround the radial canals completely and not divided by a median line on their subumbrellar surface.

Remarks : The species is indigenous in the brackish water swamps of the Bulgarian coast of the Black Sea. According to Theel (1935) occurrence of this species in widely separated area like Black Sea and U.S.A. is of great surprise and to Kramp (1955) availability of this species in this estuary is probably due to transportation with ships. The then Salt Lake is now converted into Salt Lake City. This species though oceanic invades in the less saline zone of the Salt Lake through the Matla and the Vidyadhari river. The species was not found during the present investigation.

Distribution : *In India* : West Bengal : Salt Lake, near Calcutta (Kramp, 1958). *Elsewhere* : *Mediterranean Sea* : Bulgarian coast of Black Sea; *Atlantic Ocean* : east coast of North America.

Family IV. PHIALUCIIDAE

Genus 4. *Octophialucium* Kramp, 1955

1906. *Octocanna* Mass, *Rev. Suisse Zool.*, 14 : 90.

1955. *Octophialucium* Kramp, *Atlantide Rep.*, No. 3 : 256.

1989. *Octophialucium* Zheng Zhong, *et al.*, *China Ocean Press*, Beijing : 145

Diagnosis : Radial canals eight in numbers; ocelli absent.

Remarks : Six species are so far known under this genus, of which only two species are recorded from the Indian coast but none from the estuarine waters.

* 4. *Octophialucium indicum* Kramp, 1958

1932. *Octocanna polynema* Menon, *Bull. Madras Govt. Mus., N.S., Nat. Hist. Sect.*, 3 (2) : 23, pl.3, fig. 25.

1958. *Octophialucium indicum* : Kramp, *Rec. Ind. Mus.*, 53 : 347-349, fig. 2a.

Material examined : 2 exs., Off Jambudweep, 7.xii.1980; 1 ex., near Mooriganga mouth, 3.ii.1981.

Diagnosis : Bell diameter 5–7 mm, disc-like, thick jelly; stomach short, mouth with eight short lips having crenulated margin; radial canals narrow, eight in number, extending almost to the centre; gonads very short, placed near the umbrella margin; tentacles 18-20, very short and spirally coiled; tentacle bulb conical, having prominent excretory papilla; marginal bulbs between two successive tentacles rudimentary and of equal size; velum narrow.

Remarks : According to Kramp (1955) the medusae described by Menon (1932) as *Octocanna polynema* Haeckel probably belong to *Octophialucium indicum*. During high salinity period of post-monsoon this species was found in this estuary. This species is recorded for the first time from this estuary.

Distribution : *In India* : West Bengal : Jambudweep and Mooriganga (present record); Andhra Pradesh—Vizagapatnam coast (Ganapati & Nagabhusanam, 1958); Tamil Nadu – Madras (Menon, 1932); Kerala – Trivandrum coast (Nair, 1951), Calicut (? George, 1953). *Elsewhere* : *Pacific Ocean* : China; *Indian Ocean* : Burma; Mergui Archipelago.

Family V. EIRENIDAE

Genus 5. *Eirene* Eschscholtz, 1829

1829. *Eirene* Eschscholtz, *System der Acalephen* : 48.

1988. *Eirene* : Kramp, Bouillon, *Indo-Malay Zool.*, 5(1) : 87-89

Diagnosis : Stomach small with distinct peduncle; gonads restricted to subumbrellar part of radial canals separated from stomach; lateral or marginal cirri absent.

Remarks : Out of 6 species under this genus known from the Indian coast only one species is so far reported from this estuary. One more is added to this list.

*5. *Eirene ceylonensis* Browne, 1905

1905. *Irene ceylonensis* Browne, *Rep. Pearl Oyster Fish. Ceylon* Pt.4, Suppl. Rept. No. 27 : 140, pl.3, figs. 9–11.

1988. *Eirene ceylonensis* : Bouillon, *Indo-Malay Zool.*, 5(1) : 87-99

Material examined : 2 exs., Matla river near Jharkhali, 20.ii. 1986.

Diagnosis : Bell diameter 2.5 and 4 mm; peduncle very small, narrow; gonads at the base of peduncle; tentacles 30-32, short, more or less equal in size, with one statocyst in each.

Remarks : Specimens are young and hence characters are not so prominent as in adult. This is the first report from this estuary.

Distribution : In India : West Bengal : Jharkhali (present record); Andhra Pradesh – Vizagapatnam (Kramp, 1958); Nicobars (Kramp, 1958); Kerala – Trivandrum coast (Nair, 1951); Maharashtra – Bombay (Bal & Pradhan, 1952; Lele & Gae, 1935). *Elsewhere : Indian Ocean* : Ceylon; Burma; Java Sea. *Pacific Ocean* : China; Philippines; Great Barrier Reef.

6. *Eirene menoni* Kramp, 1955

1907. *Irene ceylonensis* : Annandale, *J. Asiat. Soc. Bengal, N.S.*, 3 (2) : 79, pl.2, fig. 5.

1970. *Eirene menoni* : vanucci, M., *et al.*, *Marine Biol.*, 7 : 51

Material examined : 4 exs., Shyambazar Khal, near Calcutta, 13.v. 1926; 3 exs., Hugli river near Kachuberia, 10.iii. 1980; 2 exs., Vidya river near Gosaba, 15.ix. 1984; 5 exs., Hugli river near Diamond Harbour, 11.iii. 1985; 3 exs., Haldi river near Patikhali, 16.iii. 1985; 2 exs., Hugli river near Sibganj, 11.viii. 1988; 1 ex., Bally khal at Uttarpara, near Calcutta, 17. viii. 1988.

Diagnosis : Bell diameter 4-8 mm and 1.5-3 mm high, evenly rounded; jelly thin; gastric peduncle slender; stomach short; mouth with four prominent frilled lips; gonads somewhat sinuous arising from base of peduncle; tentacles 38-48 in number; statocyst usually one between tentacles.

Remarks : In this species tentacles attain full size in a very short time, so in no specimen young bulbs were seen. This is the second record of the species from this estuary.

Distribution : In India : West Bengal : Ganges estuary (Annandale, 1907), near Calcutta (Kramp, 1958); Gosaba, Kachuberia, Haldi, Uttarpara, Diamond Harbour (present record); Orissa—coastal area (Kramp, 1958); Tamil Nadu—Madras (Menon, 1931, 1932); Kerala – Trivandrum (Nair, 1951). *Elsewhere : Pacific Ocean* : China; N. E. Australia.

Family VI. AEQUOREIDAE

Genus 6. *Aequorea* Peron & Lesueur, 1809

1809. *Aequorea* Peron & Lesueur, *Annu. Mus. Hist. nat.*, : 14 : 336.

1961. *Aequorea* : Kramp, *J. mar. biol. Ass. U.K.*, 40 : 203.

1989. *Aequorea* : Zheng Zhong, *et al.*, *China Ocean Press*, Beijing : 145

Diagnosis : Radial canals numerous and simple; sub-umbrella without rows of papillae; gonads on radial canal, separated from stomach; marginal tentacles hollow.

Remarks : Three species of this genus are so far reported from the Indian coast, of which only one penetrates the estuary.

7. *Aequorea pensilis* (Eschscholtz, 1829)

1829. *Mesonema coelum pensile?* Eschscholtz, *System der Acalephen* : 112.

1970. *Aequorea pensilis* : Vannucci, M. *et al.*, *Marine Biol.*, **7** : 52

Material examined : 2 exs., Gangasagar, Hugli river mouth, 24.iii. 1981.

Diagnosis : Bell diameter 30 and 35 mm, jelly fairly thick, centrally biconvex and margin thin; stomach very wide; radial canals 110 and 120; gonads extending nearly the whole length of radial canals; tentacles 10 and 12; tentacle bulbs with long lateral extensions; abaxial keel absent; statocysts numerous.

Remarks : Four species of *Aequorea*, namely, *A. conica*, *A. macrodactyla*, *A. parva* and *A. pensilis*, are so far known from the Indian coast, of which the latter alone invades the estuary. It is recorded for the second time from the Ganges estuary.

Distribution : *In India* : West Bengal : Sandheads, Ganges estuary (Kramp, 1958); Gangasagar (present record); Orissa – Off Puri (Kramp, 1958); Andhra Pradesh – Vizagapatnam (Kramp, 1958; Ganapati & Nagabhusanam, 1958); Tamil Nadu – Madras (Menon, 1931, 1932); Bay of Bengal (Kramp, 1958; Rao, 1959); Kerala – Trivandrum (Nair, 1951); Calicut (George, 1953). *Elsewhere* : *Indian Ocean* : Natal; Chagos Archipelago; Red Sea; Iranian Gulf; Maldive Islands; Ceylon; Mergui Archipelago. *Pacific Ocean* : Indochina; China; Philippines; Great Barrier Reef; Japan. *Atlantic Ocean* : Mediterranean; W. of Ascension; Tortugas, Florida.

Order C. LIMNOMEDUSAE

Family VII. MOERISIIDAE

Genus 7. *Moerisia* Boulenger, 1908

1908. *Moerisia* Boulenger, *Quat. J. Micro. Sci.*, **52** : 357.

1961. *Moerisia* : Kramp, *J. mar. biol. Ass. U.K.*, **40** : 213.

Diagnosis : Tentacles 4-32 in numbers, with rings of nematocysts throughout their length; bulbs globular; stomach cruciform, without a peduncle; mouth without distinct lips; gonads on radial canals and on stomach walls.

Remarks : Of the three species of *Moerisia* two are reported from lakes and rivers, of these one is so far known from India (from a canal connected with the Ganges).

8. *Moerisia gangetica* Kramp, 1958

1858. *Moerisia gangetica* Kramp, *Rec. Indian Mus.*, **53** : 363.

1961. *Moerisia gangetica* : Kramp, *J. mar. biol. Ass. U.K.*, **40** : 214.

Material examined : 1 ex., Shyambazar Khal, Dakhindari, near Calcutta, low tide, 13.v.1926.

Diagnosis : Umbrella 3 mm in diameter, 2 mm high, jelly very thick, nearly spherical; manubrium small, quadrangular, with a simple cross-shaped mouth opening and without lips; radial canals four and ring canal narrow; gonad cross-shaped, completely enclosing manubrium and extending along four radial canals up to ring canal; marginal tentacles 19, hollow, fairly short and all of same size; ocellus on abaxial side; velum broad.

Remarks : The species was described by Kramp in 1958 from a canal connected with the Ganges near Calcutta. It is so far not reported from any other Indian localities or elsewhere. It was not available during present investigation.

Distribution : In India : West Bengal : near Calcutta (Kramp, 1958). Elsewhere : Absent.

Family VIII. LIMNOCNIDIDAE

Genus 8. *Limnocrnida* Gunther, 1893

1893. *Limnocrnida* Gunther, *Ann. Mag. Nat. Hist.*, (6) 2 : 269.

1961. *Limnocrnida* : Kramp, *J. mar. biol. Ass. U.K.*, 40 : 231.

Diagnosis : Tentacles marginal and numerous; radial canal simple; stomach simple and circular; gonads on stomach wall only.

Remarks : Two species under this genus are so far known and they inhabit freshwater rivers and lakes of the world. Of them one is reported from India.

*9. *Limnocrnida indica* Annandale, 1912

1912. *Limnocrnida indica* Annandale, *Rec. Indian Mus.*, 7 : 253-256.

1980. *Limnocrnida indica* : Dalal & Rawal, *J. Bombay nat. Hist. Soc.*, 76 (3) : 544.

Material examined : 2 exs., Bandel, Hugli, 13.viii. 1988; 1 ex., Kalna, Bardhaman, 12.i. 1989.

Diagnosis : Umbrella 7-10 mm in width and 2-3 mm in height; radial canals 4; marginal tentacles of two types : primary tentacles long, tapering, about 48-60 and secondary tentacles small and almost equal in width throughout; statocysts two between every two primary tentacles.

Remarks : The species inhabits in freshwater only and found to occur in the upper stretches of this estuary. This is an endemic form and reported from several lakes and rivers of India. But this is for the first time found in the Ganges.

Distribution : In India : West Bengal : Hugli & Bardhaman (present record). Gujarat—Junagadh (Dalal & Rawal, 1980); Maharashtra—Koyna & Yennah rivers (Annandale, 1911, 1912; Gravely & Agharkar, 1912; Rao, 1932); Yenna river (Annandale, 1918); Krishna river (Rao, 1931); Karnataka—Western Ghat (Annandale, 1912); Krishnarajasagar of Cauvery (Krishnamurthy, 1952); Thunga river (Ayengar & Venkatesh, 1955); Kerala—Periyar Lake (Darling, 1935); river

Sahyadria (Jones, 1952); Bihar—Chota Nagpur (Alcock, 1911); Meghalaya—Barapani and Ward Lake, Shillong (Haldar & Mondal, in press); *Elsewhere* : Absent.

Order D. TRACHYMEDUSAE

Family IX. GERYONIIDAE

Genus 9. *Liriope* Lesson, 1843

1843. *Liriope* Lesson, *Histoire Naturelles des Zoophytes. Acalephes* : 332.

1961. *Liriope* : Kramp, *J. mar. biol. Ass. U.K.*, **40** : 238.

Diagnosis : Stomach with peduncle; radial canals and gonads four each; marginal tentacles of two kinds, hollow and solid.

*10. *Liriope tetraphylla* (Chamisso & Eysenhardt, 1821)

1821. *Geryonia tetraphylla* Chamisso & Eysenhardt, *Nova Acta Phys.—Med. Acad. Leopold Carol.*, **10** (2) : 357, pl.27, fig.2.

1973. *Liriope tetraphylla* : Schmidt, *Marine Biol ...*, Berlin, **18**(1) : 61-68

Material examined : 1 ex., Kachuberia, Sagar Island, 20.iii. 1981; 3 exs., Gosaba, Sundarbans, 15.ix. 1984; 2 exs., Jharkhali, Sundarbans, 20.vii. 1987.

Diagnosis : 10-15 mm wide, hemispherical with thick jelly; stomach small on peduncle; mouth having four simple lips; radial canals broad; gonads variable in shapes and sizes; perradial tentacles four, long and hollow and interradial tentacles four, small and solid.

Remarks : It is a monotypic and cosmopolitan species occurring in all seas and oceans. It is reported from both the east and west coast of India but so far not from any estuary. Hence, this is a new record from the Indian estuary as well as from the Ganges.

Distribution : In India : West Bengal : Sundarbans & Sagar Island (present record); Orissa—Off Puri (Kramp, 1958); Andhra Pradesh—Vizagapatnam (Kramp, 1958; Ganapati & Nagabhusanam, 1958); Tamilnadu—Madras (Menon, 1931, 1932); Nicobars—Nancowry; Octavia Bay; Off Muz (Kramp, 1958); Kerala—Trivandrum (Nair, 1951; Menon, 1945); Calicut (George, 1953); Maharashtra—Bombay (Lele & Gae, 1935). *Elsewhere* : Warm parts of all the oceans.

Order E. CUBOMEDUSAE

Family X. CARYBDEIDAE

Genus 10. *Tamoya* Muller, 1859

1859. *Tamoya* Muller, *Abh. Naturf. Ges. halle*, **5** (1) : 1.

1961. *Tamoya* : Kramp, *J. mar. biol. Ass. U.K.*, **40** : 306.

Diagnosis : Pedalia four, simple; stomach pouches wide and deep, without diverticula, connected with subumbrella by perradial mesenteries; gastric cirri four in number extending along stomach wall.

Remarks : This genus is closely related to, if not, identical with *Carybdea*, being distinguished only by its large stomach with its perradial mesenteries and its vertical clusters of gastric cirri.

11. *Tamoya gargantua* Haeckel, 1880

1880. *Tamoya gargantua* Haeckel, *System der Acraspeden* : 444.

1961. *Tamoya gargantua* : Kramp, *J. mar. biol. Ass. U.K.*, 40 : 306-307.

Material examined : 1 ex., Sandheads between Pilot Ridge Light Vessel and Eastern Channel, 'Lady Fraser' Collection, February and March, 1928.

Diagnosis : Large specimen, 150 mm high and 70 mm broad, greatly contracted; tentacles missing but pedalia and velarium present; velarial canals ending in trident-like distal branches.

Remarks : This is a neretic species so far reported only once from this estuarine mouth by Rao (1931). According to Mayer (1910) this is an imperfectly known species. Author is unable to collect this species during present investigation as this does not enter the estuary proper.

Distribution : *In India* : West Bengal : Sandheads (Rao, 1931); Orissa—Puri Coast (Rao, 1931); Tamil Nadu—Ennur, near Madras (Rao, 1931); Bay of Bengal (Rao, 1931); Celerity passage (Rao, 1931). *Elsewhere* : Iranian Gulf; Mergui Archipelago; Malay; Samoa; New Guinea; N, Australia; New South Wales; Japan.

Order F. CORONATAE

Family XI. ATOLLIDAE

Genus 11. *Atolla* Haeckel, 1880

1880. *Atolla* Haeckel, *System der Acraspeden* : 488.

1961. *Atolla* : Kramp, *J. mar. biol. Ass. U.K.*, 40 : 311.

Diagnosis : Rhopalia 20-22 alternating with equal number of tentacles; adradial gonads 8 and subgenital ostia 4, interradial in position.

Remarks : Three species under this genus are so far known, of them only one species is reported from the Indian coast.

12. *Atolla wyvillei* Haeckel, 1880

1880. *Atolla wyvillei* Haeckel, *System der Acraspeden* : 488.

1973. *Atolla wyvillei* : Fagetti, *Revista Biol. mar.*, **15**(1) : 48-49.

Material examined : 2 exs., Off the Gangetic delta in the swatch of no ground, 570 m.

Diagnosis : Young forms, bell diameter 25 and 30 mm; central lens 20 mm in diameter; tentacles 20 in number alternating with equal number of rhopalar pedalia which are very small; marginal lappets much contracted, most of them dropped off.

Remarks : This is a cosmopolitan neretic species so far not reported from estuary proper. However, Rao (1931) dealt with some material from Off Gangetic delta and Off Kistna delta. Author is unable to collect this species during the present investigation as this does not enter the estuary proper. Study of large number of specimens helped Mayer (1910) to comment that *Atolla bairdii* and *A. wyvillei* are very closely related, if not mere individual variations of one and the same species.

Distribution : In India : West Bengal : Off Gangetic delta (Rao, 1931); Andhra Pradesh—Off Kistna delta (Rao, 1931); Andaman Sea and Lakhsadweep sea (Rao, 1931). *Elsewhere* : Cosmopolitan.

Order G. RHIZOSTOMEAE

Family XII. CASSIOPEIDAE

Genus 12. *Cassiopea* Peron & Lesueur, 1809

1809. *Cassiopea* Peron & Lesueur, *Annu. Mus. Hist. nat.*, **14** : 356.

1961. *Cassiopea* : Kramp, *J. mar. biol. Ass. U.K.*, **40** : 348.

Diagnosis : Mouth arms 8, adradial and complexly branched, bearing numerous mouth openings and vesicles; ring canal may or may not be present; rhopalar and interrhopalar canals about 16 each.

* 13. *Cassiopea andromeda* (Forsk., 1775)

1775. *Medusa andromeda* Forskal, *Descriptiones animalium avium, amphibiorum, piscium, insectorum, vermium* : 107, pl. 31.

1977. *Cassiopea andromeda* : Neumann, *Wilhelm Roux Arch. dev. Biol.*, **183** (1) : 79-83

Material examined : 1 ex., Sandheads, mouth of river Hooghly, Ganga Estuary, 4. xi. 1922, R. Smyth.

Diagnosis : Bell diameter 65 mm with a slightly raised dome in the centre about 12 mm high, flat, shield-shaped; marginal lappets short and blunt; mouth-arms dorso-ventrally flattened, long but not extending much beyond bell margin; four short branches arising from each arm irregularly; vesicles of two kinds : small ones numerous and large ones (2-3) club-shaped on each arm between the mouths.

Remarks : The specimen was traced out from the old unnamed collection, probably passed unnoticed of Dr. H.S. Rao in 1931. This species is so far not reported from Indian estuaries and hence, it is new to the area under study.

Distribution : *In India* : West Bengal : Sandheads (present record); Tamil Nadu—Gulf of Mannar (Krusadai Island and Rameswaram – Rao, 1931); west coast of India (Browne, 1916). *Elsewhere* : Widely distributed in the Indo-Pacific Ocean.

Family XIII. CEPHEIDAE

Genus 13. *Netrostoma* L.S. Schultze, 1898

1898. *Netrostoma* Schultze, *Denkschr. med.-natur. Ges., Jena*, **8** : 457.

1961. *Netrostoma* : Kramp, *J. mar. biol. Ass. U.K.*, **40** : 355.

Diagnosis : Inter-rhopalar radial canal three in each octant; exumbrella with large warts on central dome; appendages on mouth arms and arm disc stiff.

Remarks : Of the four species under this genus only one is so far reported from both the east and west coast of India and another one from this estuary.

14. *Netrostoma typhlodendrium* Schultze, 1898

1898. *Netrostoma typhlodendrium* Schultze, *Denkschr. med.-natur. Ges. Jena*, **8** : 457.

1961. *Netrostoma typhlodendrium* : Kramp, *J. mar. biol. Ass. U.K.*, **40** : 356-357.

Material examined : 3 exs., Canning Town, river Matla ; 1 ex., Maynapara Khal, river Mooriganga, 26.xii.1987; 2 exs., Prentice Island, river Saptamukhi, 7.iii.1989.

Diagnosis : Bell diameter 50-70 mm and mouth arms 25-40 mm; central dome low, sometimes flattened and covered with number of warts; rhopalar lappets conical and pointed in shape and narrower than the velar; velar and rhopalar lappets 7 and 2 respectively in each octant; ring canal absent but rhopalar and inter-rhopalar canals connected centrifugally by the extension of anastomosis.

Remarks : This species prefers coastal waters than open sea. During high salinity period the species migrate up to northern end of Sagar Island along the Hugli and up to Canning along the Matla. This is the second record of the species from this estuary.

Distribution : In India : West Bengal : Gangetic delta & Canning (Rao, 1931); Prentice Island & Mooriganga (present record). *Elsewhere* : Indian Ocean : Mergui Archipelago; Malayan Archipelago.

Family XIV. CATOSTYLIDAE

Genus 14. *Acromitus* Light, 1914

1914. *Acromitus* Light, *Philipp. J. Sci.*, **9** : 212.

1961. *Acromitus* : Kramp, *J. mar. biol. Ass. U.K.*, **40** : 368.

Diagnosis : Broad intracircular anastomosing network in direct communication with ring canal and rhopalar canals only; mouth-arms each with a terminal whip-like appendage.

Remarks : Out of five species under this genus two are reported from the Indian coast and also from estuarine areas.

15. *Acromitus flagellatus* (Maas, 1903)

1903. *Himantostoma flagellata* Mass, *Siboga Exped., Monograph*, **11** : 77, pl. 10, figs. 87-92; pl. 11, fig. 10.

1920. *Acromitus flagellatus* Stiasny, *Zool. Meded.*, Deel 5 : 226.

1961. *Acromitus flagellatus* : Kramp, *J. mar. biol. Ass. U.K.*, **40** : 368-369.

Material examined : 2 exs., Canning Town, Matla river, ?xii.1918; 1 ex., Gosaba, river Vidya, 15.ix.1984; 2 exs., Harwood Point near Kakdwip, river Hugli, 27.xii.1987.

Diagnosis : Bell diameter ranging from 90 to 120 mm; brown spots on exumbrella, usually more in the central part than on the margin; granulation on exumbrella; oſtia broad and open; mouth-arms more or less equal, stout, and as long as or longer than the radius of the umbrella; terminal mouth-arm filaments long in some and rudimentary in others.

Remarks : This species is found to occur up to middle reaches of Zone III both the river Hugli and Matla during post-monsoon period. According to Rao (1931) *Acromitus rabanchatu* described by Annandale (1915) from the Chilka Lake is closely allied to *A. flagellatus* reported herein differs chiefly in size and form of rhopalia, and of marginal lappets.

Distribution : In India : West Bengal : Canning Town & Sundarban (Rao, 1931); Gosaba & Kakdwip (present record); Orissa—Puri Coast (Rao, 1931); Tamil Nadu—Tuticorin (Rao, 1931); Madras (Gravelly, 1941); Kerala—Cochin back water (Rao, 1931) Karnataka—Karwar coast (Patil, 1951); Bay of Bengal (Rao, 1931) *Elsewhere* : Indian Ocean : Burma; Malayan Archipelago; Borneo; Java; Siam. *Pacific Ocean* : Amoy (China), Formosa; Japan.

Family XV. VERSURIGIDAE

Genus 15. *Versuriga* Kramp, 1961

1880. *Versura* Haeckel, *System der Acraspeden* : 606.

1961. *Versuriga* Kramp, *J. mar. biol. Ass. U. K.*, **40** : 362

Diagnosis : Mouth-arms three winged broad, with secondary lappets and with clubs and filaments ;

Remarks : It is a monotypic genus occurring in the Indo-West Pacific belt.

Genus 16. *Versuriga anadyomene* (Maas, 1903)

1903. *Crossostoma anadyomene* Maas, *Siboga Exped., Monograph*, **11** : 56 pl. 7, figs. 65-68.

1931. *Versura anadyomene* : Rao, *Rec. Indian Mus.*, **33** : 46-47.

1961. *Versuriga anadyomene* : Kramp, *J. mar. biol. Ass. U. K.*, **40** : 363.

Material examined : 1 ex., (damaged) Off Sandheads, mouth of the Ganges, Feb., 1892, Capt. J. H. Row.

Remarks : The damaged specimen is preserved in alcohol as a result it is stiff and brittle, and unsuitable for study. The description of species given by Rao (1931) is presented here : Umbrella more or less flat, diameter being 110 mm, resembling to a watch-glass ; velar lappets usually 8 between two rhopalia; velar and rhopalar lappets bearing a prolongation of the anastomosing net-work of canals ; length of the winged part of mouth arm 75 mm, extending beyond the margin of the umbrella.

Distribution : In India : West Bengal : Off Sandheads, mouth of the Ganges ; Bay of Bengal. Elsewhere : Mergui Archipelago ; Malayan Archipelago ; Siam ; Philippines; Australia.

OBSERVATIONS

The present study indicates the fact that salinity plays a major role in controlling the distribution of medusae in the Hugli-Matla estuary. Like Chaetognatha the occurrence of medusae in this estuary appear to be indicative of the salinity of water.

Out of 16 species under 15 genera and 15 families 7 species under 7 genera and 7 families are new record from the area under study and 5 species, viz., *B. virginica*, *M. gangetica*, *T. gargantua*, *A. wyvillei*, *C. andromeda* were not available during present investigation but the collection is available with the author. Only the last named species constitutes new locality record sorted out from old unnamed collection.

Six species, viz., *B. fulva*, *O. indicum*, *A. pensilis*, *T. gargantua*, *A. wyvillei* and *C. andromeda*, were available only at lower reaches of Zone III, while three species, viz., *E. ceylonensis*, *L. tetraphylla* and *A. flagellatus*, were found only at the middle reaches of either Zone III or Zone V. *N. typhlodendrium* was recovered from middle to lower reaches of Zones III & V while *E. menoni*, from all the reaches of Zones II to V.

Further, two species, viz., *B. virginica* and *M. gangetica*, were discovered only from the upper reaches of Zone II only. *L. indica* alone was traced from upper reaches of Zone I, though this species is hitherto known as typical freshwater form, as reported from many lakes and rivers of India.

SUMMARY

The paper deals with the occurrence of 16 species under 15 genera and 15 families from upper to lower reaches of Zones I to V of the Hugli–Matla estuarine belt. Of these seven species constitute new locality records from the area under study. Further, six species were not available during present investigation but included here from earlier study. In addition, morphology and terminology, and methods of collection and preservation are dealt herein. Further, distribution of all the species are given.

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ECHIURA AND SIPUNCULA

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INTRODUCTION

The phyla Echiura and Sipuncula comprise sedentary members dwelling in burrowed substrata. They are found in the temporarily exposed intertidal limits to the abyssal depths of vast seas and also certain tropical estuaries of the globe. Though they are typically of marine origin but a few apparently well adapt themselves to the estuarine environment. This recurrent mode of dispersal to and from the marine waters is found particularly in the tropics. The members with the estuarine habits are exclusively restricted to a single family of Echiura and, two of Sipuncula.

The paper deals with three species of Echiura, viz., *Anelassorhynchus branchiorhynchus*, *A. dendrorhynchus* and *A. microrhynchus* and a single species of Sipuncula, namely, *Phascolosoma arcuatun*. Of these, echiuran species, *A. microrhynchus* constitutes new locality record from the area under study. Previous works from this area include that of Annandale (1907), Annandale and Kemp (1915) and Haldar (1981, 1989) who reported some species from Port Canning and Chingrihata, and Sundarbans respectively.

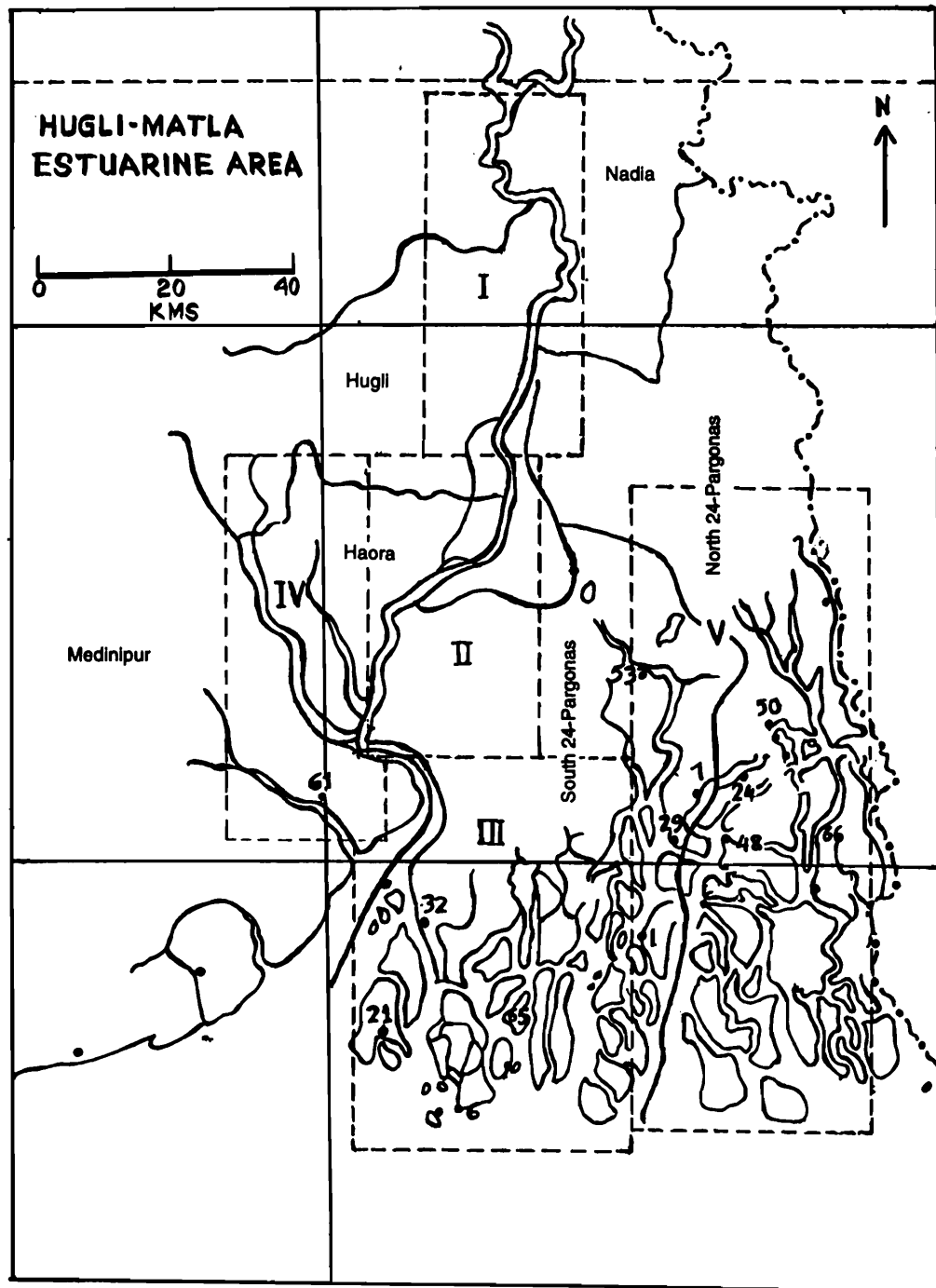
MATERIAL AND METHODS

Material for this study was collected through regular field trips from September, 1984 to March, 1989 at different localities of vast stretches of the Hughli-Matla estuarine belt and the material is mainly restricted at its lower stretch. In Matla estuary the collections are available from Parghumti downwards while in the Hugli estuary from Geonkhali downwards. The collection is mainly made from hard and sticky mud or black humus soil or mixed with fine sand granules.

After collection, narcotisation is made by sprinkling some quantity of menthol crystals or adding a few drops of 70% alcohol in the water containing specimens at frequent intervals. They are left in the relaxing medium one hour or more depending on their size. Initial fixation is made with 4% formaldehyde and permanent preservation with 70% alcohol.

List of species known from the area

Phylum	:	ECHIURA
Class	:	ECHIURIDA
Order	:	ECHIUROINEA
Family	:	THALASSEMATIDAE
Subfamily	:	THALASSEMATINAE
Genus	:	<i>Anelassorhynchus</i> Annandale



Showing the distribution of Echiura & Sipuncula in Hugli-Matla estuarine area

1. *Anelassorhynchus branchiorhynchus*—6 (Bakkhali), 7 (Basanti), 21 (Gangasagar), 24 (Gosaba), 32 (Kakdwip), 50 (Parghumti), 53 (Port Canning), 61 (Terapekhya) ;
2. *Anelassorhynchus dendrorhynchus*—1 (Ajmal mari), 7 (Basanti), 48 (Pakhiralay), 65 (Prentice Island) ;
3. *Anelassorhynchus microrhynchus*—1 (Ajmal mari), 6 (Bakkhali), 7 (Basanti), 66 (Panchamukhani) ;
4. *Phascolosoma arcutum*—6 (Bakkhali), 7 (Basanti), 29 (Jharkhali), 32 (Kakdwip).

1. *Anelassorhynchus branchiorhynchus* (Annandale & Kemp)
2. *Anelassorhynchus dendrorhynchus* (Annandale & Kemp)
3. *Anelassorgynchus microrhynchus* (Prashad)

Phylum : SIPUNCULA
 Class : PHASCOLOSOMATIDEA
 Order : PHASCOLOSOMATIFORMES
 Family : PHASCOLOSOMATIDAE
 Genus : *Phascolosoma* Leuckart

4. *Phascolosoma arcuatum* (Gray)

Phylum : ECHIURA
 Class : ECHIURIDA
 Order : ECHIUROINEA
 Family : THALASSEMATIDAE
 Subfamily : THALASSEMATINAE
 Genus : *Anelassorhynchus* Annandale

1922. *Anelassorhynchus* Annandale, *Bijdr. Dierk.*, **22** : 148

1984. *Anelassorhynchus* : Biseswar, *S. Afr. J. Zool.*, **19**(1) : 16

Diagnosis : Longitudinal and inner oblique muscle layer of uniform thickness and without specialized bands; nephrostomal lips prolonged and spirally coiled.

Key to the species of *Anelassorhynchus*

1. Proboscis well developed 2
 Proboscis reduced to a small collar *A. microrhynchus*
2. Proboscis with conspicuous ridge between the dendritic outgrowths
 *A. branchiorhynchus*
 Proboscis without ridge between the dendritic outgrowths *A. dendrorhynchus*

1. *Anelassorhynchus branchiorhynchus* (Annandale & Kemp)

1915. *Thalassema branchiorhynchus* Annandale and Kemp, *Mem. Indian Mus.*, 5 : 61-63, figs. (3) : 315.

1978. *Anelassorhynchus branchiorhynchus* : Haldar, *Bull. zool. Surv. India*, 1 (3) : 315.

Material examined : 2 exs., Forest jetty, Gosaba, 17. ix. 1984, B. P. Haldar; 4 exs., Terapekhya char in the river Haldi near Keshabpur, B. P. Haldar, 19. iii. 1985; 6 exs., south of old jetty, Canning, 26. ix. 1984, B. P. Haldar; 6 exs., East Khati, Parghumti, 8. ix. 1984, B. P. Haldar; 2 exs., Goalbari Khal, Bakkhali, 6. iii. 1985, B. P. Haldar; 2 exs., Harwood Point, Kakdwip, 8. iii. 1985, B. P. Haldar; 4 exs., Sajinatala, Basanti, 25. ii. 1986, B. P. Haldar; 8 exs., Terapekhya char in the river Haldi near Keshabpur, 17. iv. 1987, B. P. Haldar; 9 exs., north of Kapilmuni Temple, Gangasagar, 24. xii. 1987, B. P. Haldar.

Diagnosis : The measurement of the largest specimen is 85 mm in total length with proboscis 26 mm and that of the smallest one is 47 mm in total length with proboscis 15 mm. In the living condition the whole body is of deep reddish winous tinge, translucent, but not markedly so. The posterior extremity is somewhat paler than the remaining part. The proboscis is purplish pink while dendritic outgrowths is of bright red colour. The dendritic outgrowths of the proboscis margin are highly developed, having a gill-like appearance and are confined to the proximal third of the margin, the distal part of which is quite smooth. Longitudinal ridge of conspicuous nature is present on the proximal part of the ventral surface of the proboscis between the two rows of dendritic outgrowths. Ventral hooks are golden yellow in colour and placed anterior to the nephridiopores. Papillae near the posterior end of the body are conical and have a tendency to be arranged in transverse rings.

Remarks : The animal lives in a U-shaped burrow where the horizontal arm of U lies about 50 to 100 mm below the surface depending on the nature of the substrata. Some other forms like polychaete, *Gattyana fauveli* and an Isopod, *Cirolana* sp., are found in the burrow of this echinuran as commensals and they enjoy the same advantages that the host does.

So far this species is known only from two places of Sudarbans. Presently it is found occurring widely in the Hugli-Matla estuarine belt from Canning downwards along the Matla and its tributaries, and Kakdwip downwards along the Hugli and up to Terapekhya in the Haldi river upwards.

Distribution : The species was described from an estuarine area near Calcutta. But later on it was reported from marine habitat also. However, the species is endemic to India.

In India : West Bengal—24 Parganas (South) (Annandale and Kemp, 1915; Haldar, 1978; present record); Orissa—Chandipore (Prashad, 1919); Gujarat—Port Okha (Dattagupta *et al.*, 1963).

2. *Anelassorhynchus dendrorhynchus* (Annandale & Kemp)

1915. *Thalassema dendrorhynchus* Annandale and Kemp, *Mem. Indian Mus.*, 5 : 58-61, figs. 1.

1978. *Anelassorhynchus dendrorhynchus* : Haldar, *Bull. zool. Surv. India*, 1 (3) : 316.

Material examined : 3 exs., Sajinatala, Basanti, 25. ii. 1986; 2 exs., Ajmalmari, Sunderban Tiger Reserve Area, 6. iii. 1989, B. P. Haldar; 2 exs., Prentice Island, 8. iii. 1989, B. P. Haldar; 1 ex., Dayapur, near Pakhiralay, 14. iii. 1989, B. P. Haldar.

Diagnosis : The size of the fully preserved specimens ranges from 38 to 54 mm, of which the proboscis is 10 to 15 mm long. The colour of the living specimens is less conspicuous than the former species. The body wall is translucent with pale winous tinge, sometimes appear darker even black due to presence of mud in the alimentary canal. The nerve cord is visible externally as an opaque white line when the body wall remains translucent. The proboscis is cream-coloured and dendritic outgrowths tinged with brown. The proboscis is shovel shaped and its distal end is truncate. The dorsal surface is smooth while the ventral surface is devoid of longitudinal ridge but provided with inconspicuous ciliated groove. The margin of the proboscis is distinctly serrated, the serrations towards the proximal end gradually developed into small dendritic outgrowths which is less than half as long as it is wide. Ventral hooks are bright golden in colour and placed close to proboscis base. Papillae covering the body are densely placed near both extremities but the circum-anal region is devoid of papillae.

Remarks : The animal prefers comparatively soft mud as their habitat. It is very sluggish in its movement when it is taken out from the substrata. It lives in vertical burrow and it was captured from the depth of 30 to 50 mm below the surface. This species can readily be identified from the former species in the field by the presence of shovel-shaped proboscis, and dendritic marginal outgrowths which are very wide and gill-like in the former one.

Previously this species is known from the Sagar Island near the mouth of the Hugli. Present report indicates its occurrence in the lower part of the Matla and the Saptamukhi.

Distribution : This species was described from an estuarine body of Chilka lagoon. Afterwards it was reported from estuarine and marine habitat also. This species is endemic to the east coast of India.

In India : West Bengal—Sagar Island (Haldar, 1978; present record); Orissa—Chilka Lake (Type locality) (Annandale and Kemp, 1915); Tamil Nadu—Pamban (Haldar, 1978).

3. *Anelassorhynchus microrhynchus* (Prashad)

1919. *Thalassema microrhynchus* Prashad, *Rec. Indian Mus.*, 16 : 399-400, fig. 1.

1946. *Anelassorhynchus microrhynchus* : Fisher, *Proc. U. S. natn., Mus.*, 96 : 222.

Material examined : 4 exs., Bakkhali Khal near bus terminus, Bakkhali, 7. iii. 1985, B. P. Haldar; 2 exs., Sajinatala, Basanti, 25. ii. 1986; 3 exs., Goalbari Khal, Bakkhali, 1. iv. 1987,

B. P. Haldar; 7 exs., Ajmalmari, Sunderban Tiger Reserve Area, 6. iii. 1989, B. P. Haldar; 30 exs., Panchamukhani, Sunderban Tiger Reserve Area, 6. iii. 1989, B. P. Haldar.

Diagnosis : The trunk of the fully narcotised specimens ranges from 15 to 33 mm long while proboscis varies from 1 to 3 mm. In the live condition the anterior part of the trunk is somewhat translucent while the posterior part is opaque. The colour of the trunk is, in general, greyish white while the proboscis is creamy white. The proboscis is a rudimentary structure; its two lateral margins at the proximal end fused ventrally to form a tubular shape while its distal margins are free and end is truncate. The dorsal surface of the proboscis is smooth while the ventral surface have long furrows but no ciliated groove. Papillae covering the body are most numerous towards the extremities where they are arranged in rings. A small elongated ridge formed by the union of adjacent papillae is observed on the mid-ventral trunk. Circumanal region possesses papillae. Ventral hooks are well developed and their free ends are very broad and curved.

Remarks : The animal usually prefers hard muddy substrata as its habitat, but sometimes it is recovered from soft muddy bed also. In the former habitat its burrow lies in a horizontal position about 5-8 mm below the surface but in the latter habitat no clear burrow was possible to trace, however, the animal lives at depth of 7-11 mm below the surface. It is interesting to note that *Phascolosoma arcuatum*, a sipunculan, was also collected from the same bed.

This species is so far unknown in this estuarine belt. The present collection indicates occurrence of this species in the lower part of this estuarine area.

Distribution : This species was described from the estuarine zone at Chandipore, Orissa. For a span of seven decades the species was not reported elsewhere until recently from the Hugli-Matla estuarine area.

In India : West Bengal—Sundarban (present record) ; Orissa—Chandipore (Type locality) (Prashad, 1919).

Phylum	:	SIPUNCULA
Class	:	PHASCOLOSOMATIDEA
Order	:	PHASCOLOSOMATIFORMES
Family	:	PHASCOLOSOMATIDAE
Genus		<i>Phascolosoma</i> Leuckart

1828. *Phascolosoma* Leuckart, *Breves animalium quorandam ex parte marinorum descriptiones*. Heidelberg : 22, fig. 52.

1987. *Phascolosoma* : Gibbs and Cutler, *Bull. Br. Mus. nat. Hist.*, (Zool.), 52 (1) : 54.

Diagnosis : Introvert variable in length, ranging from one-third to twice the trunk length; hooks recurved and arranged in numerous rings; tentacles arranged around nuchal organ and placed dorsal to mouth; longitudinal muscle layer of body wall divided into separate bands; contractile vessel single, lacking villi; spindle muscle attached posteriorly.

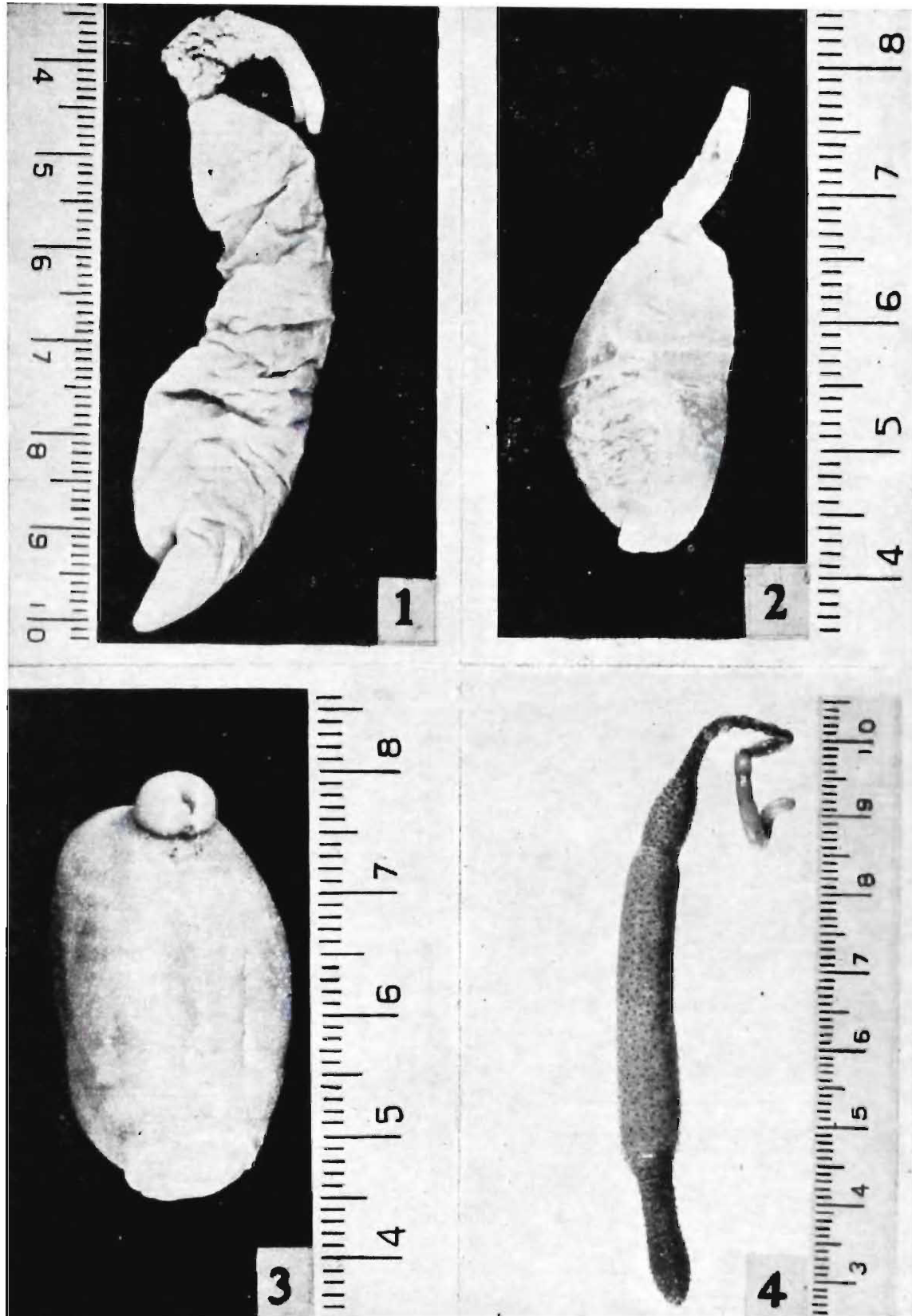


Fig. 1: *Anelas sorhynchus branchiorhynchus* (Annandale & Kemp); 2: *A. deudrorhynchus* (Annandale & Kemp); 3: Lateral view of *A. microrhynchus* (Prashad); 4: *Phacolosoma arcuatum* (Gray).

4. *Phascolosoma arcuatum* (Gray)

1828. *Sipunculus arcuatus* Gray, *Spicilegia Zoologica*, London, Treitel, Wurtz & Co. and W. Wood, (1) : 8.

1991. *Phascolosoma arcuatum* : Haldar, *Mem. zool. Surv. India*, 17 (4) : 54-56.

Material examined : 4 exs., Banamali Khal, Jharkhali, 21. ix. 1984, B. P. Haldar; 15 exs., Bakkhali Khal near bus terminus, Bakkhali, 7. iii. 1985; 1 ex., from a canal on way to Harwood jetty, Kakdwip, 8. iii. 1985, B. P. Haldar; 2 exs., Jharkhali, 21. v. 1985; B. P. Haldar; 3 exs., Jharkhali Khal, 22. v. 1985, B. P. Haldar; 2 exs., Masjidbati, near Basanti, 28. ii. 1986, B. P. Haldar; 4 exs., Jharkhali No. 4, 21. i. 1987, B. P. Haldar; 7 exs., Bakkhali, Khal near bus terminus, Bakkhali, 3. iv. 1987, B. P. Haldar.

Diagnosis : The trunk is 33-65 mm long while introvert is slender, partially retracted and 40-90 mm long. The animal is pale brown to brown coloured but anterior and posterior extremities are dark brown to blackish brown due to presence of aggregation of papillae. Tentacles are 8-10 in number, finger-like, arranged in a horse shoe-shaped fashion and placed dorsal to mouth. Hooks are arranged in 50-60 closely set complete rows; each hook is dark coloured with sharply bent apex forming an obtuse angle. Circular and longitudinal muscle layers are grouped into bands. Retractor muscles are two pairs originating more or less at the same level but arrangement is totally reverse in this species i.e., anterior muscles arise behind and ventral to posterior ones. Spindle muscle is attached at both ends. Rectum is short and without caecum. Contractile vessel is simple and without villi. Nephridia is one-third as long as trunk and attached to body wall by two-thirds of their length.

Remarks : The animal lives in comparatively hard mud forming a burrow which is a permanent one, except that from time to time they are enlarged and lengthened to accommodate growth. The shape of the burrow is apparently like a '1' or hook, though actually it is 'U' or hairpin-like, since one of the arms is sometimes blocked by silt. It was noticed that the burrow reached straightway for about 20 cms downwards, then taking a 'U' turn to reach again the soil surface and that the individual remains in one of the arms up to a depth of about one cm from the surface.

The species is generally found in the lower estuarine belt from mean high water spring tide to below mean low water spring tide water level. This is the only species of *Sipuncula* occurring in this mangrove estuary.

Distribution : This species was described by Gray from material collected from India; no specific locality was mentioned there. However, this is an Indo-west Pacific species found in tropical shallow water.

In India : West Bengal (Haldar, 1989 ; present record) ; North Andamans (Haldar, 1991) ; India (Gray, 1928). *Elsewhere* : Indian Ocean and Pacific Ocean.

GENERAL OBSERVATIONS

The burrows of two abundantly occurring species, *Anelassorhynchus branchiorhynchus*, an echiuran, and *Phascolosoma arcuatum*, a sipunculan, are actually observed. In the Hugli-Matla estuarine belt it is rather too difficult to locate the burrow of *A. branchiorhynchus* amidst a vast assemblage of those of crabs, polychaetes and other invertebrates within the muddy habitats at a depth of 5-10 cm. The substrata may be of hard and sticky or black humus soil or mixed with fine sand granules. The surfaces of such substrata is indiscriminately strewn with minute paired holes 1-2 mm in diameter, being 4-9 cm apart from each other of a given pair, through which communicate the two respective ends of an internal burrow in the form of a 'U'-tube housing the very soft and delicate singleton cylindrical echiuran. The burrow is made of mud coated with mucous secreted by the animal; the vertical arms are very narrow in comparison to its horizontal arm. The burrows are kept clean and free from debris and fecal pellets.

Phascolosoma arcuatum constructs its burrow both in the transitorily terrestrial substratum and in the intertidal bed; of these former habitat comes under the influence of tidal overflow for only a couple of days or so every fortnight and remain rather dry during rest of the period. It makes rounded burrows in the mud into which their body fits. The burrow apparently looks like a 'I' or hook and is made firmer and more secure by the secretion of a certain amount of mucous into the mud about the worm.

This sipunculan can thrive well in semiterrestrial habitat and found throughout the intertidal region starting from above the high water spring tide to low water spring tide water levels in mangrove region of lower part of this estuarine belt. The author in 1991 reported this species from the mangrove area of Bangladesh. The species occurs in the mangrove belts of the Australo-oriental region. In other words, the species elicits its preference for dwelling in the mangrove to the non-mangrove belts.

A point of great biological interest arising from these surveyworks is the occurrence to two such diverse groups under similar conditions. Further, all the three species of *Anelassorhynchus* i.e., *A. branchiorhynchus*, *A. dendrorhynchus* and *A. microrhynchus* have been collected from the same locality, at least in one case, living under apparently similar biological conditions.

Material from both the Hugli-Matla estuarine region and Chilka lagoon (Halder, in press) reveals the occurrence of 3 species of echiurans and one species of sipunculan at each of these areas. Of the total four species only the echiuran, *Anelassorhynchus dendrorhynchus*, is common at both the places and the other species of Hugli-Matla estuarine belt have been replaced at Chilka lagoon by *A. sabinus*, *Ochetostoma australiense* and *Siphonosoma australe*.

SUMMARY

The paper deals with the occurrence of three echiuran and one sipunculan species from the Hugli-Matla estuarine belt. These are *Anelassorhynchus branchiorhynchus*, *A. dendrorhynchus* and

A. microrhynchus of Echiura and *Phascolosoma arcuatum* of Sipuncula. Of these last named echiuran species constitutes new locality record from the area under study. In addition, nature of the burrow of two of these species under corresponding phyla has been incorporated.

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MOLLUSCS

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INTRODUCTION

In India there are 14 major, 44 medium and 162 minor rivers, majority of which form estuaries at their confluences with the sea. Estuaries have attracted the attention of investigators because of their highly productive nature and high fishery potential. Obviously most of the earlier works were directed towards the fishery aspects. Majority of these studies were, however, conducted in easily accessible medium and minor estuaries. Two major estuaries, which were studied in some detail for their physical parameters and fish productivity are the Gautami-Godavary and the Hugli-Matla. The latter is by far the largest and most interesting of all and in fact, estuarine studies in India started in this estuary.

The Hugli-Matla estuarine complex is a very large area, which includes about 2,340 sq. km. area of water in its various tributaries and distributaries (Mitra, 1967). The estuary is remarkable in that the tidal influence extends up to 290 km from the sea face and the salinity ranges from 0.23% to 32.77%. Tides play a prominent role in the estuary and as they cause movements of water up and down the estuary bring fresh recruits of the fauna. Some of the pelagic forms either as adults or juveniles are carried with the tides into the estuary. But the ability of various species to settle down in the estuary depends on their salinity tolerance.

Based on salinity and other physical parameters the Hugli-Matla estuary has been divided into five zones (Jhingran, 1982) as given below :

Zone I. Upper zone—Nabadwip to Konnagar

Zone II. Middle zone or Gradient zone—Konnagar to Diamond Harbour

Zone III. Lower or Marine zone—Diamond Harbour to Mouth of estuary, entire lower Sunderban

Zone IV. River Rupnarayan

Zone V. River Matla around Port Canning

The first three zones intergrade into each other and are within the stretch of the main river Hugli which debouches into Bay of Bengal at Ganga Sagar. The area of its mouth is Sand heads, which is not included in the estuary. Zones IV and V are somewhat isolated but have connections with the main estuary (Map 1).

Most of the earlier studies in Hugli-Matla were concentrated on the fauna of the Sunderbans, which is a part of Zone III. A general idea of the geographical and ecological features of the Sunderbans can be had from Chowdhury (1987) and Mandal and Nandi (1989). As far as fauna is

concerned Stoliczka (1869) was the first to initiate research on brackish animals of Lower Bengal and he was followed by Annandale (1907), Kemp (1917), Hora (1934) and others. Sewell (1934) attempted a review of the faunal investigations in the Sunderbans till that date. The most recent comprehensive treatment of the fauna of the Sunderbans Mangrove (Mandal and Nandi, 1989) summarises the data collected so far. From various publications it is possible to obtain an idea about the changing physico-chemical parameters and their influence on the biota. The waters of the Salt Lakes in 1929 used to be fairly brackish but by February, 1933 it became almost fresh. Now a large part of Salt lakes has disappeared under the impact of urbanisation, which has also its influence on the fauna of Hugli-Matla estuary. Systematics of estuarine molluscs, in general, is fairly well known and a catalogue of species has been prepared (Subba Rao and Surya Rao, 1985). Hitherto Molluscan fauna has been studied mostly in relation to mangroves. A fair amount of knowledge has accumulated on the molluscs of mangroves of Vellar, Krishna, Godavary, Mahanadi and Sunderbans (Tables-5 & 6). However, most of these earlier studies were devoted to the study of a particular area or to a few species of molluscs, mostly gastropods. Some of the recent publications (Subba Rao *et. al.*, 1983; 1987) have included notes on some bivalves also.

It is for the first time a comprehensive review of the malacofauna of Hugli-Matla estuary is attempted. The data collected during several surveys which include a total of 64 stations (Table I) at various times of the years starting from 1984 to 1988, is presented in this communication. Apart from its comprehensive nature the present communication incorporates some new data on some well known and less known species of molluscs. Some of the molluscan species were earlier known through shells only. During the present surveys the beds of certain bivalves were discovered. The data on the relative abundance of some common molluscs, population density and egg capsules of certain molluscs have also been recorded. Systematics and other relevant data of all these species can be found in our recent publication (Subba Rao *et. al.* In 1992) and hence not repeated here. The present paper has given more stress on the natural history of various species. Field observations are given only for those species for which data has been collected and all others have formed part of the general collections.

MATERIAL AND METHODS

Collections were made in various parts of the Hugli-Matla estuary for four years from 1984 to 1988. A total of 64 stations (Table 1) were established during the surveys conducted. Some of the stations were surveyed more than once and a maximum of five trips were made during the total period in different months. The samples from different stations were collected and preserved in 4% formaldehyde or 70% alcohol (for soft bodies) and was brought to the laboratory for identification.

The population counts of gastropods were made from one square meter area. An average of three counts was taken as mean value of the population. For the bivalves, a cubic meter area was combed for collection and to determine the area a square steel frame measuring 50 cm x 50 cm x 15 cm was taken. The quadrat was pushed into the sediment and the enclosed deposit was collected and sieved through 1 mm net to retain the juveniles. Surface dwelling macromolluscs falling within the quadrat were counted and the number noted. The collections were made during low tide, when the mud flats were exposed. Wood borers were extracted from the infested wood by the help of a hammer and chisel.

Breeding behavior, egg capsules etc., were observed during the survey of each station.

Cephalopods were collected from the drag nets operated by fishermen at the time of our survey.

A SYSTEMATIC LIST OF SPECIES OCCURRING IN THE HUGLI-MATLA ESTUARY

- Class : GASTROPODA
- Order : ARCHAEOGASTROPODA
- I. Family : ACMAEIDAE
1. Genus : *Potamacmaea* Peile
- (1) *Potamacmaea fluviatilis* (Blanford)
- II. Family : CYCLOSTREMATIDAE
2. Genus : *Tubiola* A. Adams
- (2) *Tubiola microscopica* (Nevill)
- III. Family : NERITIDAE
3. Genus : *Nerita* Linnaeus
- (3) *Nerita articulata* Gould
4. Genus : *Neritina* Lamarck
- (4) *Neritina smithi* Wood
- (5) *Neritina (Dostia) violacea* (Gmelin)
5. Genus : *Pseudonerita* Baker
- (6) *Pseudonerita obtusa* (Benson)
- (7) *P. sulculosa* (von Martens)
6. Genus : *Clithon* Montfort
- (8) *Clithon reticularis* (Sowerby)
7. Genus : *Septaria* Ferussac
- (9) *Septaria caerulescens* (Sowerby)
- (10) *S. lineata* (Lamarck)
- IV. Family : VIVIPARIDAE
8. Genus : *Bellamyia* Jousseau
- (11) *Bellamyia bengalensis* f. *typica* (Lamarck)
- (12) *Bellamyia dissimilis* (Mueller)

- (13) *B. crassa* (Benson)
 V. Family : PILIDAE
 9. Genus : *Pila* Roeding
- (14) *Pila globosa* (Swainson)
 Order : MESOGASTROPODA
 VI. Family : LITTORINIDAE
 10. Genus : *Littorina* Ferussac
- (15) *Littorina (Littorinopsis) melanostoma* Gray
 (16) *L. (Littorinopsis) scabra scabra* (Linnaeus)
 (17) *L. (Littoraria) undulata* Gray
 (*Littorina carinifera* Needs confirmation)
- VII. Family : IRAVADIIDAE
 11. Genus : *Iravadia* Blanford
- (18) *Iravadia ornata* Blanford
- VIII. Family : STENOTHYRIDAE
 12. Genus : *Stenothyra* Benson
- (19) *Stenothyra blanfordiana* Nevill
 (20) *S. deltae* (Benson)
 *(21) *S. nana* Annandale and Prashad
 *(22) *S. ornata* Annandale and Prashad
 (23) *S. soluta* Annandale and Prashad
 (24) *S. woodmasoniana* Nevill
13. Genus : *Gangetia* Ancey
- (25) *Gangetia miliacea* (Nevill)
- IX. Family : BITHYNIIDAE
 14. Genus : *Digoniostoma* Annandale
- (26) *Digoniostoma cerameopoma* (Benson)
- X. Family : ASSIMINEIDAE
 15. Genus : *Assimineea* Fleming
- (27) *Assimineea beddomeana* Nevill
 (28) *A. brevicula* (Pfeiffer)

(29) *A. francesiae* (Wood)

(30) *A. hungerfordiana* Nevill

(31) *A. microsculpta* Nevill

(32) *A. theobaldiana* Nevill

(33) *A. woodmasoniana* Nevill

XI. Family : ARCHITECTONICIDAE

16. Genus : *Architectonica* Roeding

(34) *Architectonica perspectiva* (Linnaeus)

XII. Family : THIARIDAE

17. Genus : *Thiara* Bolten

(35) *Thiara (Thiara) scabra* (Mueller)

(36) *T. (Melanoides) tuberculata* (Mueller)

(37) *T. (Tarebia) granifera* (Lamarck)

(38) *T. (Tarebia) lineatus* (Gray)

(39) *T. (Mainwaringia) paludomoidea* Nevill

18. Genus : *Brotia* H. Adams

(40) *Brotia costula* (Rafinesque)

19. Genus : *Larina* A. Adams

(41) *Larina burmana* Blanford

XIII. Family : POTAMIDIDAE

20. Genus : *Telescopium* Montfort

(42) *Telescopium (T) telescopium* (Linnaeus)

(*T. (T.) mauritsii* Butot—A variant of the above species)

21. Genus : *Cerithidea* Swainson

(43) *Cerithidea (Cerithideopsilla) cingulata* (Gmelin)

(44) *C. (Cerithidea) obtusa* Lamarck

XIV. Family : EPITONIIDAE

22. Genus : *Acrilla* H. Adams

(45) *Acrilla acuminata* (Sowerby)

XV. Family : NATICIDAE

23. Genus : *Natica* Scopoli

(46) *Natica gualteriana* (Recluz)

- (47) *Natica tigrina* (Roeding)
Order : NEOGASTROPODA
- XVI. Family : MURICIDAE
24. Genus : *Thais* Roeding
- (48) *Thais lacera* (Born)
- XVII. Family : PYRENIDAE
25. Genus : *Columbella* Lamarck
- (49) *Columbella duclosiana* Sowerby
- XVIII. Family : MELONGENIDAE
26. Genus : *Pugilina* Schumacher
- (50) *Pugilina cochlidium* (Linnaeus)
- XIX. Family : NASSARIIDAE
27. Genus : *Nassarius* Dumeril
- (51) *Nassarius foveolatus* (Reeve)
(52) *N. (Pygmaeonassa) orissaensis* Preston
(53) *N. stolatus* (Gmelin)
- XX. Family : OLIVIDAE
28. Genus : *Amalda* H. and A. Adams
- (54) *Amalda ampla* (Gmelin)
- XXI. Family : TURRIDAE
29. Genus : *Asthenotoma* Harris and Burrows
- (55) *Asthenotoma vertebrata* (Smith)
- XXII. Family : RINGICULIDAE
30. Genus : *Ringicula* Deshayes
- (56) *Ringicula propinquans* Hinds
- XXIII. Family : CYLICHNIDAE
31. Genus : *Tornatina* A. Adams
- (57) *Tornatina estriata* Preston
- XXIV. Family : AGLAJIDAE
32. Genus : *Melanoclamys* Cheeseman

- (58) *Melanoclamys* sp.
- XXV. Family : ATYIDAE
33. Genus : *Haminea* (Leach) Gray
- (59) *Haminea crocata* Pease
- Order : BASOMMATOPHORA
- XXVI. Family : ELLOBIIDAE
34. Genus : *Cassidula* Ferussac
- (60) *Cassidula nucleus* (Gmelin)
35. Genus : *Ellobium* (Bolten) Roeding
- (61) *Ellobium aurisjudae* (Linnaeus)
- (62) *E. (Auricula) gangeticum* (Pfeiffer)
36. Genus : *Melampus* Montfort
- (63) *Melampus pulchella* Petit
37. Genus : *Pythia* (Bolten) Roeding
- (64) *Pythia plicata* (Gray)
- XXVII. Family : LYMNAEIDAE
38. Genus : *Lymnaea* Lamarck
- (65) *Lymnaea (Pseudosuccinea) acuminata* f. *typica* Lamarck
- (66) *L. (P.) acuminata* f. *rufescens* Gray
- (67) *L. (P.) luteola* f. *typica* Lamarck
- XXVIII. Family : PLANORBIDAE
39. Genus : *Indoplanorbis* Annandale & Rao
- (68) *Indoplanorbis exustus* (Deshayes)
- Order : SOLEOLIFERA
- XXIX. Family : ONCHIDIIDAE
40. Genus : *Onchidium* Buchanan
- (69) *Onchidium pallidum* Stoliczka
- (70) *O. tenerum* Stoliczka
- (71) *O. tigrinum* Stoliczka
- (72) *O. typhae* Buchannan

- Class : SCAPHOPODA
- XXX. Family : DENTALIIDAE
41. Genus : *Dentalium* Linnaeus
- (73) *Dentalium octangulatum* Donovan
- Class : BIVALVIA
- Order : ARCOIDA
- XXXI. Family : ARCIDAE
42. Genus : *Scaphula* Benson
- (74) *Scaphula celox* Benson
- (75) *Scaphula deltae* Blanford
43. Genus : *Anadara* Gray
- (76) *Anadara granosa* (Linnaeus)
- XXXII. Family : NOETIIDAE
44. Genus : *Striarca* Conard
- (77) *Striarca lactea* (Linnaeus)
- Order : MYTILOIDA
- XXXIII. Family : MYTILIDAE
45. Genus : *Modiolus* Lamarck
- (78) *Modiolus striatulus* (Hanley)
- (79) *M. undulatus* (Dunker)
- Order : PTERIOIDA
- XXXIV. Family : ANOMIIDAE
46. Genus : *Placuna* Bruguiere
- (80) *Placuna (P.) placenta* (Linnaeus)
47. Genus : *Enigmonia* Iredale
- (81) *Enigmonia aenigmatica* (Holten)
- XXXV. Family : OSTREIDAE
48. Genus : *Crassostrea* Sacco
- (82) *Crassostrea cuttackensis* (Newton and Smith)
- (83) *C. gryphoides* (Schlotheim)
49. Genus : *Saccostrea* Dollfus and Dautzenberg
- (84) *Saccostrea cucullata* (Born)

- Order : UNIO NOIDA
- XXXVI. Family : UNIONIDAE
50. Genus : *Parreysia* Conard
- (85) *Parreysia favidens* (Benson)
- Order : VENEROIDA
- XXXVII. Family : LUCINIDAE
51. Genus : *Eamesiella* Chavan
- (86) *Eamesiella philippinarum* (Hanley)
- XXXVIII. Family : MACTRIDAE
52. Genus : *Mactra* Linnaeus
- (87) *Mactra luzonica* Deshayes
- XXXIX. Family : SOLENIDAE
53. Genus : *Solen* Linnaeus
- (88) *Solen brevis* Gray
- XXXX. Family : CULTELLIDAE
54. Genus : *Cultellus* Schumacher
- (89) *Cultellus subelliptica* Dunker
55. Genus : *Neosolen* Ghosh
- (90) *Neosolen aquaedulcioris* E.N. Ghosh
56. Genus : *Pharella* Gray
- (91) *Pharella javanicus* (Lamarck)
57. Genus : *Siliqua* Megerle von Muehlfeld
- (92) *Siliqua albida* Dunker
58. Genus : *Tanysiphon* Benson
- (93) *Tanysiphon rivalis* Benson
- XLI. Family : TELLINIDAE
59. Genus : *Tellina* Linnaeus
- (94) *Tellina corbuloides* (Hanley)
- (95) *T. irridescens* (Benson)

- (96) *T. sinuata* Spengler
60. Genus : *Strigilla* Turton
- (97) *Sirigilla splendida* (Anton)
61. Genus : *Macoma* Leach
- (98) *Macoma birmanica* (Philippi)
- XLII. Family : DONACIDAE
62. Genus : *Donax* Linnaeus
- (99) *Donax incarnatus* Gmelin
- XLIII. Family : PSAMMOBIIDAE
63. Genus : *Sanguinolaria* Lamarck
- (100) *Sanguinolaria (Soletellina) acuminata* (Deshayes)
- XLIV. Family : SEMELIDAE
64. Genus : *Theora* H. and A. Adams
- (101) *Theora opalina* (Hinds)
- XLV. Family : SOLECURTIDAE
65. Genus : *Novaculina* Benson
- (102) *Novaculina gangetica* Benson
- XLVI. Family : CORBICULIDAE
66. Genus : *Corbicula* Megerle von Muehlfeld
- (103) *Corbicula striatella* Deshayes
- (104) *C. bensoni* Deshayes
67. Genus : *Polymesoda* Rafinesque
- (105) *Polymesoda (Geloina) bengalensis* (Lamarck)
- XLVII. Family : TRAPEZIIDAE
68. Genus : *Trapezium* Megerle von Muehlfeld
- (106) *Trapezium sublavigatum* (Lamarck)
- XLVIII. Family : VENERIDAE
69. Genus : *Gafrarium* (Bolten) Roeding
- (107) *Gafrarium pectinatum* (Linnaeus)
70. Genus : *Meretrix* Lamarck

- (108) *Meretrix meretrix* (Linnaeus)
71. Genus : *Pelecypora* Dall
- (109) *Pelecypora trigona* (Reeve)
- XLIX. Family : GLAUCONOMIDAE
72. Genus : *Glaucanome* Gray
- *(110) *Glaucanome cerea* Reeve
- (111) *sculpta* (Sowerby)
Order : MYOIDA
- L. Family : MYIDAE
73. Genus : *Sphenia* Turton
- (112) *Sphenia perversa* Blanford
- LI. Family : CORBULIDAE
74. Genus : *Corbula* Bruguiere
- (113) *Corbula abbreviata* Preston
- (114) *C. calcarea* Preston
- (115) *C. gracilis* Preston
- LII. Family : PHOLADIDAE
75. Genus : *Martesia* Sowerby
- (116) *Martesia fragilis* Verrill and Bush
76. Genus : *Lignopholas* Turner
- (117) *Lignopholas fluminalis* (Blanford)
77. Genus : *Barnea* Leach
- (118) *Barnea candida* (Linnaeus)
- LIII. Family : TEREDINIDAE
78. Genus : *Bactronophorus* Tapparone-Canefri
- (119) *Bactronophorus thoracites* (Gould)
79. Genus : *Dicyathifer* Iredale
- (120) *Dicyathifer manni* (Wright)

80. Genus : *Bankia* Gray
- *(121) *Bankia carinata* (Gray)
- (122) *B. campanellata* Moll and Roch
- (123) *B. nordi* Moll
- (124) *B. rochi* Moll
81. Genus : *Nausitora* Wright
- (125) *Nausitora dunlopei* Wright
- LIV. Family : LATERNULIDAE
82. Genus : *Laternula* Roeding
- (126) *Laternula truncata* (Lamarck)
- LV. Family : CUSPIDARIIDAE
83. Genus : *Cuspidaria* Nardo
- (127) *Cuspidaria chilkaensis* (Preston)
- Class : CEPHALOPODA
- Order : SEPIOIDEA
- LVI. Family : SEPIIDAE
84. Genus : *Sepia* Linnaeus
- (128) *Sepia aculeata* d'Orbigny
85. Genus : *Sepiella* Gray
- (129) *Sepiella inermis* (d'Orbigny)
- Order : TEUTHOIDEA
- LVII. Family : LOLIGINIDAE
86. Genus : *Loliolus* Steenstrup
- (130) *Loliolus investigatoris* Goodrich

* recorded in literature only.

TABLE—1

List of Collecting Stations, Distance from Sea, Date of Collection and No. of Species Collected at each.

Sl. No.	Collecting station	Distance from sea (Approx. in Km)	Date of collection	No. of species collected
1.	Ajmalhari-Koikalhari junction	51	08.11.88	G 21, B 3
2.	Amjhora	109	02.03.86	G 8, B 3
3.	Arbesi-2 (Opp. to Jhingakhali)	81	12.11.88	G 18, B 1
4.	Baghagan (Rangabelia)	83	13.11.88	G 16, B 8
5.	Ballykhal	184	17.08.88	G 5
6.	Bakkhali	5	03.03.85,10.12.87 18.12.87	G 9, B 6
7.	Basanti	83	25.02.86,21.06.86	G 12, B 5
8.	Bhangankhali	78	01.03.86	G 9, B 8
9.	Birajmanirchar	76	16.09.84	G 4, B 2
10.	Budge Budge	145	16.08.88	
11.	Champta-South West	38	04.11.88	G 15, B 1
12.	Chandannagar	220	13.08.88	G 4, B 1
13.	Chandpal Ghat	163	17.08.88	G 4
14.	Chhotahardi	24	25.08.87	G 10, B 2
15.	Chhotamollakhali,	90	12.09.84	G 8, B 2
16.	Chulkati	12	09.11.88	G 28, B 4
17.	Chunchura	224	13.08.88	G 2
18.	Diamond Harbour	80	11.03.85,09.04.87	G 8, B 2
19.	Falta	105	24.03.85	G 6, B 1
20.	Gadiwara	117	11.08.88,04.01.89	G 10, B 2
21.	Gangasagar	0	21.12.87,24.12.87	G 24, B 14
22.	Geonkhali	116	21.03.85,20.04.87	G 4, B 1
23.	Gona North East	15	13.09.83,04.11.88	G 5, B 1
24.	Gosaba	77	15.09.84,24.05.85 20.06.86	G 12, B 8
25.	Haldia	48	16.03.85,13.04.89	G 4, B 2

TABLE—1 (Contd.)

Sl. No.	Collecting station	Distance from sea (Approx. in Km)	Date of collection	No. of species collected
26.	Haldibari	19	22.08.87,05.11.88	G 10, B 4
27.	Halliday Island	12	01.09.87,06.11.88	G 21, B 2
28.	Jambu Island	2	17.12.87	G 8, B 6
29.	Jharkhali	60	21.09.84,20.05.85 26.06.86,20.07.87 07.11.88	G 16, B 6 C 1
30.	Kalas	0	10.11.88	G 8, B 12
31.	Kaikhali	64	07/11/88	G -12, B 8
32.	Kakdwip	25	08.02.85	G 14, B 7
33.	Kalna	256	20.08.88,11.01.89	G 11, B 2
34.	Kalyani	234	14.08.88	G 6, B 2
35.	Khatuajhuri	65	12.11.88	G 5, B 2
36.	Khidirpore	160	17.08.88	G 3, B 1
37.	Kishorimohanpur	40	08.11.88	G 32, B 5
38.	Kumirmari (Bagna)	75	13.11.88	G 4, B 2
39.	Marichjhapi (Jhila-1)	78	13.11.88	G 21, B 1
40.	Matla Chhothardi junction	19	25.09.87,10.11.88	G 28, B 4
41.	Mosjidbari	77	28.02.86,27.08.87	G 8, B 2
42.	Nabadwip	290	14.01.89	G 5, B 1
43.	Naihati	226	15.08.88	G 6
44.	Namkhana	19	16.12.87	G 14, B 7
45.	Naubankichar	41	27.08.87,30.08.78	G 8, B 2
46.	Netidophani-Tiger Project Jetty	42	03.11.88	G 8, B 8
47.	Nurpur	115	07.01.89	G 5, B 1
48.	Pakhiralaya	67	16.09.84	G 3, B 1
49.	Palta	201	07.01.89	G 6, B 1

TABLE—1 (*Contd.*)

Sl. No.	Collecting station	Distance from sea (Approx. in Km)	Date of collection	No. of species collected
50.	Pargumti	102	09.09.84,10.09.84	G 10, B 5
51.	Parseymari (Chulkati)	43	09.11.88	G 12, B 2
52.	Pirkali	55	29.05.85,02.11.88	G 15, B 1
53.	Port Canning	105	26.09.84,05.03.86	G 14, B 7
54.	Purandar	101	26.02.86,18.06.86	G 8, B 2
55.	Saimari	18	23.09.83,04.11.88	G 15, B 3, S 1
56.	Sajnakhali	68	16.09.84.14.11.88	G 20, B 1
57.	Sandeshkhali	109	30.05.85	G 10, B 1
58.	Sibganj	163	11.08.88	G 9, B 1
59.	Soladanarchar (Basirhat)	154	05.09.84,02.04.87	G 8, B 2
60.	Sultanpur	79	11.03.85	G 7, B 1
61.	Terapekha	50	14.03.85	G 6, B 1
62.	Tribeni	230	14.08.88	G 6, B 1
63.	Uttarpara	184	16.08.88	G 7
64.	Vidya Matla Junction (Netidophani)	41	03.11.88	G 8, B 4

G = Gastropoda

B = Bivalvia

S = Scaphopoda

C = Cephalopoda

FIELD OBSERVATIONS

Family I ACMAEIDAE

It is represented by only one species viz., *Protamacmaea fluviatilis* (Blanford), which is mostly found attached to the stem of *Avicennia* plant up to the height of 90 cm above the ground. It was also found in the crevices of algal coated bricks and dykes at Pargumti, it was observed to breed during May-June.

Family II CYCLOSTREMATIDAE

The species *Tubiola microscopica* (Nevill) was observed during low tide on the mudflat on the bank of Matla river at Saimari.

Family III NERITIDAE

Eight species were recorded from the estuary. *Nerita articulata*, *Neritina N. violacea*, *N. smithi* and *Pseudonerita sulculosa* were relatively abundant whereas *Clithon reticulasis* were collected from Hugli estuary at Falta and Geonkhali. *N. articulata* was observed throughout the area attached to the mangrove plant up to the height of 2 meter above the ground level. It was also observed on wooden pillars, in the crevices of dykes, either in solitary condition or in clusters, up to 9 individuals. Young ones (3 mm) were observed during the month of May under the bark of mangrove plants. *N. violacea* was found mainly in upper mud flat, attached to pillars or in crevices of the bricks. *P. sulculosa* was found adhering to wood under its bark or in the empty tunnels of shipworms and crevices of dykes which were not completely exposed during low tide.

Family IV VIVIPARIDAE

Three species of this freshwater family were observed in the Zone 1 (with minimum 0.2 mg/L salinity) from Chandannagar to Tribeni. They were *Bellamya bengalensis f. typica* (Lamarck), *B. dissimilis* (Mueller) and *B. crassa* (Benson); the last mentioned was a rare one, whereas the other two were common.

Family V PILIDAE

The amphibious snail, *Pila globosa* (Swainson) occurs in zone I & IV.

Family VI LITTORINIDAE

The species viz., *Littorina melanostoma* Gray and *L. scabra* (Linnaeus) were common at the supratidal zone attached to the mangroves and shrubs. Individual snails were observed crawling up to the height of 1.75 meter above the ground level. The population density of these species varies with season and locality. *L. melanostoma* Gray was observed in solitary or sometimes in aggregations up to 8-9/m². *L. scabra* (Linnaeus) was found to be gregarious with a maximum of

120/m². It was seen that the population density of this species registered an increase in locations towards the sea.

Family VII STENOTHYRIDAE

Stenothyra deltae (Benson) was recorded crawling in the muddy areas of the estuary. It prefers lower salinity zones (up to 1.65 mg/L) and almost absent towards the higher salinity area (above 20 mg/l). The population density varied from 2 to 485/m² and it was maximum during the month of September.

Family VIII ASSIMINEIDAE

Assiminea brevicula (Pfeiffer) and *A. beddomeana* Nevill were abundant throughout the estuary. *A. brevicula* (Pfeiffer) either crawls on the mud or remains attached to grasses in muddy localities. They were recorded even beyond 10 meters above the high water mark. The maximum population density recorded was 250/m² with an average of 100 to 120/m². The population of young ones was recorded upto 2106/m² on an average from October to April. Copulating pairs were frequently observed from August to December.

A. beddomeana Nevill was recorded in the holes and crevices of the muddy substratum. The maximum population density was upto 550/m². Copulating pairs were very frequently observed from May to November and juveniles were observed from January onwards.

Assiminea francesiae (Wood) was abundant from Nabadwip to Diamond Harbour and at Ganga Sagar which either crawl on the mud or remains attached to bricks, stones, wood grass etc. on the bank. Maximum population recorded was 230/m² with an average of 90-100/m², in Zones I and IV.

Family IX ARCHITECTONICIDAE

Architectonica perspectiva (Linnaeus) was observed at Parseymari/Chulkati during November along with its egg capsule. The egg capsule was a long, tubular and coiled structure attached at one end to the substratum. The tubular structure was creamy white and measured about 50 cms in length.

Family X THIARIDAE

Thiara (Thiara) scabra (Mueller), *T. (Melanoides) tuberculata* (Mueller), *T. (Tarebia) granifera* (Lamarck), *T. (Tarebia) lineatus* (Gray) and *Brotia costula* (Rafinesque) were observed in zone 1 (when the salinity was 0.3 mg/l).

T. (Mainwaringia) paludomoidea Nevill was observed on mangrove vegetation upto the height of 40 cms above the ground level. They were very common on plants locally known as "Nonagira" Besides *T. paludomoidea* Nevill the only other saltwater inhabitant of the family was *Larina burmana* Blanford. It was observed crawling on the muddy substratum at Kishorimohanpur. The population density was 4-5/m². Egg capsules were recorded from Bakkhali during the month of December.

Family XI POTAMIDIDAE

Telescopium telescopium (Linnaeus) was common on the exposed areas of small ditches, shallow pools or canals with a little flow of water or at the extreme high water mark in the soft mud or on pneumatophores of mangroves. The population density on an average was 8-10/m², but it was 20 to 25/m² in the mangrove regions. They were observed to concentrate in large numbers on the muddy banks at many places like Saimari, Kalas, Chulkati, Parseymari. A huge population concentration consisting of 50% juveniles, was observed at Namkhana during April-May. In many places, near the sea, mainly at Chulkati and Kishorimohanpur they were observed to occur in association with *Saccostrea cucullata* (Born).

Cerithidea obtusa Lamarck was found crawling on the mud or on plants which get wet during the spring tide. It was also seen on the mangrove plants at the height of 1.5 meters above the ground level in most of the localities which had abundant mangrove vegetation. Population density ranged from 2 to 10/m². Some of the individuals were attached to mangrove plants with a thin mucus thread and remain in a hanging position with their aperture turned upwards.

Cerithidea cingulata (Gmelin) was observed crawling on the mud mainly near the back water canals. It was a dominant species in the mangrove areas, mainly at Kishorimohanpur, Kalas, Saimari, Halliday with an average population density of 1400-1500/m². The young ones were found towards the low water mark with the adults gradually replacing them towards high water mark.

Family XII EPITONIDAE

Acrilla acuminata (Sowerby) was observed at Gosaba and Chhotahardi on the mudflats where a little amount of water was retained even during low tide. Egg capsules were observed in bunches which are attached to the substratum with the help of mucus. Each bunch consisted of approximately 500 ash-coloured capsules (Fig. 1a, & b, Pl. 1, figs. 1 & 2). In each capsule there were 225 to 250 white and round eggs. The egg capsules were seen during the month of May.

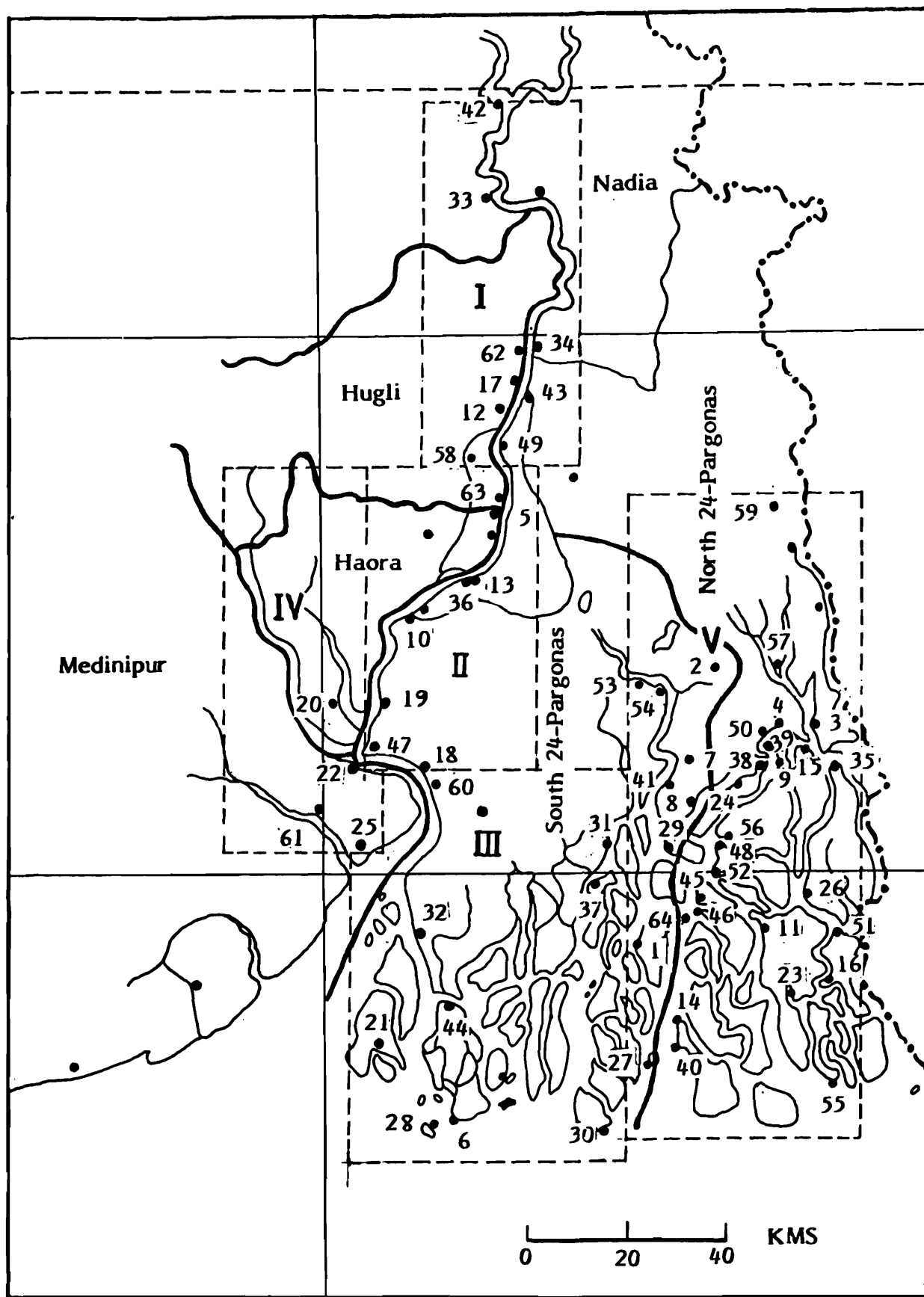
Family XIII NATICIDAE

Two species, viz., *Natica tigrina* (Roeding) and *N. gualteriana* (Recluz) were observed in the areas nearer to sea. *N. tigrina* (Roeding) occurs in sandy mud. It remains active as long as the substratum was wet but once it gets dried up the snail burrows inside the sand and remains there till the next tide washes them. *N. gualteriana* (Recluz) was found in the intertidal zone of Bakkhali, Sagar island, Saimari and Kalas.

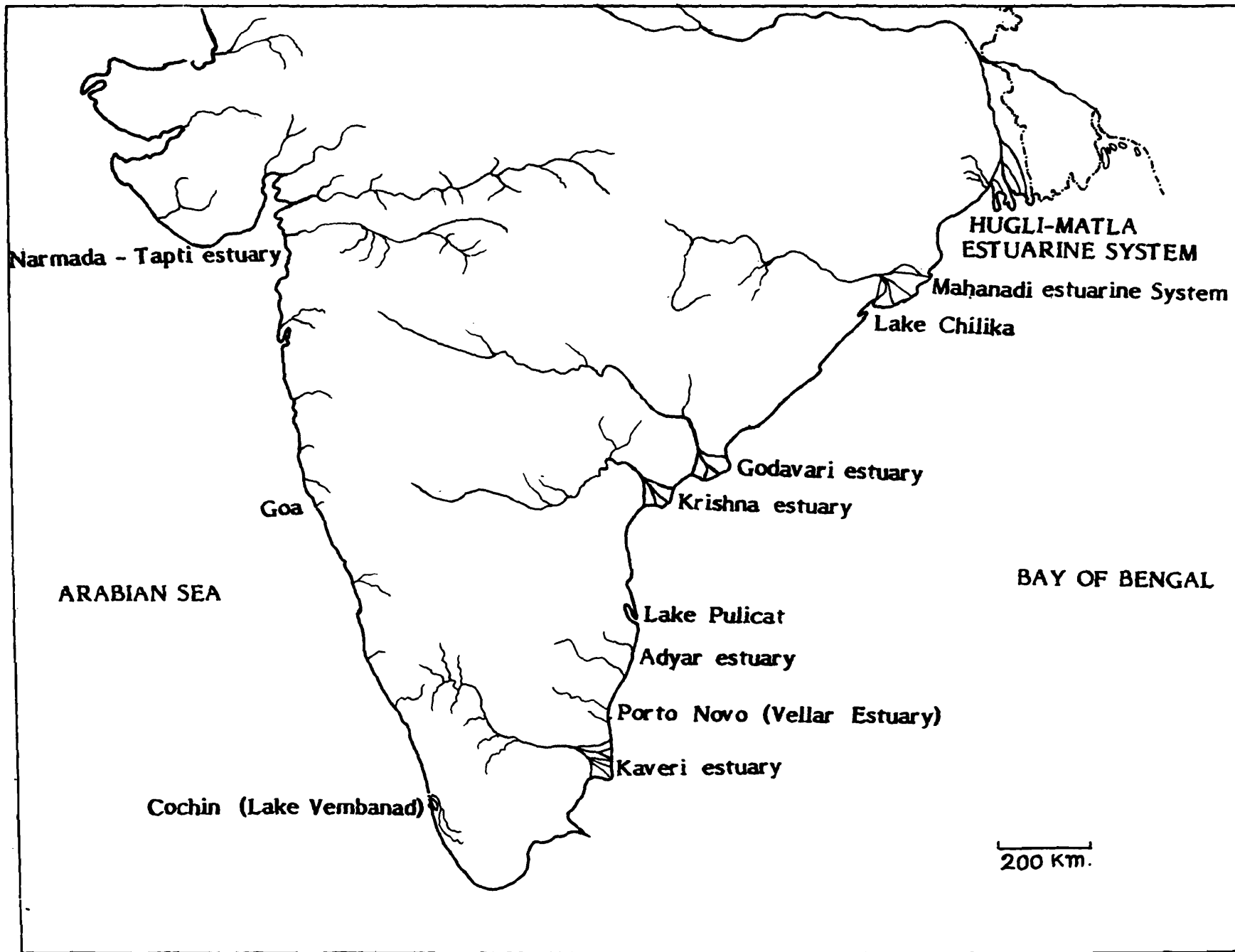
Egg capsules, generally known as sand collars, are greyish in colour, ribbon-like and form an open ring, encrusted with sand particles. These were observed at Saimari and Kalas during November-December & March-April.

Family XIV MURICIDAE

Thais lacera (Born) was very common in jetties, backwater and river mouths attached to the



Map-1. Hugli-Matla estuary showing the different zones and collecting stations.



Map-2. Different estuarine systems of India.

rocks, bricks, boulders, pillars and decomposed mangrove stems. The population was observed to be maximum at Parseymari being 5 to 6/m² on an average. Copulating pairs were very common and more than 10 pairs were observed in about 100 meters stretch of the estuary. Egg-capsules, attached in clusters to the broken pitchers, bricks, and pieces of shell were observed during March/April and November/December. There were 10-20 capsules in a cluster. The colour of the capsule was greenish-yellow with pinkish tinge. Each capsule was a small, cylindrical tube bulged in the middle but narrower at both ends. The top of the capsule bears an oval-shaped hole covered with a membrane (Fig. 2).

Family XV PYRENIDAE

Columbella duclosiana Sowerby was found in clusters attached to bricks, decomposed wood, mangrove etc., near the low water mark. It was also found attached to the pneumatophores of mangrove at a height of 35 cms above the ground level.

Family XVI MELONGENIDAE

Pugilina cochlidium (Linnaeus), a widely distributed species of the family was observed crawling on the mud throughout the large part of the Sunderbans. The population was observed to be maximum 5/m² at Parseymari. A large number of copulating pairs were observed from November to March and more than 15 nos in about 300 meters stretch of the estuary.

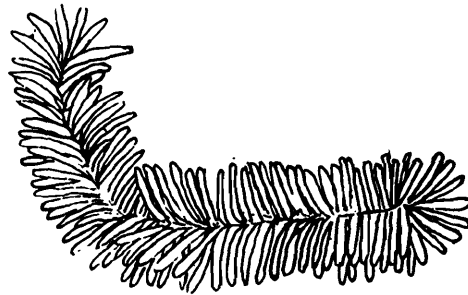
Egg capsules were seen attached to the broken pieces of bricks, shell etc. Capsules were yellowish green in colour, broad at the top but become gradually narrow downwards with an elongate stalk at the base. They were flattened and bounded by low longitudinal ridges at two ends and became pointed at the tip. Each cluster contained 10 to 30 capsules (Fig. 3).

Family XVII NASSARIIDAE

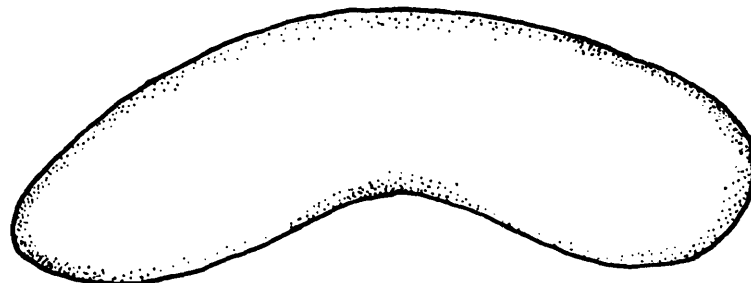
Two species viz., *Nassarius foveolatus* (Reeve) and *N. stolatus* (Gmelin) were observed crawling on the mud. Egg capsules of these species were also recorded from November to April. These were attached to broken bricks, pitchers, shell or wooden structures. (Fig. 4)

Family XVIII ATYIDAE

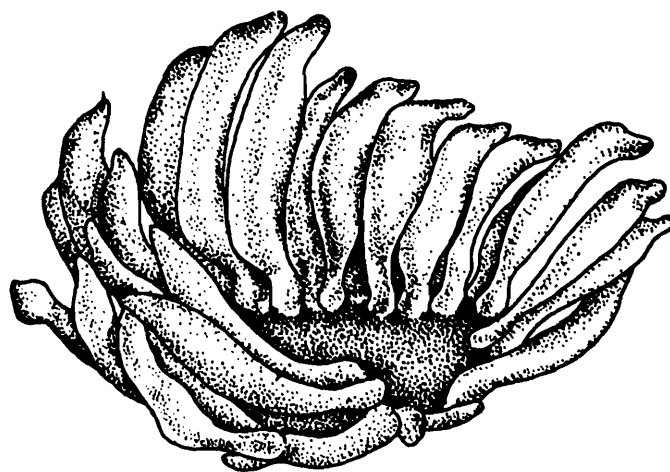
Haminea crocata Pease was common in muddy areas. Population density varied from 2 to 3/m² at Namkhana and at Kakdwip. The population density was 80-90/m² at Kishorimohanpur. Juveniles (upto 5mm) were recorded during January/February at Namkhana. Copulating pairs were observed from April to May. Egg capsule usually floats in water with the lower end attached to the muddy substratum and free at the other. Capsules were gelatinous, transparent and whitish in colour. Each capsule contained 15 to 25 light yellowish or creamy eggs which were visible from outside. A large number of egg capsules were observed floating on water at Kishorimohanpur during the low tide in the month of November.



3A



3B



4

3.(a) Egg Capsule of *Acrilla acuminata* 3 (b) Egg Capsule of *Acrilla acuminata*
4. Egg Capsule of *Cymia lacera*

Family XIX ELLOBIIDAE

Five species viz., *Ellobium aurisjudae* (Linnaeus), *E. (Auricula) gangeticum* (Pfeiffer), *Cassidula nucleus* (Gmelin) *Melampus pulchella* Petit and *Pythia plicata* (Ferussac) were observed in the holes and crevices of the mud flats and also in the crevices of stones, forming a part of dyke erected for the prevention of erosion. Population density ranged from 1 to 3/m². *P. plicata* (Ferussac) was found above the high water mark. *M. pulchella* Petit was found on the undersurface of the leaves, logs in damp and wet places.

C. nucleus (Gmelin) and *E. aurisjudae* (Linnaeus) were found often attached to the pneumatophores in the eulittoral zone. *Cassidula nucleus* (Gmelin) was mostly found on the upper mud flat where there was growth of *Avicennia* and especially *Aegialites rotundifolia* Roxberg. The species mostly crawls on the mud or stays in the shade along with *Cerithidea obtusa* Lamarck. Some times it was found on the trunk of *Avicennia* i.e. during hightide when the area gets inundated. Juveniles (5 mm) were recorded during August at Nikarikhali near Haldibari.

Family XX LYMNAEIDAE

Three species *Lymnaea (Pseudosuccinea) acuminata* f. *typica* Lamarck, *L. (P.) acuminata* f. *rufescens* Gray and *L. (P.) luteola* f. *typica* Lamarck were collected in the freshwater region (Zone I) where the salinity was less than 0.3 mg/l.

Family XXI OCHIDIIDAE

Represented by three species viz. *Onchidium tenerum* Stoliczka, *O. tigrinum* Stoliczka, and *O. typhae* Buchannan and an additional species of *O. pallidum* Stoliczka as recorded in the literature. The former three species were found crawling on the mud, bricks and crevices during low tide. These marine slugs are nocturnal in habit. Breeding season was observed to be February/March. *O. typhae* Buchannan is the most abundant species of all. The egg capsule of *O. typhae* is a transparent and ribbon-like structure extending to about 90 cms. as it was collected from Gadiwara (Pl. 1, Figs. 3 & 4).

BIVALVES

Family 1 ARDICAEE *ARCIDAE*

Represented by three species viz., *Anadara granosa* (Linnaeus), *Scaphula deltae* Blanford and *S. celox* Benson.

S. deltae Blanford was recorded in the region between Barrackpore and Diamond Harbour where the salinity varied from trace to maximum of 4 mg/l. They were found attached to algae, weeds or even to the mud by the help of fine byssus threads.

A. granosa (Linnaeus) was found on the muddy substratum at Port Canning, Ganga Sagar, Jharkhali, Jumbudweep, Netidophani, Naubankichara, Parseymari and Kishorimohanpur in the mid-tide region. A good population was observed at Kishorimohanpur and Jumbudweep in the mud (2-3 /m²). It lives buried in the substratum with its ventral margin directed upwards.

Family 2 NOETIDAE

Striarca lactea (Linnaeus) occurs at Bakkhali and Jharkhali in crevices of mud covered with rocks and oyster beds.

Family 3 MYTILIDAE

Two of the common species viz. *Modiolus striatulus* Hanley and *M. undulatus* (Dunker) were found attached to rocks, stones, wooden jetties in submerged water (Dunker) *M. undulatus* common on Prentice island. *M. straitulus* Hanley, which causes major nuisance in Palta water works seems to have declined in numbers over the years.

Family 4 ANOMIIDAE

Plauna (P.) placenta (Linnaeus) found only at Jharkhali lies on its right valve below the surface soil of mudflats from midtidal zone down to a distance of 20 meters.

Another species viz., *Enigmonia aenigmatica* (Holten) lies attached by its right valve to the trunk of *Avicennha* plant, where tides regularly inundate the plant especially during the hightide. The umbo is always pointed downward.

Family 5 OSTREIDAE

Three species viz., *Crassostrea cuttackensis* (Newton and Smith), *C. gryphoides* (Schlotheim) and *Saccostrea cucullata* (Born) were observed. Beds of *C. gryphoides* (Schlotheim) were observed at Bagbagan, Rangabelia and Bagna, where they occur attached to the lock gates, bricks and dykes and also in the river bed.

S. cuulata (Born) was very common at most of the stations. It attaches to concrete and wooden jetties, bricks, dykes, dead mangrove stems, wooden pillars and even to shells, when an otherwise suitable substratum is not available. In Chulkati a number of these oysters were seen on the shells of *Telescopium telescopium* (Linnaeus).

Family 6 SOLENIDAE

Solen brevis Gray was recorded in the mud from low tide zone onwards at Basirhat, Pargumti, Kakdwip, Bakkhali, Gosaba, Jharkhali and Port Canning. There was a predominance of juveniles and an average population density of 2.8/m² was recorded at Kakdwip. It however does not occur in the main river but only in small creeks leading to the river.

Family 7 CULTELLIDAE

Four species viz. *Pharella javanicus* (Lamarck), *Neosolen aquaedulcioris* Ghosh, *Siliqua albida* Dunker and *Tanysiphon rivalis* Benson were observed in the muddy areas.

P. javanicus (Lamarck) was observed to be maximum near the Tiger Project jetty at Gosaba and Port Canning upto 8/m². These bivalves occur in hard upper mudflats, where the *Sonneratia* plants grow. Externally the existence of these bivalves can be noticed by the distinct slit-like shape of their burrows. The bivalves burrow and lie below at a depth which measures 2-3 times of their body length.

Siliqua albida (Dunker) was observed in the creeks, which retain a small amount of water even during low tide. Juveniles (upto 8mm) were recorded from January to April with an average population density of 2 to 8.6/m².

T. rivalis Benson was observed at Gangasagar and Geonkhali on the muddy substratum. These bivalves prefer low salinity (up to 4.0 mg/l) areas. Population density was observed to be 80-90/m² at Geonkhali.

Family 8 TELLINIDAE

Four species viz. *Tellina corbuloides* (Hanley), *T. iridescens* (Benson), *Strigilla splendida* (Anton) and *Macoma birmanica* (Philippi) were observed within the estuary.

T. corbuloides (Hanley) were observed on the muddy banks of the creeks at Bakkhali.

T. iridescens (Benson) was observed on the muddy banks of creeks with preference to salinity areas (up to 12.0 mg/l) whereas *S. splendida* (Anton) prefers comparatively high salinity areas (above 20.0 mg/l), especially near river mouth.

M. birmanica (Philippi) occupies a mid zone. These clams were common at Jharkhali, Sagar Island, Champta, Gona and Kishorimohanpur. They were detritus feeders and suck the mud, algae and organic matter by their long siphon during low tide. The siphon which was of orange colour extends to 0.7 to 1.00 meter (approximately 8 to 15 times more than its body length). The population of young ones were observed from July to November at 4-5/m².

Family 9 PSAMMOBIIDAE

Sanguinolaria (Soletellina) acuminata (Deshayes) was collected at Gangasagar, Saimari and Kalas beach. It prefers sandy-clay substratum, which contains organic matter. Their presence inside the burrows can be noticed by the characteristic circular holes through which water is ejected by their siphons when disturbed. The depth at which the animal burrows varies from 50 cms. to more, depending on the size of animal.

Family 10 TRAPEZIIDAE

Represented by *Trapezium sublaevigatum* (Lamarck) which occurs in the empty holes of pneumatophores of *Avicennia* plants to which they attach with the byssus threads.

Family 11 VENERIDAE

Two species viz., *Meretrix meretrix* (Linnaeus) and *Pelecypora trigona* Reeve occurs on the muddy areas of creeks. A large population 2320 to 2800/m² of *M. meretrix* (Linnaeus) was observed at Port Canning and Parseymari. *P. trigona* Reeve was common in the canals and small creeks. Young ones were noticed during April. Population varied from 1-2/m² to 106-108/m² with the maximum record being during the month of March.

Family 12 GLAUCONOMIDAE

A single species viz., *Glaucanome sculpta* (Sowerby) occurs in the hard mud from mid-tide level to the low-tide mark. They remain at 2-4 cms below the substratum and their presence inside

can be made out by the comb-like appearance of holes in the area. The population density varied from place to place. It was recorded to be 10-12/m² at Netidophani but maximum density was up to 300-350/m² at Bakkhali and Ganga Sagar (450-503/m², Subba Rao *et. al.*, 1987).

Family 13 PHOLADIDAE

Martesia fragilis Verrill and Bush was found boring into brickworks and submerged wood whereas *Barnea candida* (Linnaeus) was observed along with *G. sculpta* (Sowerby) in the hard mud in many places of Sunderbans.

Family 14 TEREDINIDAE

Six species viz., *Bactronophorus thoracites* (Gould), *Dicyathifer manni* (Wright), *Bankia companellata* Moll and Roch, *B. nordi* Moll, *B. rochi* Moll and *Nausitora dunlopei* Wright which cause extensive damage to wooden logs, jetties and boats in several places of Sunderbans, were collected at various places and during various surveys of the estuary.

CEPHALOPODA

Family 1 SEPIIDAE

Two species viz., *Sepia aculeata* d'Orbigny and *Sepiella inermis* d'Orbigny were collected from drag nets in Matla river mouth and upto Basanti in the upstream as for the information given to us. Cephalopods were caught in the net throughout the year.

Family 2 LOLIGINIDAE

Catches of *Loliolus investigatoris* Goodrich were made in Matla river mouth and also from Jharkhali as evidenced by drag net catches in the estuary.

On 26.6.86 at Jharkhali (Sunderbans), at the time of low tide, exposure was maximum on the mud flat on the bank of Matla river, south west of irrigation bungalow where salinity and water temperature were 2.8 mg/l and 30°C respectively. At the lowest low water mark the egg capsule was noticed in a pot hole. In appearance it looked like a completely bloomed sea anemone with light golden colour. When examined under field microscope the egg capsules were found to be that of a Cephalopod.

The single capsule (Pl.1 fig.) is taken from the bunch. It is bulbous and elongated with a string at one end. There are about 40 such capsules and all these are attached with their strings at a common point. Each capsule has 21 eggs in it. It is estimated that there are a total of 21 x 40 = 480 eggs in a bunch of capsules. A single capsule measures 25 mm in length and its widest portion measures 8 mm. The developmental stage is noticed with the yolk sac in the egg. The young one measures 1.675 mm in length and 1.425 mm in width and the young with yolk sac measured 3.425 mm. The chromatophores on the body are (pl. 1, fig. 5) distinctly seen corresponding to the stage 27 of the development stage, as noted by Arnold (1965) in the development of *Loligo pealii*. He described that chromatophores appeared in stage 26 or late 25 and secondary cornea began to cover the eye by stage 27.

It is assumed that this is an egg capsule of *Loliolus investigatoris* Goodrich because the young and adult of this species were collected from the area.

Probably it is the first record of a cephalopod egg capsules away from the sea.

TABLE 2. Distribution of Molluscs In Hugli-Matla Estuary (Zone wise)

	ZONE I			ZONE II			ZONE III				ZONE IV		ZONE V			
	Nabadwip	Naihati	Barrackpore	Bally Khal	Falta	Diamond Harbour	Kakdwip	Bakkhali	Sagar Island	Sandhead	Haldia	Geonkhali	Port Canning	Gosaba	Jharkhali	Sajnakhali
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	

A. From Vegetation/Pneumatophores

i. Gastropoda

1. <i>Potamacmaea fluviatilis</i> (Blanford)													+	+	+
2. <i>Nerita articulata</i> Gould							+		+				+	+	+
3. <i>Littorina (Littorinopsis) melanostoma</i> Gray						+	+	+	+				+	+	+
4. <i>Littorina (Littorinopsis) scabra scabra</i> (Linnaeus)						+	+	+	+		+		+	+	+
5. <i>Thiara (Mainwaringia) paludomoidea</i> Nevill							+						+		
6. <i>Cerithidea (Cerithidea) obtusa</i> Lamarck							+		+					+	+
7. <i>Columbella duclosiana</i> Sowerby						+		+						+	+
8. <i>Cassidula nucleus</i> (Gmelin)														+	+

ii. Bivalvia

9. <i>Enigmonia aen. natica</i> (Holten)							+							+	
10. <i>Succostrea cucullata</i> (Born)													+	+	+
11. <i>Trapezium sublevigatum</i> (Lamarck)														+	

TABLE-2 (Contd.)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
B. From Bricks/Wooden Pillars/logs/dykes/Jetty etc.															
I. Gastropoda															
1. <i>Potamacmaea fluviatilis</i> (Blanford)													+	+	+
2. <i>Nerita articulata</i> Gould							+		+				+	+	+
3. <i>Neritina smithi</i> Wood					+				+						
4. <i>Neritina (Dostia) violacea</i> (Gmelin)									+						
5. <i>Pseudonerita sulculosa</i> (Von Martens)					+	+			+		+	+	+		
6. <i>Clithon reticularis</i> (Sowerby)					+							+			
7. <i>Littorina (Littoraria) undulata</i> Gray						+							+	+	+
8. <i>Larina burmana</i> Blanford									+		+				
9. <i>Thais lacera</i> (Born)								+	+				+	+	+
10. <i>Ellobium (Auricula) gangeticum</i> (Pfeiffer)					+	+	+				+		+		+
11. <i>Onchidium tenerum</i> Stoliczka					+	+			+		+				+
12. <i>O. tigrinum</i> Stoliczka						+	+		+				+	+	+
13. <i>O. typhae</i> Buchannan			+	+	+	+			+		+	+	+	+	+
II. Bivalvia															
14. <i>Modiolus undulatus</i> (Dunker)							+		+				+		
15. <i>Saccostrea cucullata</i> (Born)													+	+	+
16. <i>Martesia fragilis</i> Verrill and Bush														+	
17. <i>Lignopholas fluminalis</i> (Blanford)						+							+		
18. <i>Dicyathifer manni</i> (Wright)													+	+	+
19. <i>Bankia campenellata</i> Moll and Roch							+						+	+	+
20. <i>B. nordi</i> Moll													+	+	+
21. <i>B. rochi</i> Moll									+				+	+	+
22. <i>Nausitora dunlopei</i> Wright													+	+	+
23. <i>Bactronophorus thoraçites</i> (Gould)													+	+	+

TABLE-2 (Contd.)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
C. From mud and sand mix muddy area															
I. Gastropoda															
1. <i>Tubiola microscopica</i> (Nevill)															+
2. <i>Neritina (Dostia) violacea</i> (Gmelin)					+	+					+	+			+
3. <i>Pseudonerita sulculosa</i> (Von Martens)					+	+					+	+	+	+	+
4. <i>Septaria caeruleascens</i> (Sowerby)			+	+	+							+			
5. <i>S. lineata</i> (Lamarck)			+			+		+							+
6. <i>Bellamyia bengalensis</i> f. <i>typica</i> (Lamarck)	+		+									+			
7. <i>B. dissimilis</i> (Muller)	+														
8. <i>B. crassa</i> (Benson)	+														
9. <i>Pila globosa</i> (Swainson)	+											+			
10. <i>Digonoistoma cerameopoma</i> (Benson)	+														
11. <i>Iravadia ornata</i> Blanford														+	
12. <i>Stenothyra blanfordiana</i> Nevill														+	
13. <i>S. deltae</i> (Benson)					+	+	+	+	+		+			+	+
14. <i>S. soluta</i> Annandale and Prashad													+		
15. <i>S. woodmasoniana</i> Nevill													+		
16. <i>Gangetia miliacea</i> (Nevill)							+						+		
17. <i>Assiminea beddomeana</i> Nevill							+	+	+		+		+	+	+
18. <i>A. brevicula</i> (Pfeiffer)							+	+	+		+		+	+	+
19. <i>A. francesiae</i> (Wood)	+	+	+	+	+	+		+	+		+	+			

TABLE-2 (Contd.)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
20. <i>A. microsculpta</i> Nevill													+		
21. <i>A. theobaldiana</i> Nevill													+		
22. <i>A. woodmasoniana</i> Nevill													+		
23. <i>Architectonica perspectiva</i> (Linnaeus)						+				+				+	+
24. <i>Thiara (Thiara) Scabra</i> (Mueller)	+				+	+						+			
25. <i>T. (Melanoides) tuberculata</i> (Muller)	+	+	+	+											
26. <i>T. (Terebia) granifera</i> (Lamarck)	+	+	+												
27. <i>Thiara (Terebia) lineatus</i> (Gray)	+	+	+												
28. <i>Brotia costula</i> (Rafinesque)	+	+	+	+											
29. <i>Larina burmana</i> Blanford								+	+		+				
30. <i>Telescopium (T.) telescopium</i> (Linnaeus)						+	+	+	+				+	+	+
31. <i>Cerithidea (Cerithidiopsis) cigulata</i> (Gmelin)							+	+	+				+	+	+
32. <i>Acrilla acuminata</i> (Sowerby)									+					+	+
33. <i>Natica gualteriana</i> (Recluz)								+	+				+		
34. <i>N. tigrina</i> (Roeding)						+		+	+				+	+	+
35. <i>Pugilina cochliaium</i> (Linnaeus)								+	+				+	+	+
36. <i>Nassarius foveolata</i> (Reeve)								+	+				+	+	+
37. <i>N. orissaensis</i> Preston							+							+	+
38. <i>N. stolatus</i> (Gmelin)							+	+	+				+	+	+
39. <i>Amalda ampla</i> (Gmelin)								+	+	+					
40. <i>Asthenotoma vertebrata</i> (Smith)															+

TABLE-2 (Contd.)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
41. <i>Ringicula propinquans</i> Hinds								+							
42. <i>Tornatina estriata</i> (Preston)															+
43. <i>Melanoclamys</i> sp.								+	+						
44. <i>Haminea crocata</i> Reeve							+	+	+						
45. <i>Cassidula nucleus</i> (Pfeiffer)							+							+	+
46. <i>Ellobium aurisjudae</i> (Linnaeus)														+	+
47. <i>Melampus pulchella</i> Petit							+				+		+		
48. <i>Pythia plicata</i> (Ferussac)					+	+	+		+				+	+	+
49. <i>Lymnaea (Pseudosuccinea) acuminata</i> f. <i>typica</i> Lamarck			+												
50. <i>L. (P.) acuminata</i> f. <i>rufescens</i> Gray	+	+	+												
51. <i>L. (P.) luteola</i> f. <i>typica</i> Lamarck	+														
52. <i>Indoplanorbis exustus</i> (Deshayes)	+	+	+												
II. Scaphopoda															
53. <i>Dentalium octangulatum</i> Denovan									+						+
III. Bivalvia															
54. <i>Scaphula celox</i> Benson			+												
55. <i>S. deltae</i> Blanford			+		+	+									
56. <i>Anadara granosa</i> (Linnaeus)									+				+	+	+
57. <i>Striarca lactea</i> (Linnaeus)								+							+
58. <i>Modiolus striatulus</i> (Hanley)			+	+									+		
59. <i>M. undulatus</i> (Dunker)															

TABLE-2 (Contd.)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
82. <i>C. bensoni</i> Deshayes	+											+			
83. <i>Polymesoda (Gelonia) bengalensis</i> (Lamarck)								+			+				+
84. <i>Gafrarium pectinatum</i> (Linnaeus)					+				+						
85. <i>Meretrix meretrix</i> (Linnaeus)						+		+	+				+	+	+
86. <i>Pelecypora trigona</i> Reeve							+		+				+	+	+
87. <i>Glaucanome sculpta</i> (Sowerby)								+	+			+			
88. <i>Sphenia perversa</i> Blanford													+		
89. <i>Corbula abbreviata</i> Preston													+		
90. <i>C. calcarea</i> Preston													+		
91. <i>C. gracilis</i> Preson													+		
92. <i>Barnea candida</i> (Linnaeus)								+	+						
93. <i>Laternula truncata</i> (Lamarck)													+		
94. <i>Cuspidaria chilkaensis</i> (Preston)													+		

N.B. This table does not include 33 marine species (16 Gastropods, 14 Bivalves and 3 Cephalopods) recorded from Sandhead.

RESULTS

The macro benthic molluscs of the estuary, can be broadly grouped under three categories (i) those living attached to stems, pneumatophores and leaves of living plants (arboreal), (ii) those living attached to or in the crevices of dykes, bricks, wooden pillars, jetties etc., and (iii) those living on the muddy substratum, either moving freely on it (epifauna) or burrowing into it (infauna). A few of the gastropod species may have overlapping habitats. But, in general, it has been observed that the species which are arboreal do not usually occur on the ground except for a short duration. Those living in the crevices of dykes, jetties etc., do not usually forsake the crevice-dwelling habit. But there are certain exceptions ; *Nerita articulata* and *Potamacmaea fluviatilis* are usually found attached to mangrove trees but in the absence of those trees the snails cling to the crevices in jetties, etc. *Columbella duclosiana* is usually found attached to pneumatophores but often found crawling on the muddy substratum.

Out of 120 species observed in the estuary only 11 species (8 gastropods and 3 bivalves, vide Table 2) occur as arboreal epifauna. Thirteen species of gastropods dwell in the crevices of dykes, jetties, brick-work or on the wooden pillars. Eight species of bivalves are recorded as borers inside the wooden structures, but rarely in living trees. Maximum number of species (52 of gastropods, 41 of bivalves and one of Scaphopoda) are substratum dwellers. While all the bivalve species live buried in the mud, only a few species of gastropods have the habit of getting below the mud surface.

The molluscs are not evenly distributed throughout the estuary. There is no single species which occurs in all the five zones of the estuary. The species of gastropods, namely, *Littorina scabra*, *Onchidium typhae*, *O. tenerum*, *O. tigrinum*, *Assimineia francesiae*, *Neritina violacea*, *Stenothyra deltae* and *Telescopium telescopium* have wider distribution in the estuary. All the species except *A. francesiae* do not however, occur in Zone I (Nabadwip to Konnagar), whereas *A. francesiae* has not extended its distribution to Zone V (River Matla around Port Canning) (Table-2). *Telescopium telescopium* and *Natica tigrina* occur in Zones III & V with a little extension into Zone II. Among littorinids, *L. scabra* is found to occur from Zone II to Zone V. It has been observed that except for six species of bivalves all the others are restricted to Zones III and V with preponderance in the latter. Species of the freshwater gastropoda families, namely, Viviparidae, Pilidae, Thiaridae (except two species), Lymnaeidae, Planoridae and bivalves, Unionidae and Corbiculidae are restricted to Zone I, while at the other extreme there are a number of species which do not extend in their distribution above or lower reaches Zone V. In general there is paucity of molluscs in Zone IV. Cephalopods have been found usually in the mouth of Matla river often swimming up the stream as a as Jharkhali.

The distribution and relative abundance of molluscs is not uniform throughout the estuary. Their abundance may vary from 2-10/m² as in the case of *Cerithidea obtusa* or 5/m² for *Pugilina cochlidium* to 1400-1500/m² as in the case of *Cerithidea cingulata*, or 2320-2800/m² for *Meretrix meretrix*. Maximum population density recorded for any mollusc was that of *M. meretrix* (Misra and Barua, 1987). The gastropod species in order of relative abundance in their habitats are *Assimineia brevicula*, *Cerithidea cingulata*, *Stenothyra deltae*, *A. beddomeana*, *Littorina scabra*,

Haminea crocata, *Telescopium telescopium* and *Pugilina cochlidium*. All other species do not form large populations. Bivalve species in the order of their abundance in a given locality are *Meretrix meretrix*, *Pelecycora trigona*, *Macoma birmanica*, *Saccostrea cucullata* and *Sphenia perversa*. Most of the bivalve occur in beds, which have concentrations of their population. Some of the species which have been encountered during the surveys were *Crassostrea gryphoides*, *Pharella javanicus*, *Strigilla splendida*, and *Sanguinolaria acuminata*. Majority of the bivalves were observed to prefer sheltered estuarine zones usually in the Lower or Middle zone of the exposed mud flats. In Matla river the bivalves were so dominant in the middle zone that out of four broad zones based on the indicator animals two were recognised as the lower *Meretrix* zone and the lowest *Dosinia* (= *Pelecycora*) zone (Misra & Barua, 1987).

A number of gastropods are amphibious or semi-terrestrial and are capable of withstanding exposure to air. The snails belonging to the families Littorinidae, Neritidae, Assimineidae, Potamididae and Ellobiidae occur in areas, which experience exposure during a large part of the day. These families have a good representation in the mangrove biotope. There are certain species which live entirely submerged in water even during low tide. Species of *Stenothyra*, *Haminea*, *Nassarius* and *Haminea* were always found partly submerged in water. Ellobids were recorded at the supratidal level, followed by littorinids, which generally occur at the highwater mark.

Bivalves were observed in creeks and mudflats. Since majority of these are burrowers interstitial water is enough for maintaining the moist conditions needed for their survival. All the bivalves were collected below the mid-water level as the exposure time will be less when compared to the Zone at HWL. However, *Pharella javanicus* occurs near the HWL, buried within the substratum with population density of 6-8/m². In the estuary out of a total of 53 bivalve species recorded 19 species inhabit the substratum either near or within the mangrove biotope.

Spawning : Egg cases of 18 species of gastropods were collected during various surveys. Ten species were observed to lay eggs during November-December while a few extend their spawning to March-April (fig. 7). Spawn of *Assiminea* spp. were observed from August to December and that of *P. cochlidium* from November to March. Three species; namely, *Natica tigrina*, *N. gualteriana* and *Thais acera* were seen to lay eggs during November-December and March-April. The egg ribbons of *N. gualteriana* are smaller in size and greyish in colour while that of *N. tigrina* are larger and have a blackish eye. All the three species of *Onchidium* seem to breed during February-March and the eggs are deposited in a white gelatinous string, much like that of the garden slug, *Laevicaulis alte*. The species of *Nassarius* and *Macoma birmanica* were observed to breed for six months during the year. Eggs of former were seen during October to April, while the juveniles of *Macoma* during May to October. In general it is seen that most of the species have no specific breeding period.

DISCUSSION

The Hugli-Matla estuary has been divided into five hydrological zones, as stated in the introduction. There is paucity of molluscs in Zones I and IV. There is a consensus of opinion that temperature, salinity range and nature of substratum are important factors, which influence the distribution of organisms in an estuary. These factors are dependant on the topography of the estuary, the extent of freshwater flow, tides and the time of the year. The general categorisation of

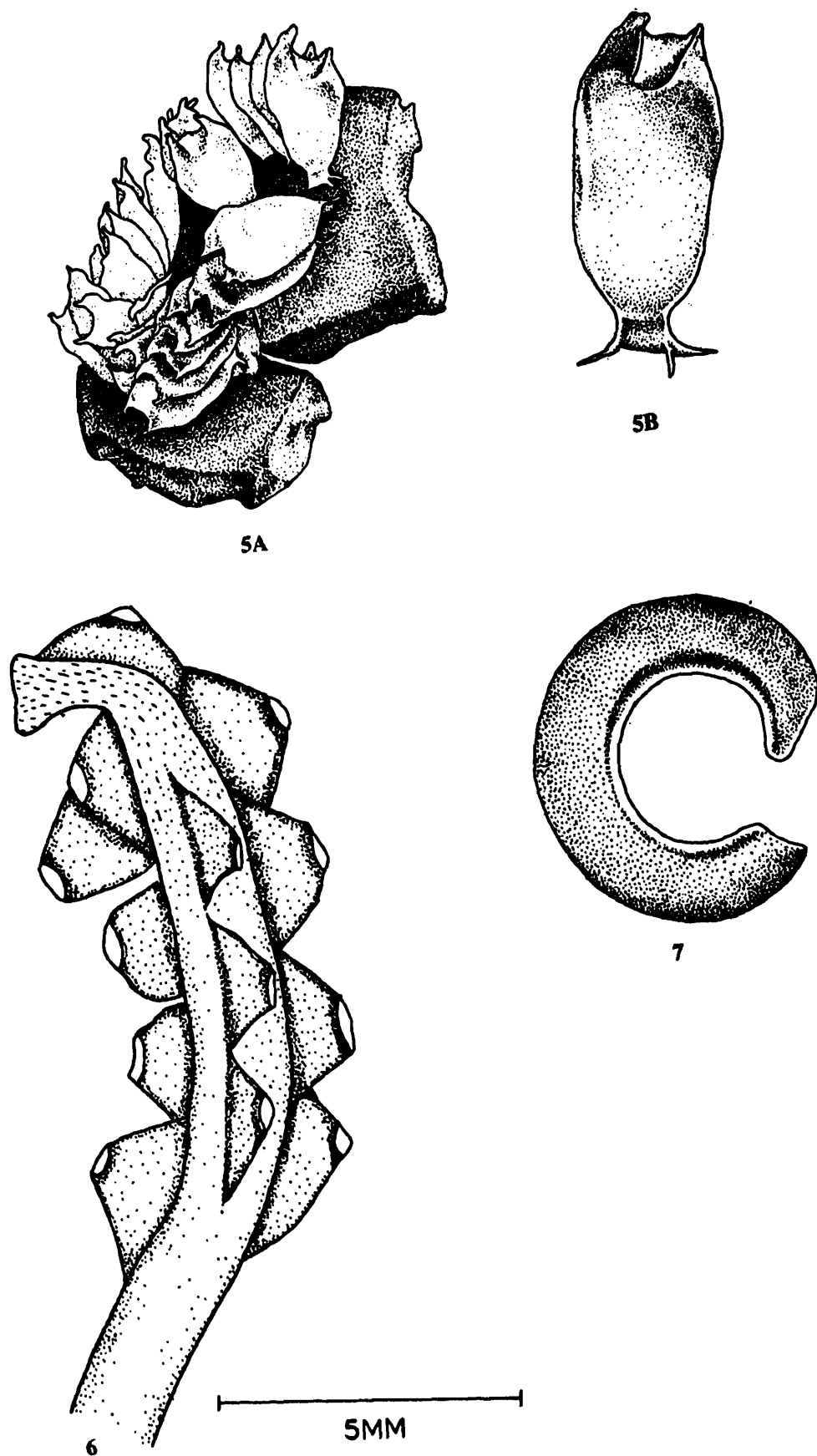


Fig. 5 Egg Capsule of *Pugilinus conchilidium* A. Capsules attached on substratum B. Individual capsule
 Fig. 6 Egg Capsule of *Nassarius* sp. Fig. 7 Egg Capsule of *Natica* sp.

animals into five categories as oligohaline, true estuarine, euryhaline marine, stenohaline marine and migrants is based on the salinity tolerance of animals concerned. As far as molluscs are concerned majority are sedentary and come under the first four categories, while only a few species of cephalopods fall under the category of migrants. Three species of Cephalopod have been found to migrate into Matla river (zone V) up to Jharkhali, a distance of about 60 Kms from the sea. The occurrence of eggs cases as far as Jharkhali suggest that the species is a regular migrant to the river, when conditions are favourable to it. There is no influx of freshwater into Matla river and the drop in salinity was not very significant. A large number of other stenohaline marine molluscs occur in this zone.

In zone I typical freshwater conditions prevail and in this zone 17 species (14 gastropods and 3 bivalves) are recorded (Table 2). Among these, three species, namely, *Septaria caerulea*, *S. lineata* and *Thiara scabra* which are oligohaline also extend into Zone II during certain parts of the year. Whereas *Assiminea francesiae* is a true estuarine molluscs, extending its distribution Zone I and II. Two other common assiminiids, *A. beddomeana*, and *A. brevicula* are not found to penetrate into Zone III.

Although salinity seems to be a critical factor in the distribution of a number of molluscs, the nature of substratum has also a major influence on their occurrence in the estuary. Molluscs have adapted to estuarine conditions without osmoregulation. When the acclimitisation is spread over a long period the mollusc is able to withstand gradual reduction of salinities by appreciable levels (Panikkar, 1951).

The preponderance of sediment associated molluscs in the Hugli-Matla estuary, when all other factors are optimal, suggest that sediment influences their distribution. Sediment associated molluscs, especially burrowing forms experience interstitial salinity, which however, may be more stable than the salinity of overlying waters.

The dominant substrata in the estuary is mud. The sediments along the banks are composed of fine alluvial clay. In the mangrove region where there is mixed *Avicennia*, *Sonneratia* and tall grass *Myriostachya* and also *Acanthus* the substratum consists of loose mud. The marsh flat contains silt and clay with hard substratum (Anonymous, 1987). The percentage of organic carbon in the soil varies in different parts of the estuarine environment. The distribution of molluscs is influenced to some extent by the nature of sediment and the organic content. The regions with fine sediments are rich in organic carbon and the fine texture of soil reduces evaporation and provides a habitat for burrowers (Radhakrishna and Ganapati, 1969; Sasekumar, 1974). In Kakinada Bay *Tellina* sp., *Anadara granosa* and *Placenta placenta* are restricted to fine sediments with rich organic carbon (Radhakrishna and Ganapati, 1969). An unstable substratum, strong currents and long exposure to air are not conducive for burrowing bivalves. There is complete depletion of benthic fauna in regions which experience high rate of erosion (Untawale and Parulekar, 1976). Provided the substratum is suitable, majority of gastropods can withstand large exposure to air. In Malayan mangroves most gastropods occur in areas with over 90% exposure time, with only a few exceptions like *Columbella duclosiana*, *Stenothyra polita* and *Nassarius* spp. (Sasekumar, 1974). In Hugli-Matla estuary also the dominant gastropod molluscs are able to withstand exposure to air.

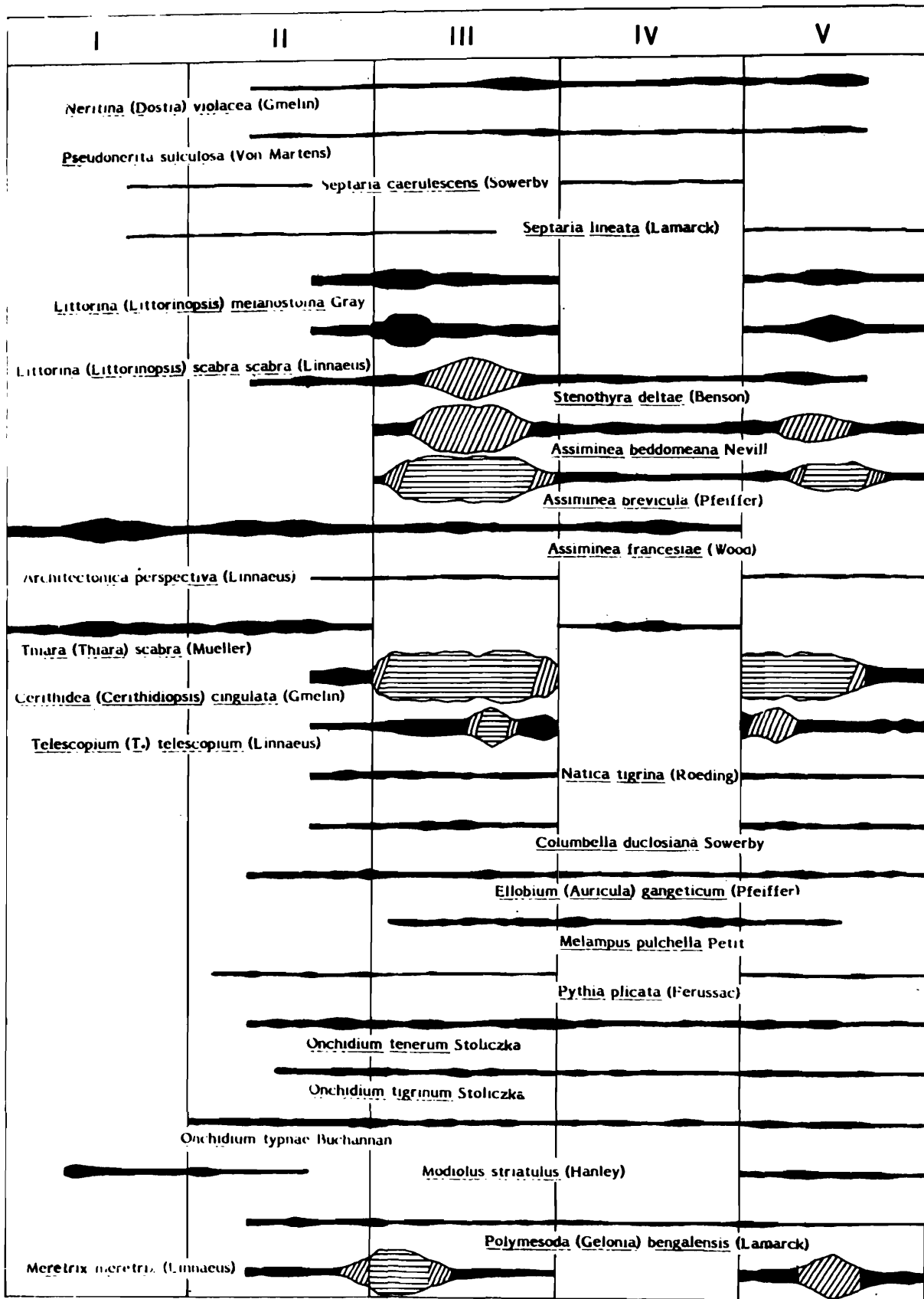


Fig. 8. Population density of different species based on field observation and data

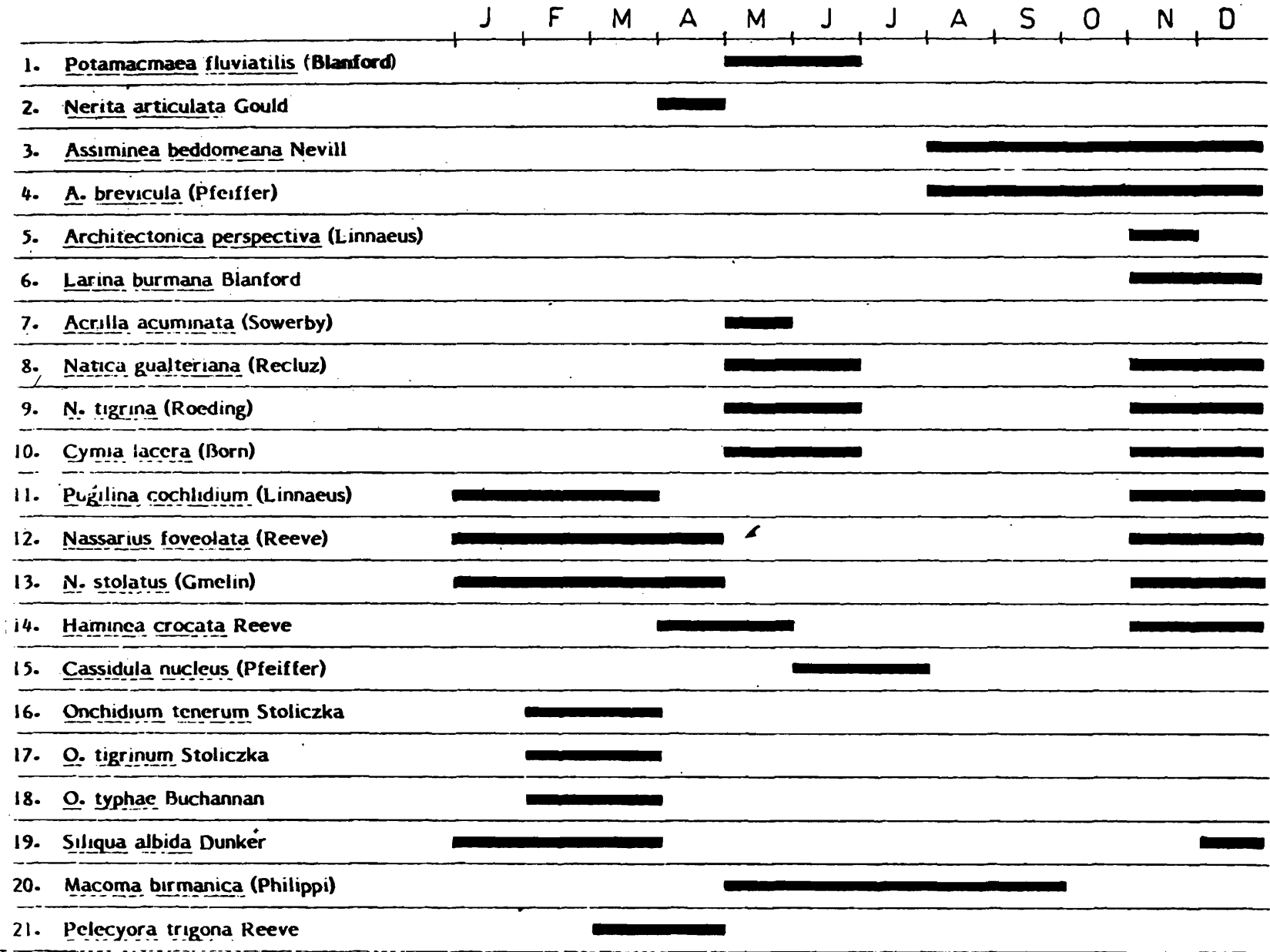


Fig. 9 : Breeding periods of some species on the basis of availability of spawn in the field. No attempt has been made to find out the intensity of breeding activity of various species.

Some of these gastropods especially the tree-dwelling prosobranchia and air-breathing ellobiids have developed adaptations for terrestrial existence and converted their mantle cavities into lungs.

The importance of organic carbon content and sediment particle size in the distribution of molluscs has been brought out by studies in other estuaries. *Cerithidea cingulata* which is a common species to all Indian estuaries prefers sand mixed with clayey substratum. It has penetrated into the estuary up to 3 km from the river mouth in the Nizampatnam Canal and up to 8 km in the Vellar estuary. But in the Hugli-Matla estuary it is distributed much interior at about 60 km from the sea face although the population size is less. Sediment grain size is important for the settlement of detritus and microorganisms, which form the food of detritus feeding molluscs like *C. cingulata* and other potamidids (Balaparameswara Rao & Sukumar, 1981; Sreenivasan, 1985). In general it is seen that detritus feeders (potamidids, assiminids) and amphibious species are the dominant fauna in the estuary.

There is attenuation of species from the lower reaches to the head of the estuary. In Zuari and Mandovi estuaries, Goa, the macrobenthic fauna decreased in densities and species number along the salinity gradient (Ansari *et. al.*, 1986). Amphibious molluscs and the burrowing forms are able to penetrate a greater distance up the estuary than those which are affected by salinity fluctuations in the water. The former are found extending up to the freshwater zone (Zone I) while the latter could not penetrate estuary beyond Diamond Harbour, a distance of about 80 km from the sea face.

In the estuary there are different biotopes like mangroves, mud flats, creeks and jetties. Majority of the species especially bivalves occur in the vicinity of mangals. Molluscs dominate the macrobenthos of Prentice Island, having large concentration in mangrove biotope (Choudhury *et. al.*, 1984). But when overall picture of the estuary is taken into account about 29% of the species occur either within or near the mangal area. Mudflats seem to support more molluscan species than any other biotopes. (Choudhury *et. al.* 1984) found actiniarians to dominate (65.1% of the population) on the mud flats followed by molluscs. The biologically rich and stable environment of the mangal permits colonization by a number of bivalves (Morton, 1983). But present studies to the contrary, corroborate earlier observations by Mandal and Nandi (1989) on the occurrence of molluscs in the mangrove fringed muddy area. The species composition of mangrove bivalves constitute about 45.2% of the total number of bivalves recorded from the the estuary. Bivalves being filter feeders take water through inhalent siphon. The environment which has shifting sediments and heavy silt load would be detrimental to their existence.

The behaviour of some of the species may differ in different localities. *Cerithidea cingulata* was reported to climb trees in the Vellar estuary (Srinivasan, 1985). But the same behaviour was not noticed by us in Hugli-Matla nor by Balaparameswara Rao & Sukumar (1982) in Nizampatnam estuary. The relative importance of different limiting factors on the distribution of molluscs may vary with the locality. *Telescopium telescopium* which prefers muddy, sandy and intermediate types of substrata may often occur in areas of high sand content during monsoon. Thus, even within the same area there is a variation in the preference for the type of substrata (Rambabu and Balaparameswara Rao, 1987).

The distribution of molluscs may not be based on any single hydrological parameter. The richness of fauna in tropical estuaries may be correlated with an increased osmregulatory ability in

higher temperatures (Panikkar, 1951). This is applicable more to the less motile estuary inhabiting organisms like molluscs. The percentage of organic carbon, dissolved oxygen, pH of water and sediment, and nature of substratum were found to influence their distribution.

With the limited data available for us on the breeding periods of certain species occurring within the estuary it appears that these species breed continuously for major part of the year. Continuous breeding all the year round but with more activity during a certain part of the year has been noticed in tropical marine animals (Paul, 1924).

BIOGEOGRAPHICAL COMMENTS

Indo-west Pacific region constitutes a separate unit. Within this region a few divisions are recognised on the basis of faunal and floral components. Macnae (1968) recognised eight divisions whereas Vermeij (1974) divided it into nine subareas. The west coast of India, and Lakshadweep fall under the Western Indian Ocean, and the South-east India, the Bay of Bengal with the Andaman and Nicobar Islands are included in a West-central division or the Indo-Malayan region. Obviously, the molluscs of Hugli-Matla estuary should bear more similarities with that of Indo-Malayan estuaries.

The gastropods of mangals in the Indo-Pacific region are fairly known. On culling information from various sources (Macnae, 1968, Sasekumar, 1974, Vermeij, 1974) it is seen that the gastropod fauna in estuaries and mangals is represented by 27 families, 30 genera and 65 species (Table 3). Hitherto the knowledge on Indo-west Pacific mangrove fauna was based on those from South African Madagascar and Malayan regions. Some of the families, namely, Neritidae, Littorinidae, Potamididae, Assimineidae, Ellobiidae and Onchidiidae have more representatives than other families in mangroves of the Indo-Pacific. The diversity of gastropods is not same in all the subareas. There is greater diversity of mangrove gastropods in Singapore relative to Madagascar and the Ivory coast. But this diversity is not achieved by an increase in the species: family ratio but rather by an increase in the number of families (Vermeij, 1974). The increasing diversity towards the foci of mangrove development is due to increase in families and genera. The same pattern is noticed in Hugli-Matla. At least 12 families are found exclusively in this estuary and the representation of genera is more than that recorded for the entire Indo-west Pacific (Table 3). The families Potamididae and Ellobiidae which are well represented in other Indo-west Pacific estuaries, are, however, less represented at the species level. Neritidae is the most dominant family in the estuary. On the other hand *Terebralia palustris* which is common in most of the mangals of Indo-Pacific is conspicuously absent in the estuary. *Mainwaringia paludomoiëea* is endemic to Hugli-Matla estuary. Although Annandale (1923) mentioned its occurrence in back water near Madras and Rangoon river we have not seen any such material.

In an estuary the main source of food is detritus and it is expected that sediment associated gastropods should be more than those occurring in other biotopes. Thus, we find that assiminiids and ellobiids are widely distributed in the estuary (Table 5). As in Singapore sediment associated gastropods tend to be small. Although their marine relatives are brilliantly coloured there is absence of brilliance in estuarine molluscs and a few have degenerate eyes and highly developed tactile organs (Annandale, 1922).

Morton (1983) had admirably summed up our existing knowledge on mangrove bivalves and in a check list of mangrove bivalves of the Indo-Pacific, he listed 19 families (=18 families) and 86 species (Table 4). However, his survey of the literature on Indian mangroves is far from complete. A comparison of bivalves of Hugli-Matla estuary with that of the Indo-Pacific region reveals that except for two families all others are represented in the former. At the species level the occurrence of a total of 49 species in a single estuary as against 86 of the entire Indo-Pacific region is quite impressive.

TABLE—3
Numerical analysis of Gastropods from Hugli-Matla estuary
collated with the of Indo-West Pacific Mangroves

Sl. No.	Family	Hugli-Matla		Indo-West Pacific	
		Genus	Species	Genus	Species
1.	Acmaeidae	1	1	—	—
2.	Turbinidae	—	—	1	1
3.	Cyclostrematidae	1	1	—	—
4.	Neritidae	5	8	2	7
5.	Littorinidae	1	3	1	4
6.	Iravadiidae	1	1	—	—
7.	Stenothyridae	2	5	1	1
8.	Assimineidae	1	6	1	2
9.	Architectonicidae	1	1	—	—
10.	Thiaridae	2+1	2+5	—	—
11.	Potamididae	2	3	5	15
12.	Epitoniidae	1	1	1	1
13.	Naticidae	1	2	—	—
14.	Muricidae	1	1	4	8
15.	Pyrenidae	1	1	1	1
16.	Melongenidae	1	1	—	—
17.	Nassariidae	1	3	2	3
18.	Olividae	1	1	—	—
19.	Vexilliidae	—	—	1	1
20.	Turridae	1	1	—	—
21.	Ringiculidae	1	1	—	—
22.	Cylichnidae	1	1	—	—
23.	Aglajidae	1	1	—	—
24.	Atyidae	1	1	1	2
25.	Amphibolidae	—	—	1	1
26.	Ellobiidae	4	5	6	14
27.	Elysiidae	—	—	1	2
28.	Onchidiidae	1	3	1	2
		34+1	54+5	30	65

N.B. : + indicates freshwater species

TABLE-4

Numerical analysis of Bivalves from Hugli-Matla estuary collated with that of Indo-West Pacific Mangroves

Sl. No.	Family	Hugli-Matla		Indo Pacific	
		Genus	Species	Genus	Species
1.	Arcidae	2	3	—	—
2.	Noetiidae	1	1	—	—
3.	Mytilidae	1	2	4	13
4.	Isognomonidae	—	—	1	4
5.	Anomiidae	2	2	1	2
6.	Ostreidae	2	3	2	5 + 12*
7.	Lucinidae	1	1	1	1
8.	Ungulinidae	—	—	2	2
9.	Mactridae	1	1	—	—
10.	Solenidae	2	2	2	2
11.	Cultellidae	4	4	1	1
12.	Tellinidae	3	5	2	5
13.	Donacidae	1	1	—	—
14.	Psammobiidae**	1	1	3	3
15.	Semelidae	1	1	—	—
16.	Solecurtidae	1	1	—	—
17.	Trapeziidae	1	1	1	2
18.	Corbiculidae	1 + 1	1 + 2	1	3
19.	Veneridae	3	3	8	13
20.	Glauconomidae	1	1	1	4
21.	Myidae	1	1	—	—
22.	Corbulidae	1	3	—	—
23.	Pholadidae	3	3	3	3
24.	Teredinidae	4	6	3	11
25.	Laternulidae	1	1	1	1
26.	Cuspidariidae	1	1	—	—
Total		40 + 1	49 + 2	40	86 + 12*

* By Gomez

** Includes Asaphidae by Morton (1983)

+ indicates the freshwater species

The proportion of species in each family in the Indo-Pacific is different from that of Hugli-Matla estuary. The families Ostreidae, Mytilidae, Veneridae and Teredinidae account for 55.1% of the total recorded species in the Indo-Pacific, whereas in the Hugli-Matla the families Arcidae, Tellinidae, Cultellidae and Teredinidae are known by 52.6% of the total recorded bivalves species in the estuary. The families Mytilidae and Veneridae are represented in the estuary by only 2 and 3 species respectively as against 13 of each in the Indo-Pacific.

Among bivalves there are two typical mangrove associates, namely, *Isognomon isognomon* and *Enigmonia aenigmatica* which usually occur in all the estuaries but in Hugli-Matla the former has not been recorded. The byssally-attached bivalve species of the families Arcidae, Mytilidae and Trapeziidae are only seven in number. The diversity of byssally attached bivalves are less in the estuary relative to other mangroves in the Indo-Pacific (Table 3). The members of this group are gregarious in nature and usually seen in large populations wherever these occur such as in Prentice Island. *Modiolus striatulus*, which was once reported as abundant at Palta water works is scarcely available now. The species occurred in such an abundance at Palta and Baranagar that it was the major nuisance causing mollusc of the water works (Krishnamoorthi & Rajagopalan, 1970). But these species, in general, are represented by sparse populations in the estuary. *Scaphula deltae* and *S. celox* can also be considered as rare in the estuary. Perhaps the turbidity and salinity fluctuations in overlying waters are some of the factors that inhibit the settlement of larvae of those bivalves. Although we are not in a position to specify the causative factors for the less abundance or absence of certain species which were once so abundant, it may be inferred that some changes have taken place in the estuary during the last few years.

Sediment associated bivalves constitute a significant community in the estuary. There are eight families which have their representatives only in this estuary but not in any mangrove of the Indo-Pacific. Besides, the species of the families Tellinidae (5 spp) and Cultellidae (4 spp) are quite interesting as none of these species were reported from the mangroves of Indo-Pacific.

As in the case of gastropods, in bivalves also the diversity is not achieved by an increase in the species : family ratio but by an increase in the number of families *Tanysiphon rivalis* and *Neosolen aquaedulcioris* are endemic to the estuary. In its bivalve component the estuary bears striking similarity to that of Irawaddy estuary. *Scaphula celox*, *S. deltae*, *Theora opalina*, *Novaculina gangetica* and *Sphenia perversa* are some of the species that are common to both the estuaries.

The status of some of the bivalves is different from what it used to be once. *Novaculina* and *Scaphula* spp. once flourished in the middle reaches of Ganges (Annandale, 1922) and the former was collected from Palta water works recently, about two decades ago (Krishnamoorthi & Rajagopalan, 1970). But their occurrence at present beyond the estuary (Zone III) is doubtful.

Another significant aspect of the molluscs of this estuary is the penetration of members of Scaphopoda and Cephalopoda in the estuary which do not seem to penetrate into any other estuary of the Indo-Pacific.

COMPARISON WITH OTHER INDIAN ESTUARIES

A check list of molluscs of Indian estuaries includes a total of 245 species (120 of Gastropoda and 125 of Bivalvia) [Subba Rao and Surya Rao (1985)]. Excluding the primary freshwater species numbering 14 there are 55 species of gastropods and 49 species of bivalves which occur within the Hugli-Matla estuary (Table-586). In all, four classes of the phylum molluscs, namely, Gastropoda, Bivalvia, Scaphopoda and Cephalopoda have their representatives in the estuary.

A comparison of the malacofauna of the Hugli-Matla estuary with that of other Indian estuaries had to be attempted with some reservations as no other estuary has been studied as extensively and as intensively as the present one. Further, all the earlier investigations in the

TABLE-5
Numerical Analysis of Gastropods from different estuaries/Mangroves of India

Sl. No.	Family	Hugli-Matla		Mahanadi		Gautami Godavari		Krishna		Vellar-Coleron		Andamans	
		Genus	Sp.	Genus	Sp.	Genus	Sp.	Genus	Sp.	Genus	Sp.	Genus	Sp.
A. 1.	Acmacidae	1	1	—	—	—	—	—	—	—	—	—	—
2.	Cyclostrematidae	1	1	—	—	—	—	—	—	—	—	—	—
3.	Neritidae	5	8	2	2	1	1	1	1	2	2	4	16
4.	Littorinidae	1	3	1	3	1	4	1	2	1	2	1	2
5.	Iravadiidae	1	1	1	1	—	—	—	—	1	1	—	—
6.	Stenothyridae	2	5	—	—	—	—	—	—	—	—	1	2
7.	Assimineidae	1	6	1	4	—	—	1	1	1	1	1	3
8.	Architectonicidae	1	1	—	—	1	2	—	—	—	—	—	—
9.	Thiaridae	2 +1	2 +5	—	—	—	—	—	—	—	—	1	1
10.	Potamididae	2	3	2	3	3	5	2	2	3	4	2	3
11.	Epitonidae	1	1	—	—	—	—	—	—	—	—	—	—
12.	Naticidae	1	2	—	—	4	9	—	—	1	1	1	1
13.	Muricidae	1	1	1	1	1	2	—	—	—	—	7	8
14.	Pyrenidae	1	1	—	—	—	—	—	—	—	—	—	—
15.	Melongenidae	1	1	1	1	1	1	—	—	—	—	—	—
16.	Nassariidae	1	3	1	1	1	5	—	—	1	1	1	3
17.	Olividae	1	1	—	—	1	2	—	—	—	—	—	—
18.	Turridae	1	1	—	—	—	—	—	—	—	—	—	—
19.	Ringiculidae	1	1	—	—	—	—	—	—	—	—	—	—
20.	Cylichnidae	1	1	—	—	—	—	—	—	—	—	—	—
21.	Aglajidae	1	1	—	—	—	—	—	—	—	—	—	—
22.	Atyidae	1	1	1	1	1	1	—	—	1	1	—	—
23.	Ellobiidae	4	5	—	—	—	—	2	2	3	3	4	9
24.	Onchidiidae	1	3	1	1	1	1	1	1	—	—	1	2
		34 +1	54 +5	12	16	16	33	8	9	14	16	24	50

N. B.: + indicates freshwater species

TABLE-5 (Contd.)

Sl. No.	Family	Hugli-Matla		Mahanadi		Gautami Godavari		Krishna		Vellar-Coleron		Andamans	
		Genus	Sp.	Genus	Sp.	Genus	Sp.	Genus	Sp.	Genus	Sp.	Genus	Sp.
B. 1.	Ischnochitonidae	—	—	—	—	—	—	—	—	—	—	1	1
2.	Trochidae	—	—	—	—	1	1	—	—	1	1	1	1
3.	Turritellidae	—	—	—	—	1	2	—	—	—	—	—	—
4.	Strombidae	—	—	—	—	1	1	—	—	—	—	1	3
5.	Vanikoridae	—	—	—	—	—	—	—	—	—	—	1	1
6.	Calyptasidae	—	—	—	—	1	2	—	—	—	—	—	—
7.	Planoxidae	—	—	—	—	—	—	—	—	—	—	1	1
8.	Cypraeidae	—	—	—	—	1	1	—	—	—	—	1	1
9.	Tonnidae	—	—	—	—	1	1	—	—	—	—	—	—
10.	Ficidae	—	—	—	—	1	1	—	—	—	—	—	—
11.	Buccinidae	—	—	—	—	1	1	—	—	—	—	1	1
12.	Vasidae	—	—	—	—	1	1	—	—	—	—	—	—
13.	Cancellaridae	—	—	—	—	1	1	—	—	—	—	—	—
14.	Mitridae	—	—	—	—	—	—	—	—	—	—	1	2
15.	Terebridae	—	—	—	—	—	—	—	—	1	1	—	—
16.	Hydatinidae	—	—	—	—	1	1	—	—	—	—	—	—
		34+1	55+5	12	16	16+11	33+13	8	9	14+2	16+2	24+8	50+11

N. B. : + indicates either freshwater or marine species.

TABLE-6

Numerical Analysis of Bivalves From Different Estuaries/Mangroves of India

Sl. No.	Family	Hugli-Matla		Mahanadi		Gautami Godavari		Krishna		Vellar-Coleron		Andamans	
		Genus	Sp.	Genus	Sp.	Genus	Sp.	Genus	Sp.	Genus	Sp.	Genus	Sp.
1.	Arcidae	2	3	—	—	1	3	—	—	1	2	3	3
2.	Neotiidae	1	1	—	—	—	—	—	—	—	—	—	—
3.	Mytilidae	1	2	1	1	1	2	—	—	1	1	2	2
4.	Isognomonidae	—	—	—	—	—	—	—	—	—	—	1	1
5.	Pinnidae	—	—	—	—	1	1	—	—	—	—	—	—
6.	Anomiidae	2	2	1	1	1	1	—	—	—	—	—	—
7.	Ostreidae	2	3	1	1	1	1	—	—	2	2	2	3
8.	Lucinidae	1	1	—	—	1	1	—	—	—	—	1	1
9.	Mactridae	1	1	—	—	—	—	—	—	—	—	—	—
10.	Solenidae	2	2	—	—	2	2	—	—	1	1	—	—
11.	Cultellidae	4	4	—	—	—	—	—	—	—	—	—	—
12.	Tellinidae	3	5	—	—	1	2	—	—	1	1	—	—
13.	Donacidae	1	1	—	—	1	3	—	—	1	1	1	2
14.	Psammobiidae	1	1	—	—	—	—	—	—	2	2	—	—
15.	Semelidae	1	1	—	—	—	—	—	—	—	—	—	—
16.	Solecurtidae	1	1	—	—	—	—	—	—	—	—	—	—
17.	Trapeziidae	1	1	—	—	—	—	—	—	—	—	—	—
18.	Corbiculidae	1 +1	1 +2	1	1	—	—	—	—	—	—	2	4
19.	Veneridae	3	3	—	—	6	9	—	—	2	3	4	4
20.	Glauconomiidae	1	1	—	—	—	—	—	—	—	—	—	—
21.	Myidae	1	1	—	—	—	—	—	—	—	—	—	—
22.	Corbulidae	1	3	—	—	—	—	—	—	—	—	—	—
23.	Pholadidae	3	3	1	1	2	2	1	1	2	2	1	1
24.	Teredinidae	4	6	8	11	3	4	5	5	5	8	8	10
25.	Latenulidae	1	1	—	—	—	—	—	—	1	1	—	—
26.	Cuspidariidae	1	1	—	—	—	—	—	—	—	—	—	—
		40 +2	49 +2	13	16	21	31	6	6	19	24	26	32

N. B. : + indicates freshwater species

Indian estaries were biased towards the more conspicuous and easy-to-collect gastropods and the destructive wood-boring bivalves. However, from the data available it is seen that no other estuary has such a diversity of species as the Hugli-Matla estuary. The total number of species of gastrpods, wood-boring and other bivalves recorded from various estuaries are 32 species from Mahanadi, 64+13 species from Gautami-Godavary, 15 species from Krishna and 40 species from

Vellar-Coleran (Tables 5 & 6). Although there are no typical estuaries in Andaman Islands, the sheltered marine mangroves support a rich diversity of malaco fauna (84 species) (Das & Dev Roy, 1989).

Gastropods occurring in various Indian estuaries and mangroves of Andaman Islands are shown in Table 5. It lists 24 families under category A, the species of which are either estuarine or euryhaline. There are another 16 families, which are listed under category B, the representatives of which are stenohaline marine. These have been reported from the Kakinada Bay, in Gautami-Godavari estuary (Radhakrishna & Ganapati, 1969) and from mangroves of Andaman Islands (Das & Dev Roy, 1989). *Pugilina cochlidium* is a marine stenohaline form in Kakinada Bay but in the Hugli-Matla estuary it occurs under estuarine conditions.

The families Neritidae, Littorinidae, Stenothyridae, Assimincidae, Potamididae, Ellobiidae and Onchidiidae have been the major contributors towards the diversity in the estuary. The richness of Andaman fauna is more due to the presence of marine component.

The gastropod species which are common to all Indian estuaries are as follows:

Naritina (Dostia) violacea, *Littorina melanostoma*, *L. scabra*, *Assiminea brevicula*, *Telescopium telescopium*, *Cerithidea cingulata*, *C. obtusa*, *Natica tigrina*, *N. gualteriana*, *Nassarius stolatus*, *Cassidula nucleus*, and *Ellobium aurisjudae*.

Terebralia palustris which has been reported from Mahanadi, Godavary, Krishna and from Adayar, Madras, is conspicuously absent in Hugli-Matla. On the other hand *Larina burmana* is known from Hugli-Matla and Irawaddy estuary.

The epifaunal component includes representatives of families like Arcidae, Mytilidae, Anomiidae, Ostreidae and Isognomonidae. These are usually found in estuaries. Until all the estuaries are surveyed with specific reference to members of these families it is not advisable to comment on their existence or absence in the estuary. The wood-borers (Pholadidae and Teredinidae) of all estuaries have been investigated and majority of the species are common to all estuaries.

The molluscan diversity in this estuary is rich in comparison to that of other Indian estuaries. Some of the families have their representatives only in Hugli-Matla but not in any other estuary. The age and largeness of the estuary, rich sediments and more stable conditions in certain areas may be some of the factors that have contributed to the richness of molluscs.

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Fig. 1 : Shell of *Acrilla acuminata* ; 2 : Egg Capsule of *A. acuminata* ; 3 : *Onchidium typhae* with egg capsule ; 4 : Egg capsule of *O. typhae* ; 5 : Individual egg capsule of *Loliolus* sp.

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POLYCHAETES

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INTRODUCTION

The Hugli-Matla estuarine complex in the Gangetic delta (West Bengal), one of the largest and widest estuarine complex of the tropical world, supports a luxuriant growth of mangrove forests and a faunistic community quite rich in variety and abundance, of which the polychaetes constitute one of the most important macrobenthic infaunal components. The polychaetes are quite common in the intertidal areas particularly in the lower reaches of the estuary, subjected to inundation and exposure twice in every twentyfour hours along with wide range of seasonal salinity fluctuations. Whenever a sample is taken from the littoral sediments polychaetes are almost certainly to be present. Considering the abundance of the polychaetes in this extuarine complex, a detailed investigation of this group of animals has recently been carried out by the present author (Misra, in press).

Most important earlier works on the taxonomy of polychaetes pertaining to Indian waters are those of Fauvel (1932, 1953). But taxonomic literature on the brackish-water polychaete fauna of India is poor in comparison to that of its marine component. However, recent ecological investigations relating to the benthos of the different brackish-water areas of India, indicate that the polychaete is one of the dominant and diversified groups. Southern (1921) is the pioneer in providing a comprehensive account of the brackish-water polychaetes of India. In all, he recorded 30 species of polychaetes from the Gangetic delta, Chilka lake and Cochin backwater. A total of three new genera and 27 new species were described from the above-mentioned areas. However, the earliest record of brackish-water polychaete from India dates back to 1908 when Stephenson described a capitellied worm *Matla bengalensis*, wrongly designating it as an oilgochaete worm, from Port Canning, Gangetic delta. But later, in 1910, he himself recognised that as a polychaete. From the same locality Willey (1908) described a spionid worm *Spio bengalensis*. Feuvel (1932) made the first extensive studies on the collections of the Zoological Survey of India and recorded 300 species of polychaetes including only 40 species from the brackish-water environments of India. In a monumental work, Fauvel (1953) reviewed all the earlier works on polychaetes from India and its adjacent areas wherein he recorded 450 species, of which 283 belong to the Indian territory, including 47 brackish-water forms. He, however, believed that this number represented only about one-half of the expected total. A careful review of literature by the present author reveals 167 species of polychaetes under 38 families (Table-3) are recorded in the brackish-water localities of India.

Taxonomic accounts of eight species of polychaete by Southern (1921), 30 species by Fauvel (1932), 27 species by Misra *et al.*, (1984) and 68 species by Misra (in press) from the

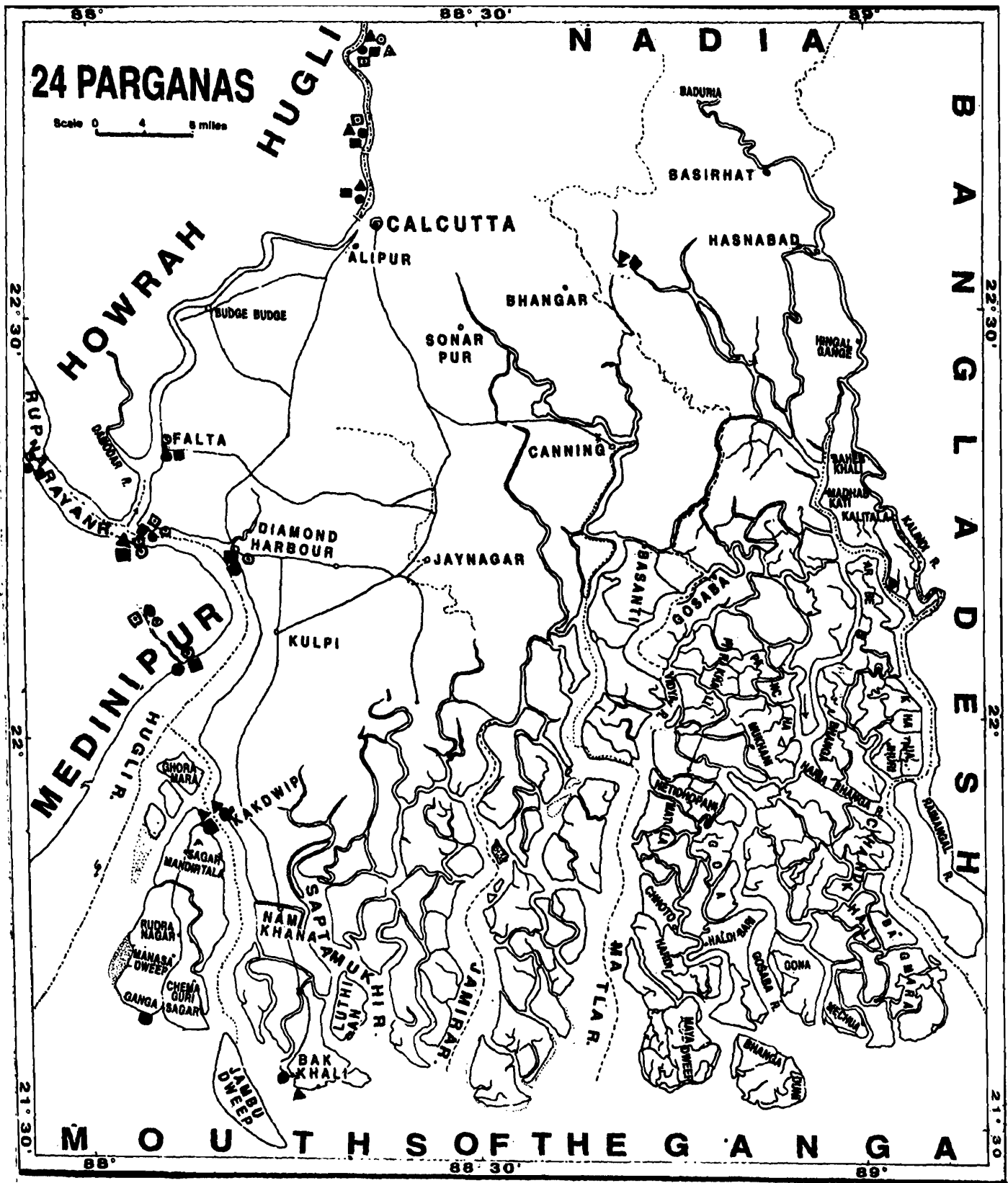


Fig.-1. Distribution of most common brackish-water polychaete species in the Hooghli-Matla estuarine System. ● *D. Heteropoda*; ▲ *N. indica*; ■ *N. fauveli*; ○ *N. neggitti*; △ *N. oligobranchia*; □ *N. polybranchia*.

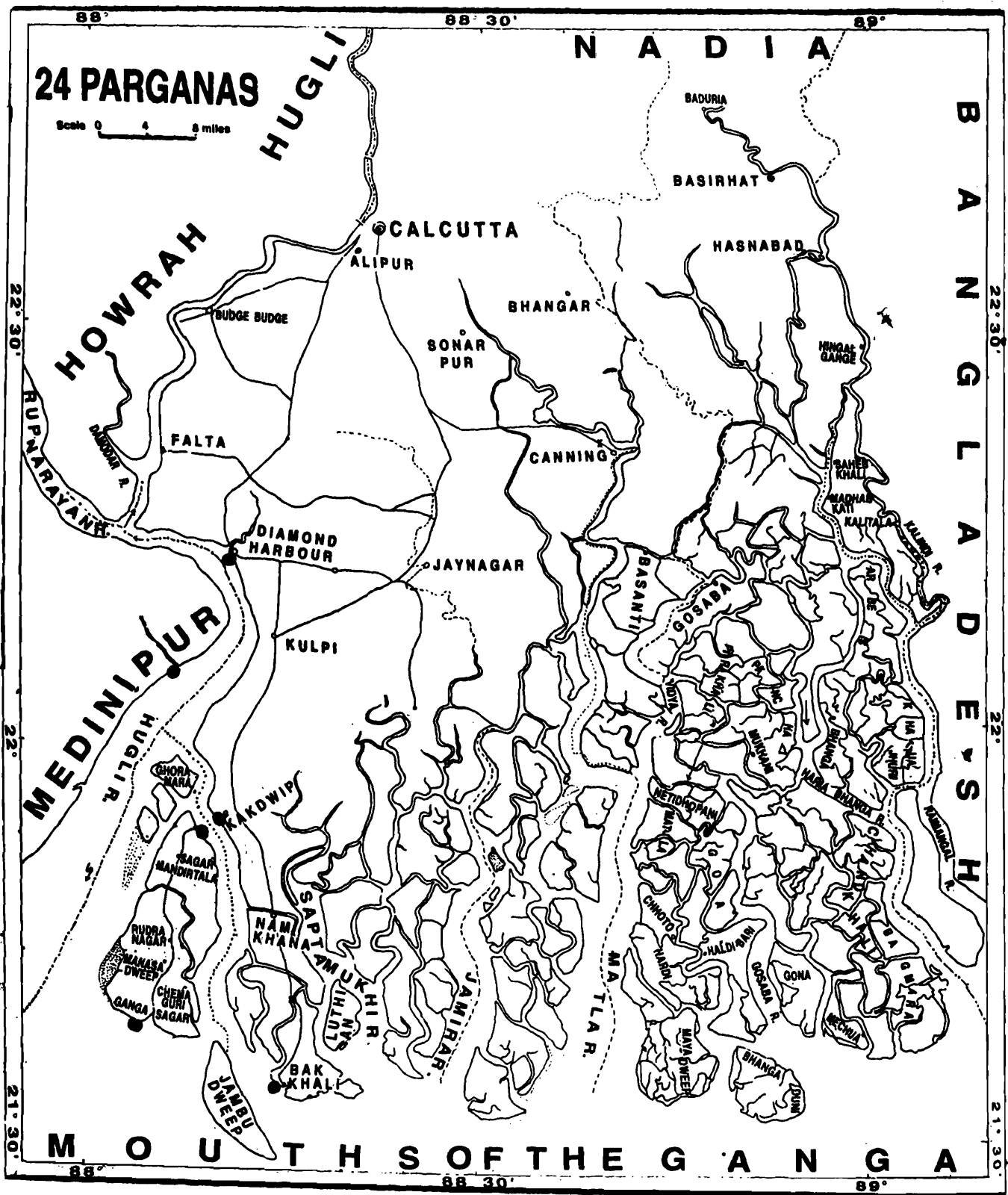


Fig.-2. Distribution of *Mastobranchus cf. indicus* (●) in the Hugli-Matla estuarine system.

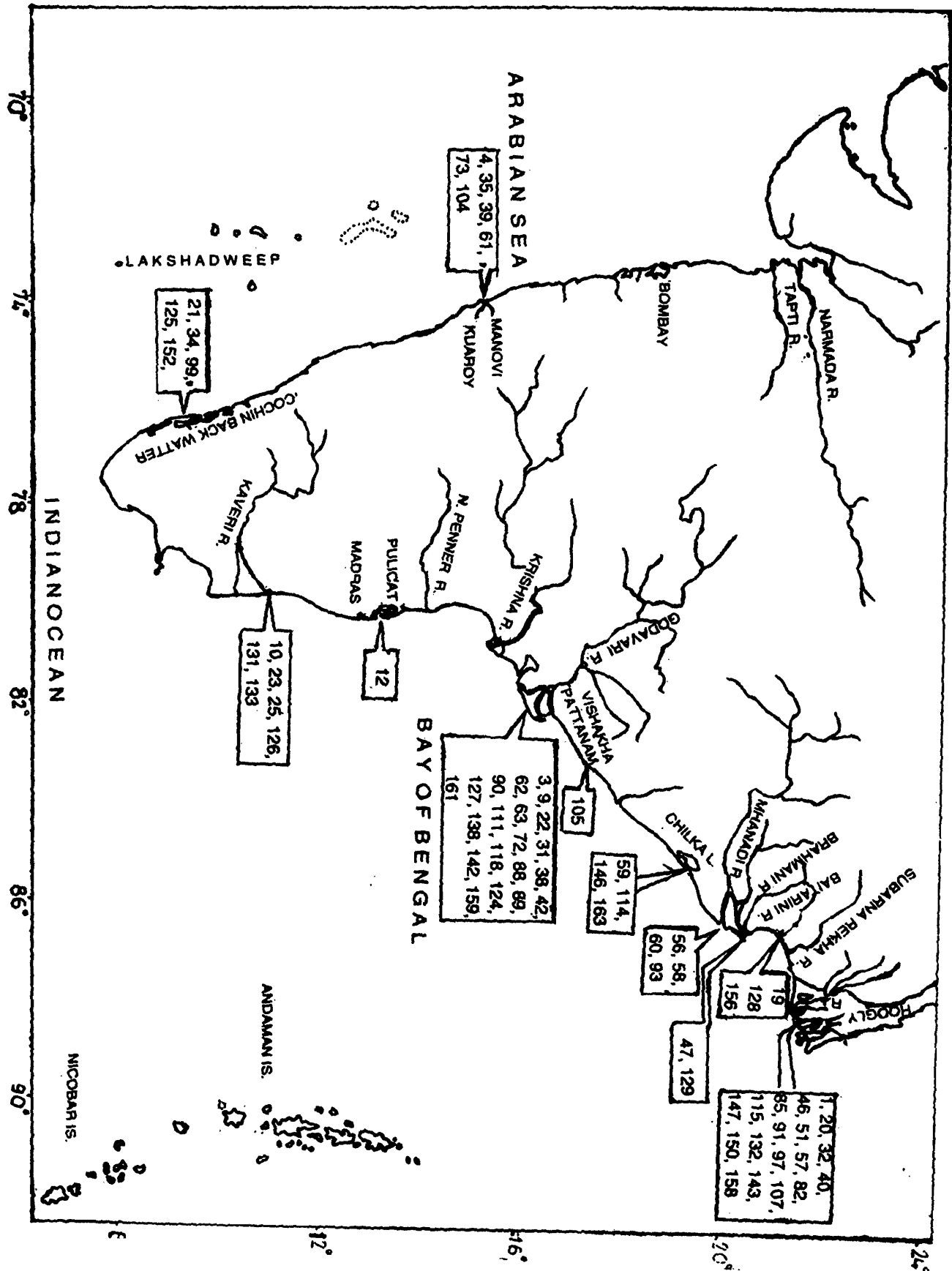


Fig.-3. Distribution of Polychaete species in different brackish-water bodies of India, showing restricted distribution. Figure in blocks indicates serial number against species as dealt with in Table 3.

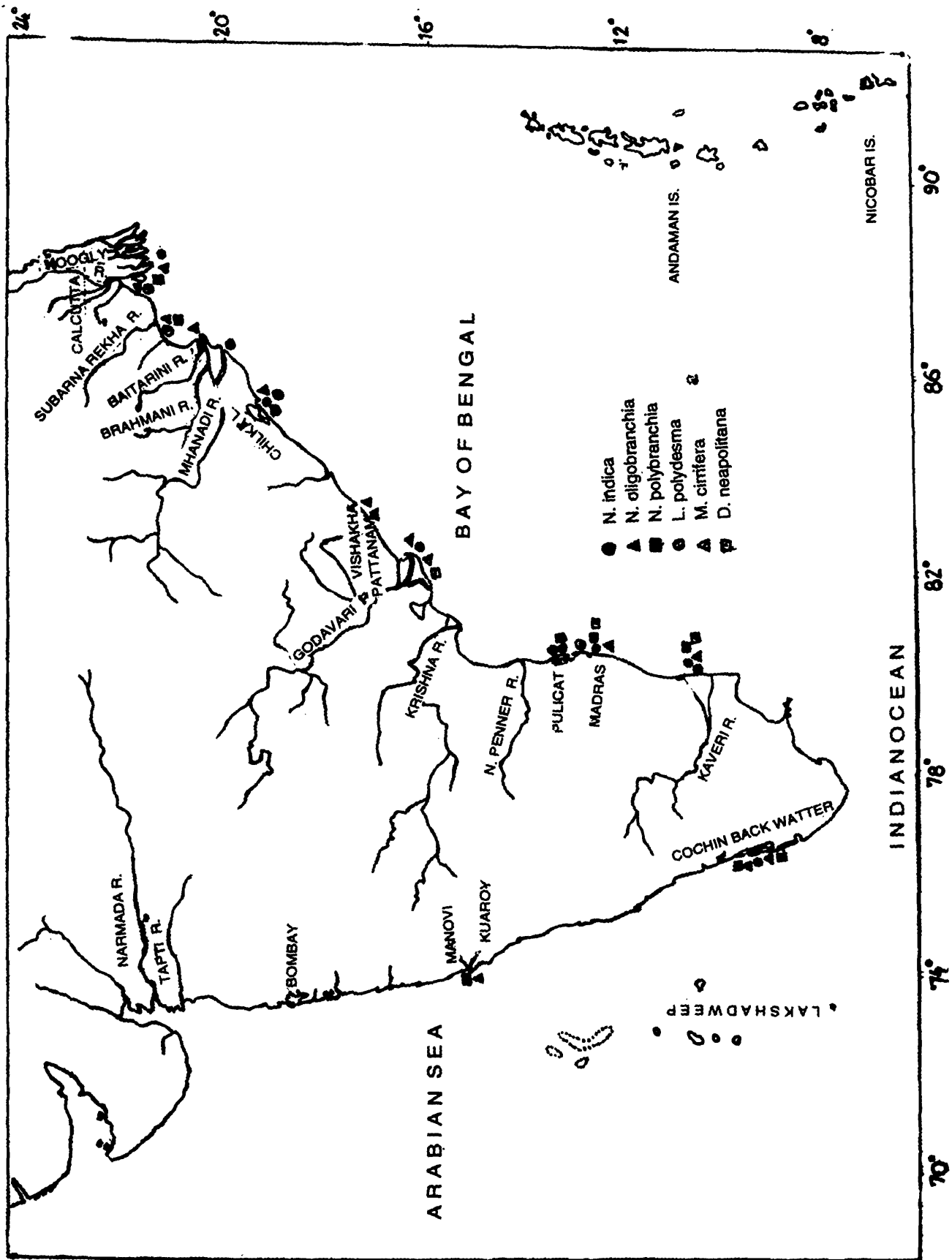


Fig.-4. Distribution of polychaete species in different brackish-water bodies of India, showing wider distribution.

brackish-water environments in the State of West Bengal, are available. However, most of the recent ecological investigations on the macrobenthos of the area indicate that this group is one of the most important components of the benthic fauna (Datta & Sarangi, 1980; Bhunia & Choudhury, 1981; Nandi & Choudhury, 1983; Choudhury *et al.*, 1984 a, b; Anonymous, 1987).

The information gathered during several surveys conducted by the Zoological Survey of India parties in the past one decade, are represented in this paper. The present communication has given more stress on the basic distributional pattern of the polychaete species along the estuarine complex as well as in other brackish-water bodies of India so as to provide a realistic range of the species. Moreover, the distributional patterns of the elements under study in relation to that of some other global regions, like Africa and Australia have also been discussed. Further, the possible reasons for the apparent richness of polychaete species in the Hugli-Matla estuary have also been presented.

MATERIAL AND METHOD

Samples of macrobenthic polychaete fauna were collected on the intertidal regions down the shore starting from HWM to LWM as well as along the shore following the river course during the low tide periods. The soft substratum was generally dug out in small blocks using a spade or shovel and placed in large container. That was then broken up by hand and visible organisms were picked up. After hand sorting, the samples were screened through 1mm sieve. However, only sitly sand samples thus sieved produced good results. Tube dwelling polychaetes were very carefully collected by digging the soil following the course of the tubes. Burrowing forms were detected first by carefully observing their castings, if any, then tried to collet by digging the soil.

After collection, material was washed in brackish-water and then allowed to relax in 7% MgCl₂ prepared in brackish-water to avoid twisting or breaking of the specimens. Narcotization was done by addition of 70% alcohol drop by drop, slowly. Before fixation, polychaetes of the family phyllodocidae, Nereididae and Glyceridae were treated with sudden addition of strong alcohol for everting their pharynx. Standard fixing reagent used for polychaetes was 10% neutral brackish-water formalin.

Preserved samples were sorted very carefully using a low power stereo-microscope. Among the enviromental parameters, salinity determination was made regularly following the Knudsen's method.

SYSTEMATIC NOTES

With the initiation of the Ganga Action Plan in India increasing ecological studies on the estuaries and mangrove belt of the deltaic region of Bengal seem imperative. Such investigations can not successfully be carried out without a comprehensive knowledge of the faunal resources.

Hedgpeth (1957) recommends that the first procedure in any ecological research is the 'exercise in systematics' It is, therefore, imperative that taxonomic studies of the organisms of the Gangetic estuary especially of the particular group of animals which constitutes one of the major components of macrobenthic fauna of the area, shall ultimately be helpful to ecological works for the assessment of the benthic condition as well as the quality of the environment.

As the taxonomic account of most of the species dealt with herein are available in the author's earlier publication (Misra, in press), only the diagnostic features with habitat description are included here. Moreover, the present author has collected most of the material, therefore, the collector's name is omitted in the material column to avoid repetition, unless otherwise stated.

Family POLYNOIDAE

Key to Subfamilies

Lateral antennae attached distally on prostomiumLEPIDONOTINAE
Lateral antennae attached subdistally or ventrally on prostomium.....HARMOTHOINAE

Subfamily LEPIDONOTINAE

Genus *Lepidonotus* Leach, 1816

Key to Species

Prostomium wider than long, without anterior cleft; elytra with well-developed lateral fringes of papillae *L. tenuisetosus*.

Prostomium as long as wide, with anterior cleft; elytra with very small lateral fringes of papillae*Lepidonotus* sp.

1. *Lepidonotus tenuisetosus* (Gravier, 1901)

1901 *Euphione tenusetosa* Gravier, *Nouv Archs. Mus. Hist. Nat. Paris* (Sr. 4), 3 : 222, pl. 8, figs. 123–126, text figs 228–231.

Material : 2 exs., Kachuberia, Sagar Isand, 5.7.1975; 4 exs., Bakkhali, 10.4.1978; 2 exs., Jingakhali, 12.9.1983, Coll. B.P.Halder & Party; 1 ex., Gona, Sundarban, 4.11.1988.

Diagnosis : Prostomium wider than long, without anterior cleft. Antennae attached distally on prostomium. Elytra 12 pairs, with well-developed lateral fringes of papillae.

Habitat : Crevices of wooden posts and pillars of jetty towards LWM; salinity 8‰–19‰.

Distribution : Indo-west Pacific and eastern Atlantic.

2. *Lepidonotus* sp.

Material : 1 ex., Gangasagar, Sagar Island, 18.8.1983.

Diagnosis : Prostomium globular, as long as wide with a median cleft. Antennae attached terminally. Elytra 12 pairs, with very small lateral fringes of papillae.

Habitat : Attached to a submerged brick at LWM; salinity 12‰.

Subfamily HARMOTHOINAE

Key to genera

Elytra covered with honey-combed polygonal areas; lateral fringes of papillae present
.....*Gaudichaudius*.

Elytra without any honey-combed polygonal areas; lateral fringes of papillae absent
.....*Gattyana*.

3. *Gattyana fauveli* Misra, in press

Gattyana fauveli Misra, in press

Material : 1 ex, Gangasagar, Sagar Island 22.3.1981.

Diagnosis : Prostomium with frontal peaks and a wide anterior notch. Lateral antennae attached sub-distally. Elytra 15 pairs, without any fringes of papillae or honey-combed polygonal areas. Pigments on elytra concentrating to form black crescentic markings on posterior half.

Habitat : Within the burrow and in association with the echiuran worm *Anelassorhynchus branchiorhynchus* (Annandale and Kemp) towards LWM; salinity recorded as 18‰.

Distribution : Endemic in east coast of India.

4. *Gaudichaudius cimex* (Quatrefages, 1866)

1866. *Iphione cimex* Quatrefages, *Histoire naturelle* douce. *Annelides et Gephyriens*, 2-3. 270.

1932. *Gattyana deludens* Fauvel, *Men. Indian Mus.*, 12 : 18, figs 1-2.

Material : 5 exs., Gangasagar, Sagar Island, 22.3.1981; 10 exs., Bakkhali 20.4.1985, coll. B.P. Halder & party.

Diagnosis : Prostomium bilobed without distinct cephalic peaks. Lateral antennae inserted ventrally. Elytra 15 pairs with lateral fringes of papillae and honey-combed polygonal areas.

Habitat : Attached preferably to the surface of hermit-crab shells towards the LWM; salinity 19%–22%.

Distribution : Indo-west Pacific.

Family : AMPHINOMIDAE

5. *Chloeia parva* Baird, 1870

1870. *Chloeia parva* Baird, *Linn. Soc. Zool. Lond.*, **10** : 233, pl. 4, fig. 8a-b.

Material : 1 ex., Sandheads, mouth of river Hooghly, 11.1.1926. Coll. G.Parks of P.V. "Lady Fraser"

Diagnosis : Dark marks in the form of Roman T arranged in a row along middle of the dorsum.

Habitat : Lives under stones or in crevices, also swims well and is often collected in trawl nets.

Distribution : Indo-west Pacific.

Family : PHYLLODOCIDAE

Key to Genera

Tentacular cirri 4 pairs *Anaitides*

Tentacular cirri 2 pairs *Eteone*

6. *Anaitides madeirensis* (Langerhans, 1880)

1880. *Phyllodoce madeirensis* Langerhans, *Z. Wiss. Zool.*, **33** : 307, pl. 17, fig. 44.

Material : 2 exs., Canning, 17.11.1982, 1 ex., Jhingakhali, Sundarbans, 12.9.1983, Coll. B.P.Haldar & Party; 4 exs., Kakdwip, 10.3.1985, Coll. B.P.Haldar & Party; 1 ex., Parseymari, Sundarbans, 9.11.1988.

Diagnosis : Prostomium heartshaped with a deep posterior notch sheltering an occipital papillae. Tentacular cirri 4 pairs. Pharynx with 6 lumpy ridges on distal part and 6 lateral rows of papillae on basal part. Dorsal cirri brightly coloured.

Habitat : Soft mud in the zone between MTL and LWM; sometimes on surface; salinity 8‰–15‰.

Distribution : Widely distributed in temperate and tropical waters.

Genus *Eteone*, Savigny, 1818

Key to Species

- Body yellowish-white; pharynx with 5 rows of distal swollen papillae *E. barantollae*

 Body with three rows of dark spots; pharynx with 3–4 rows of swollen papillae *E. ornata*

7. *Eteone barantollae* Fauvel, 1932

1932. *Eteone barantollae* Fauvel, *Men Ind. Mus.*, **12** : 72, fig., 13a–d.

Material : 4 exs., Gangasagar, Sagar Island, 28.2.1979; 6 exs., 12.10.1979; 4 exs., 12.7.1983.

Diagnosis : Body yellowish-white. prostomium oval, as long as wide, with 2 pairs of short antennae. Pharynx with 5 rows of distal swollen papillae; mid-dorsal row broader than lateral ones.

Habitat : Lives in mud impregnated with fine sand in the zone between MTL and LWM; sometimes on the surface of soil during low-tide period; salinity ranges from 12‰ to 19‰.

Distribution : Endemic in east coast of India.

8. *Eteone ornata* Grube, 1878

1978. *Eteone ornata* Grube, *Mem. Acad. Sci. S. Peterb.* **25** : 106.

Diagnosis : Body with three rows of dark spots. Prostomium oval, longer than wide, notched laterally. Pharynx eversible with 4 rows of large soft papillae proximally and 3 rows distally.

Remarks : Collected only once, that too, from the Sandheads at the Hooghly river mouth (Fauvel, 1932). Afterwards, there is no further record of the species from the region under present consideration.

Distribution : Indo-west Pacific

Family : HESIONIDAE

9. *Hesione splendida* Savigny, 1818.

1818. *Hesione splendida* Savigny, *Histoire naturelle des animaux sans vertebres*, p. 316.

Material : 1 ex., Kishorimohanpur, Sundarbans, 8.11.88.

Diagnosis : Prostomium deeply notched posteriorly with 2 small antennae and 2 pairs of eyes. Pharynx eversible, smooth with an ovoid dorsal tubercle, without jaws or marginal papillae. Tentacular cirri and dorsal cirri jointed, the latter borne on long cirrophores. Setigerous lobe stout with small presetal and postsetal lips and a superior conical papilla.

Habitat : Soft mud towards the MTL.

Distribution : Cosmopolitan

Family PILARGIDAE

Key to Genera

Antennae 3, longer than palps; notopodial hooks without basal swellings; free-living

..... *Sigambra*

Antennae 2, subequal to palps; notopodial hooks with basal swellings; commensal

..... *Sigatargis*

10. *Sigambra constricta* (Southern, 1921)

1921. *Ancistrosyllis constricta* Southern. *Mem. Indian mus.*, 5 : 573, pl. 19, fig. 1A-G.

Material : 1 ex., Bakkhali, 24 Parganas (South), 7.3.1985, Coll. B.P.Haldar & Party; 1 ex., Marichjhapi, Sundarbans, 13.11.1988.

Diagnosis : Prostomium with biarticulate palps and three antennae. Tentacular segment achaetous and apodous, completely fused with the first setiger. Dorsal cirri of first setiger longer than those of the rear ones. Pharynx eversible without jaws; mouth slit-like guarded by 14 large papillae. Parapodia sub-biramous.

Habitat : Lives in soft muddy substratum admixed with very fine sand on the sheltered area below LWM; salinity 10‰.

Distribution : Endemic in India.

11. *Sigatargis commensalis* Misra, in press

Sigatargis commensalis Misra, in press

Material : Holotype, An 2244/1, Birajmani char, Gosaba, Sundarbans, 27.5.1985, coll. B.P. Halder & party; Paratype 1 ex., An 2245/1, other data same as above.

Diagnosis : Prostomium broad with biarticulate palps, antennae paired, short, digitiform and subequal to palps. Tentacular cirri 2 pairs, posterodorsal pair slightly longer than anteroventrals. Parapodia sub-biramous, notopodia indistinct with hooked seta from setiger 3.

Habitat : Lives in burrows of the hemichordate, *Saccoglossus* sp., below MTL; firmly attached to the gastric region of the hemichordate; salinity 25‰.

Distribution : Endemic in India.

Family TALEHSAPIIDAE

12. *Talehsapia annandalei* Fauvel, 1932

1932. *Talehsapia annandalei* Fauvel, *Mem. Indian Mus.*, 12 : 251, pl. 9, figs, 13–20.

Material : 3 exs., Canning, 18.11.1982; 2 exs., Muriganga creek, Sagar Island, 4.9.1983, Coll. S. Chakraborty; 4 exs., Jhingakhali, 17.9.1983. 2 exs., Kakdwip, 10.3.1985 Coll. B.P. Halder & Party; 4 exs., Namkhana, 6.10.1982, Coll. B.P. Halder & Party; 1 ex., Banga, Sundarbans, 13.11.1988.

Diagnosis : Prostomium Small and conical without eyes, antennae and palps. Peristomium apodous and achaetous, without tentacular cirri. Anterior 5–6 setigers inflated and bulbous with tessellated epidermis having polygonal areas. Pharynx eversible, armed with a pair of curved jaws. Parapodia sub-biramous.

Habitat : Lives in solid comparatively hard clayey soil near MTL; salinity 5‰ to 17‰.

Distribution : Indo-west Pacific

Family NEREIDIDAE

Key to Subfamilies

Parapodia sub-biramous, without ligulesNAMANEREIDINAE
Parapodia biramous, with ligulesNEREIDINAE

Key to Genera

1. Some notopodia with branchiae 2
 Notopodia without branchiae 3
2. Branchiae arise from dorsal cirri; setae composite spinigers throughout *Dendronereis*
 Branchiae arise from notopodial lobes; setae composite spinigers and falcigers *Dendronereides*
3. Paropodia sub-biramous throughout, without ligules *Namalycastis*
 Paropodia biramous from third setiger onwards, with well-developed ligules 4
4. Parapodia of first 2 setigers sub-biramous; pharynx with soft papillae having apically thickened cuticle *Ganganereis*
 Parapodia of first 2 setigers uniramous; pharynx with soft papillae or chitinous paragnaths 5
5. Tentacular cirri 3 pairs; chitinous paragnaths absent *Lycastonereis*
 Tentacular cirri 4 pairs; chitinous paragnaths present 6
6. Paragnaths on group VI transverse bars *Perinereis*
 Paragnaths on group VI conical *Neanthes*

Subfamily NAMANEREIDINAE

Genus *Namalycastis* Hartman, 1959*Key to Species*

1. Dorsal cirri short and conical, slightly enlarged in posterior setigers; antennae very small or indistinct; neuropodial falcigers modified, unusually heterogomph *N. fauveli*
 Dorsal ; cirri slender, gradually enlarged in middle and posterior setigers; antennae distinct; neuropodial falcigers not modified 2
2. Notosetae 2–5; neuropodium bilobed conical process *N. meraukensis*
 Notosetae 1–2; sometimes absent; neuropodium unilobed conical process *N. indica*

13. *Namalycastis fauveli* Rao, 1981

1981 *Namalycastis fauveli* Rao, *Bull. zool. surv. India* 3 (3); 215.

Material : 2 exs., Kachuberia, 12.6.1977; 12 exs., Kakdwip, 8.9.1979; 3 exs., Bhushighata, 12.8.82; Several exs., Diamond Harbour, 11–13.3.1983; several exs., Haldia, 16–17.3.1983; 9 exs., Patikhali, Haldia, 18.3.1983; 2 exs., Raychak, 7.12. 1983; 4 exs., Nurpur, 7.12.1983; 5 exs., Narayanpur, 9.3.1984; 10 ex., Geonkhali; 23.3.1985; Several ex. Falta, 26–27.3.1985; 4 exs., Bally, 2.6.1986; 2 exs., Salkia, Howrah 10.6.1986; 4 exs., Naihati; 4.6.1986 Coll. B.P.Haldar; 2 exs., Barrackpur, 3.6.1986; 2 exs., Marichjhapi, Sundarbans, 13.11.1988; 4 exs., Phuleswar, 4.4.1989; 10 exs., Naihati, 15.8.1989.

Diagnosis : Prostomium wider than long, without anteromedian groove; antennae very small and indistinct. Tentacular cirri short. Parapodia sub-biramous, with reduced notopodia. Neuropodial falcigers unusually heterogomph.

Habitat : Lives in soft clayey soil in the zone between HWM and LWM; salinity ranges from 0‰ to 10‰.

Distribution : Endemic in north-east coast of India.

14. *Namalycastis indica* (Southern, 1921)

1921. *Lycastis indica* southern, *Mem. Indian. Mus.*, 5 : 578, pl. 19, fig. 2a–j, text fig. 2a–d.

Material : 3 exs., Kachuberia, 12.6.1977; 4 exs., Kakdwip, 9.9.1979; 2 exs., Bakkhali, 5.10.1982; 6 exs., Bhushighata, 18.10.1982; 5 exs., Geonkhali, 9.3.1984; several exs., Haldia, 15.3.1985; several exs., Falta, 25.3.1985; several exs., Salkiaghat, Howrah 10.6.1986; 10 exs., Naihati, 4.6.1986, Coll. B.P.Haldar & Party; 4 exs., Barrackpur, Coll. B.P.Haldar & Party.

Diagnosis : Prostomium wider than long, with a short anteromedian groove; antennae short and slender. Tentacular cirri long and slender. Parapodia sub-biramous. Notosetae 1 or 2 per setiger. Dorsal cirri gradually increasing in size, broad and flattened in middle and posterior setigers.

Remarks : Lives in compact clayey soil in the zone between HWM and MTL; salinity ranges from 0‰–10‰.

Distribution : Indo-west pacific.

15. *Namalycastis meraukensis* (Horst, 1918)

1918. *Lycastis meraukensis* Horst, *Zool. Meded. Leiden*, 4 : 246.

Material : 1 ex., Geonkhali, 23.3.1985; 2 exs., Falta, 25.3.1985, Coll. B.P.Haldar & Party.

Diagnosis : Prostomium wider than long, with a long anteromedian groove; antennae short and slender. Tentacular cirri long. Parapodia sub-biramous. Notosetae several hemigomph spinigers. Dorsal cirri with large cirrophores, flattened and leaf-like posteriorly.

Habitat : Lives in hard soil at MTL; salinity 0‰.

Distribution : Indowest Pacific.

Subfamily NEREIDINAE

16. *Ceratonereis burmensis* Monro, 1937

1937. *Nereis (Ceratoneries) burmensis* Monro, *Ann. Mag. Nat. Hist. Lond.*, Sr. 10, 19 : 532.

Material : 3 exs., Birajmanichar, near Gosaba, Sundarbans, 25.5.85, Coll B.P.Haldar & Party.

Diagnosis : Prostomium without any groove. Paragnaths absent on basal ring. Notopodia with 3 triangular ligules. neuropodia with 3 lobes. Falcigers confined to a short mid-body region.

Habitat : Lives in sandy soil towards LWM.

Distribution : Indian ocean.

Genus *Dendronereides* Southern, 1921

Key to Species

Branchiae formed as culsters of branched filaments; neuropodia with 3 digitate lobes*D. heteropoda*

Branchiae formed as whorls of several simple filaments; neuropodia with bilobed anterior process and a short rounded posterior lobe *D. Gangetica*

17. *Dendronereides gangetica* Misra, in press

Dendronereides gangetica Misra, in press

Material : Paratypes—1 ex., An 2248/1, Gangasagar, Sagar Island, 15.8.1993; 1 ex., An 2249/1, Muriganga creek, Sagar Island, 18.8.1983, Coll. S. Chakraborty, 1 ex., An 2250/1, Jhingakhali Sundarbans, 12.9.1983; 2 ex., Nurpur 7.12.1983, Coll. B.P.Haldar & Party.

Diagnosis : Prostomium deeply indented, with 2 short tapered antennae. Tentacular cirri 4 pairs, longest pair reaching setiger 4. Pharynx eversible with soft papillae on both rings. Biramous parapodia with 3 conical notopodial ligules and a short anterior acicular lobe; neuropodium with

bluntly bifid presetal lobe and short rounded postsetal lobe. Branchial filaments arranged in whorl commencing from setiger 10 and extending up to setiger 38.

Remarks : Lives in soft mud in the zone towards LWM; salinity ranges form 0‰ to 12‰.

Distribution : Endemic in India.

18. *Dendronereides heteropoda* Southern, 1921

1921. *Dendronereides heteropoda* Southern, *Mem. Indian. Mus.*, **12** : 603, text. fig. 10a–b, pl. 21, fig. 6a–n.

Material : 4 exs., Kakdwip, 12.7.1980; 6 exs., Bhusighata, 18.10.1982; 5 exs., Raychak, 7.12.1983; 10 exs., Haldia, 6.3.1984; 2 exs., Teropekhya, 7.3.1984; several exs., Narayanpur (near Geonkhali), 9.3.1984; 3 exs., Bakkhali, 7.3.1985; several exs., Diamond Harbour, 11.3.1985; several exs., Falta, 25.3.1985; several exs., Salkia, Howrah, 10.6.1986; Coll. G.C.Roy; 5 exs., Barrackpur, 3.6.1986; 1 ex., Sibgung, 11.8.1989; 1 ex., Gadiwara, 31.3.1989.

Diagnosis : Prostomium broad, slightly indented in front, with 2 small antennae. Tentacular cirri 4 pairs, longest pair reaching setiger 4–6. Pharynx eversible with soft papillae on both rings. Biramous parapodia with 2–3 notopodial ligules; neuropodium with 2 anterior and a posterior digitiform lobes. Branchiae arising below dorsal cirrus, in the form of branched bunches of filaments, starting from setiger 7–8 and extending up to setiger 20–22.

Habitat : Lives in burrows in soft silty mud from MTL to LWM; salinity ranges from 0‰ to 10‰.

Distribution : Indian Ocean.

Genus *Dendronereis* Peters, 1854

Key to Species

Branchial filaments bipinnately arranged on dorsal cirri
*D. aestuarina*

Branchial filaments unipinnately arranged on dorsal cirri
 *D. dayi*

19. *Dendronereis aestuarina* Southern, 1921.

1921. *Dendronereis aestuarina* Southern, *Mem. Indian. Mus.*, **12** : 598, pl. 20, fig. 4.

Material : 1 ex., Sandeshkhali, 14.3.1985; 2 exs., Namkhana, 7.10.1982; 12 exs., Jhingakhali, 12.9.1983, Coll. B.P. Halder & Party. 3 exs., Kachuberia, 26.9.1980.

Diagnosis : Prostomium deeply cleft. Pharynx eversible, with soft papillae. Biramous parapodia with 3 notopodial ligules and 10–12 neuropodial lobes. Branchiae as bipinnate divisions of dorsal cirri, commencing from setiger 15 and extending up to 21–22.

Habitat : Lives in soft mud towards the LWM; salinity ranges from 8‰ to 12‰.

Distribution : Indo-west Pacific.

20. *Dendronereis dayi* Misra

Dendronereis dayi Misra, in press.

Material : Paratypes – 1 ex., An 2252/1, Bhangatushkhali, 14.3.1975; 1 ex., An 2254/1, Kakdwip, 12.7.1980; 3 ex., An 2255/1, Canning, 17.11.1982; 2 ex., An 2257/1, Bakkhali, 7.3.1985.

Diagnosis : Prostomium deeply cleft, with 2 short antennae, basally broad palps, and 3 pairs of eyes. Tentacular cirri 4 pairs, longest reaching setiger 9. Pharynx eversible with soft papillae on both rings. Biramous parapodia with 3 notopodial ligules and a short anterior setigerous lobe; neuropodium with 2 anterior digitiform lobes and 1–2 small lobes between them. Branchial filaments unipinnately arranged, commencing from setiger 8 and extending up to 21.

Habitat : Lives in soft mud in the zone towards LWM; salinity ranges from 5‰ to 15‰.

Distribution : Endemic in the north-east coast of India.

21. *Ganganereis sootai* Misra

Ganganereis sootai Misra, in press.

Material : Holotype – An 2258/1, Jhingakhali, Sundarbans, 12.9.1983; Paratypes – 5 exs., An 2259/1, Naraharipur, 10.11.1982; 3 exs., An 2260/1, Champatala, 27.6.1983; 2 exs., An 2261/1, Jhingakhali, Sundarbans, 12.9.1983, Coll. B.P. Halder & party; 1 ex., Jharkhali, 22.1.1987.

Diagnosis : Prostomium partly withdrawn into tentacular segment, with deep groove. Palps with dilated and segmented palpophores. Tentacular cirri 4 pairs, longest pair reaching setiger 17. Pharynx eversible with horny papillae on maxillary ring and soft papillae on oral ring. Biramous parapodia with 2 notopodial ligules; neuropodium with 2 presetal lobes and a postsetal lobe.

Habitat : Lives in burrows extending up to 100 to 150 cm, in the zone between MTL and LWM; salinity ranges from 8‰ to 16‰.

Distribution : Endemic in north-east coast of India.

22. *Lycastonereis indica* Rao, 1981

1981. *Lycastonereis indica* Rao, *Bull. Zool. Surv. India*. 3 (3) : 213, fig. 1A–D.

Material : 2 exs., Kakdwip canal, Kakdwip, 10.3.1985; 10 exs., Bhushighata, 12.8.1982; Several exs., 17.11.1982; 1 ex., Marichjhapi, Sundarbans, 13.11.1988.

Diagnosis : Prostomium with dark brown spots extending in 3 rows upto setiger 24–26. Pharynx eversible with fleshy papille on oral ring only. Biramous parapodia with 2 postsetal notopodial ligules and a small presetal notopodial lobe, neuropodium with 3 lobes. Inferior notopodial ligule absent.

Habitat : Lives in soft black muds in the zone near MTL, particularly abundant in sewage outfall areas; salinity ranges from 5‰–10‰.

Distribution : Endemic in north–east coast of India.

Genus *Neanthes* Kinberg, 1866

Key to Species

1. Paragnaths on basal ring arranged in a continuous belt; falcigerous setae absent *N. chingrighattensis*
- Paragnaths on basal ring arranged in groups; falcigerous setae present 2
2. Notopodia trifold on posterior setigers; paragnaths on group VI = 1 + 1, on group VII & VIII = a single row of small cones *N. glandicincta*
- Notopodia bifid on posterior setigers; paragnaths on group VI = 5(6) + 5 (6), in round clusters, on groups VII & VIII = 3–4 irregular rows of large and small cones *N. meggitti*

23. *Neanthes chingrighattensis* (Fauvel, 1932)

1932. *Nereis chingrighattensis* Fauvel, *Men. Indian. Mus.*, 12 : 90, fig. 14a–h.

Material : 3 exs., Kakdwip, 11.9.1977; 2 exs., Gangasagar creek, Gangasagar, 21.1.1983; 2 exs., Diamond Harbour, 11.3.1985; 2 exs., Haldia, 16.3.1985; 4 exs., Gadiara, 22.4.1987.

Diagnosis : Prostomium without any frontal groove. Pharynx eversible with paragnaths on both rings. Biramous parapodia with 3 notopodial ligules; neuropodium with 3 lobes. Setae all spinigers only.

Habitat : Lives in soft mud, rotten logs, algal mat over any surface at MTL and LWM; salinity ranges from 5‰ to 16‰.

Distribution : Endemic in India.

24. *Neanthes glandicineta* (Southern, 1921)

1921. *Nereis (Nereis) glandicineta* Southern, *Mem. Indian. Mus.*, 5 : 589, pl. 23, fig. 9A–L, text fig. 5a–e.

Diagnosis : Prostomium narrow in front, longer than wide. Tentacular cirri 4 pairs, longest pair reaching up to setiger 3. Pharynx eversible with paragnaths on both rings. Biramous parapodia with 3 notopodial ligules.

Remarks : The species has not been collected during the present investigation. The diagnosis is based on earlier reports.

Distribution : Indo-west Pacific.

25. *Neanthes meggitti* (Monro, 1931)

1931, *Nereis (Neanthes) meggitti* Monro, *Ann. Mag. nat. Hist. (ser. 10)* 8 : 580, figs. 1–6.

Material : 6 exs., Raychak, 7.12.1983; 5 exs., Haldia, 6.3.1984; 5 exs., Teropekhya, 7.3.1984; several exs., Diamond Harbour, 11.3.1985; several exs., Geonkhali, 21.3.1985; several exs., Falta, 25.3.1985; 5 exs., Uttarpara Library Ghat, Hooghly, 12.6.1986; coll. G. Roy.

Diagnosis : Prostomium short, quadrangular, as broad as long. Pharynx eversible with paragnaths on both rings. Notopodia with 3 conical pointed subequal ligules; neuropodia with 2 unequal lobes, Median notopodial ligule gradually decreasing in size and disappear after setiger 28–30. Notosetae homogomph spinigers, and neurosetae homo- and heterogomph spinigers and heterogomph falcigers.

Habitat : Lives in soft mud under bricks, stones, etc., in the zone at MTL, up to the depth of 1–3 cm; salinity varies from 0‰ to traces.

Distribution : Indian Ocean.

Genus *Perinereis* Kinberg, 1866*Key to Species*

1. Paragnaths absent in group V *P. cavifrons*
- Three paragnaths present in group V, forming a triangle 2
2. Paragnaths 6–12 in group I, forming a cluster *P. nigropunctata* (Horst)
- Paragnaths 2–3 in group I, forming a vertical line *P. cultrifera* (Grube)

26. *Perinereis cavifrons* Ehlers, 1920

1920. *Nereis (Perinereis) cavifrons* Ehlers, *K.Ges. Wiss. Gottingen, n.f.*, **10**(7) : 47, pl. 1, figs. 6–10.

Material : 1 ex., Harwood Point, Kakdwip, 11.9.1977.

Diagnosis : Prostomium globular with 2 short frontal antennae and 2 thick, bulb-like palps. Eversible pharynx with paragnaths on both rings. Notopodia with 2 bluntly conical ligules and a small anterior setigerous lobe. Neuropodia with a bluntly conical setigerous lobe and a thick, blunt inferior ligule. Notosetae homogomph spinigers only ; neurosetae homo and heterogomph spinigers and heterogomph falcigers.

Habitat : Lives in clayey soil at LWM; salinity 5‰.

Distribution : Indian Ocean.

27. *Perinereis cultrifera* (Grube, 1840)

1940. *Nereis cultrifera* Grube, *Actinien Enhinodermen and Wiirmen des Adriatischen and Mittelmeeres*, p. 74..

Material : 2 ex., An 1215/1, champatala, Sagar Island, 10.5.1978.

Diagnosis : Prostomium sub-pyriform with dark longitudinal bands of pigments between anterior pair of eyes. Pharynx eversible with paragnaths on both rings. Notopodia with 2 blunt finger-like subequal ligules, and a small anterior acicular lobe ; neuropodia with a bluntly conical setigerous lobe and a blunt inferior ligule. Notosetae homo-and heterogomph spinigers and heterogomph falcigers.

Habitat : Lives in soft mud at LWM ; Salinity 12‰.

Distribution : Indo-pacific.

28. *Perinereis nigropunctata* (Horst, 1889)

1989. *Nereis nigro-punctata* Horst, *Notes Leyden Mus.*, **11** : 171, pl. 8, figs. 1-3.

Material : 3 ex., An 1465/1, Kachuberia, Sagar Island, 5.11.1975; 1 ex., Jhingakhali, Sundarbans, 12.9.1983; Coll. B.P. Haldar & Party; 1 ex., Canning, 24 Parganas (south), 25.9.1983.

Diagnosis : Prostomium sub-pyriform. Pharynx eversible with paragnaths on both rings. Notopodia with 2 ligules and a small anterior acicular lobe, superior notopodial ligules enlarged bearing dorsal cirri on upper distal margin. Neuropodia with a bluntly conical setigerous process and a blunt club-shaped inferior ligule. Notosetae homogomph spinigers only. Neurosetae homo-and heterogomph spinigers and heterogomph falcigers.

Habitat : Lives in soft muddy substratum towards LWM; salinity varies form 6‰-12‰.

Distribution : Indo-west Pacific.

Family NEPHTYIDAE

Genus *Nephtys* Cuvier in Audouin & Milne Edwards, 1833

Key to Species

- Interramal cirri commencing on stiger 5, absent after setiger 23–24
 *N. oligobranchia*
- Interramal cirri commencing on setiger 2, extending up to posterior end
 *N. polybranchia*

29. *Nephtys oligobranchia* Southern, 1921

1921. *Nephtys oligobranchia* Southern, *Mem. Indian. Mus.*, 5 : 610, pl. 24, fig 12.

Material : 10 exs., Barrackpur, 3.6.1986; 4 exs., Uttarpara Library Ghat, Hooghly, 10.6.1986, Coll. B.P. Haldar & Party.

Diagnosis : Prostomium rectangular with a pair of short palps and a pair of small antennae. No prominent nuchal organs. Pharynx eversible, divisible into short muscular distal region and inflated proximal region; distal region with a long, slender dorsomedian subdistal papillae and 16 bifid distal papillae surrounding mouth and also with 14–16 longitudinal rows of papillae. Interramal cirri commencing on setiger 5, absent after setiger 23–24.

Habitat : Lives in soft mud or silty mud in the zone near and below LWM; salinity varies from 0‰-5‰.

Distribution : Indo-west Pacific.

30. *Nephtys polybranchia* Southern, 1921.

1921. *Nephtys polybranchia* southern, *Mem. Indian. Mus.*, 5 : 607, pl. 24, fig. 11A–G. text fig. 11a–b.

Material : 4 exs., Teropekhya, 19.3.1985; 2 exs., Geonkhali, 23.3.1985; 5 exs., Falta, 25.3. 1985; 12 exs., Barrackpur, 3.6.1986; 4 exs., Uttarpara Library Ghat, Hooghly, 10.6.1986.

Diagnosis : Prostomium rectangular, with a pair of antennae and a pair of palps. Nuchal organs papillae-like and paired. Pharynx eversible, divisible into short muscular distal region and

inflated proximal region; distal region with 20 bifid papillae surrounding mouth and also with 22 longitudinal rows of papillae. Interramal cirri commencing on setiger 2, extending nearly to the posterior end.

Habitat : Lives in soft sediments, muddy sand, in the zone near and below LWM; salinity varies from 0‰ to traces.

Distribution : Indo-west Pacific.

Family GLYCERIDAE

Genus *Glycera* Savigny, 1818

Key to Species

1. Branchiae absent 2
 Branchiae Present 3
2. Postsetal lobe double *G. lancadivae*
 Postsetal lobe single *G. tessellata*
3. Branchial filaments start from the dorsal edge of setiger 35–40 *G. convoluta*
 Branchial filaments start from the anterior surface of setiger 22–24 *G. rouxii*

31. *Glycera convoluta* Keferstein, 1862.

1862. *Glycera convoluta* Keferstein, *Z. wiss. Zool.*, **12** : 106.

Material : 6 exs., Jambu Is., 21.10.17; 3 exs., Gangasagar, Sagar Island, 22.3.1981.

Diagnosis : Prostomium with 10–12 rings, 2 small eyes and 4 small tentacles distally. Pharyngeal papillae of 2 kinds : mostly cylindrical with cape-like sheath and distal mammilated tip and others rounded, Parapodia with 2 long, cirriform and acicular presetal ligules, and a short rounded postsetal lobe. Branchiae simple, starting from setiger 35–40, extending beyond the tip of presetal lobes.

Habitat : Lives in silty sand in the zone between MTL and LWM; salinity varies from 10‰–19‰.

Distribution : Cosmopolitan

32. *Glycera lancadivae* Schmarda, 1861

1861. *Glycera lancadivae* Schmarda, *Neue wirbellase Thiere and Anneliden* p. 95.

Material : 1 ex., Gangasagar, 21.1.1980

Diagnosis : Prostomium small with 12 rings. Pharyngeal papillae of 2 kinds; triangular and rounded. Parapodia with 2 slender acicular presetal ligules, and a short rounded postsetal lobe – emarginate dorsally. Branchiae absent.

Habitat : Lives in silty sediments near LWM; salinity 16‰.

Distribution : Indo–west Pacific.

33. *Glycera rouxii* Audouin & Milne Edwards, 1878

1878. *Glycera rouxii* Audouin & Milne Edwards, *Annl. Sci. nat.*, **29** : 264.

Material : 1 ex., Gangasagar, 12.10.1979; 3 exs., Canning, 18.11.1982.

Diagnosis : Prostomium narrow and conical, with 10–12 rings. Pharyngeal papillae smooth, conical and globular. Parapodia with 2 slender, subequal presetal ligules, and a short rounded postsetal lobe. Branchiae simple, slender and retractile, starting from the anterior surface of setiger 22–24.

Habitat : Lives in soft silty sediments near or below LWM; salinity varies from 12‰–14‰.

Distribution : Indo–Pacific and North Atlantic.

34. *Glycera tessellata* Grube, 1863

1863. *Glycera tessellata* Grube, *Arch. Naturgesch.*, **29** : 41, pl. 4, fig. 4.

Diagnosis : Prostomium with 12–14 rings. Pharyngeal papillae uniform, very long and grooved, without rings. Parapodia each with 2 triangular, subequal presetal ligules, and 2 shorter, rounded, subequal postsetal lobes. Branchiae absent.

Remarks : The species has not been recorded during the present investigation. The diagnosis is based on earlier reports.

Distribution : Cosmopolitan.

Family GONIADIDAE

Key to Genera

Pharynx eversible without V-shaped paragnaths or chevrons ; Pharyngeal organs of several kinds.....*Glycinde*.

Pharynx eversible with V-shaped paragnaths or chevrons ; Pharyngeal organs usually of one kind.....*Goniada*.

35. *Glycinde oligodon* Southern, 1921.

1921. *Glycinde oligodon* southern, *Mem. Indian. Mus.*, 5 : 629, pl. 28, fig. 18.

Material : 2 exs., Namkhana, 24.1.1979; 1 ex., Taldi (north of canning), 12.1.1980, Coll. N. Sarangi.

Diagnosis : Anterior region with 19–20 uniramous parapodia, subsequent ones biramous. Neuropodial presetal lobes enlarged and lamellar in middle setigers, reducing posteriorly.

Haritat : Lives in soft muddy substratum towards the LWM; salinity 8‰.

Distribution : Endemic in India.

36. *Goniada emerita* Audouin & Milne Edwards, 1833

1833. *Goniada emerita* Audouin & Milne Edwards, *Annl. Sci. nat.*, 29 : 268.

Material : 1 ex., Haldi, Sundarbanas, 11.1983, Coll. A. K. Mondal ; 1 ex., Jharkhali, Sundarbans, 20.5.1985 Coll B. P. Haldar & Party; 2 exs., Gangasagar, An 1345/1, 30.7.1978, Coll. A. Choudhury.

Diagnosis : Worms yellowish-brown in life, dark brown in preserved state. Pharynx eversible, with small rounded papillae and V-shaped chevrons having 5–8 chitinous pieces on each side. Parapodia uniramous for anterior 37 to 39 setigers, next 10 to 12 setigers transitional, succeeding ones biramous.

Habitat : Lives in clayey soil or fine sandy substratum at MTL; salinity varies from 12‰–16‰.

Distribution : Indo-west Pacific and North Atlantic.

Family ONUPHIDAE

Key to Genera

Tentacular cirri present; branchial filaments arranged in whorl *Diopatra*

Tentacular cirri absent; branchial filaments simple *Hyalinoecia*

37. *Diopatra cuprea* (Bosc, 1802)

1802. *Nereis cuprea* Bosc, *Histoire naturelle* *nature*, Paris, 1 : 143.

Material : 5 exs., Bhangatushkhali, 13.3.1975; 4 exs., Gangasagar, 9.7.1975, 4 exs., Champatala, 17.11.1975., 1 ex., Gangasagar, 12.4.1978., 1 ex., Kachuberia, 13.4.1978., 5 exs., Canning, 12.1.1983., 3 exs., Bakkhali, 7.3.1985., Coll. B. P. Halder & Party.

Diagnosis : Prostomium with a pair of short, subulate frontal antennae, a pair of oval cushion-like palps, and 5 occipital antennae. Tentacular cirri slender, as long as ceratophore of the longest occipital antenna. Anterior parapodia well developed, with long, triangular dorsal and ventral cirri, notopodia represented by the bases of branchiae and dorsal cirri supported by 2–3 fine acicula, neuropodia well developed, supported by 2–3 acicula, each with a long, conical postsetal lobe and a short, rounded presetal lobe. First 4 or 5 setigers with presetal lobes having larger superior and smaller inferior processes.

Habitat : Lives in tough tube, about 100–150 cm long, embedded in stiff mud, sometimes admixed with fine sand in the zone between MTL and LWM or below, often forming dense bed in sheltered areas. Three to five centimetres of the tube projects and curls over the surface of substratum and are impregnated with shell fragments, leaves, etc salinity varies from 8‰–16‰.

Distribution : Warm and tropical Atlantic and Indian Ocean.

38. *Hyalinoecia tubicola* (Müller, 1776)

1776. *Nereis tubicola* Müller, *Zoologica Danicae* *popularium*, p. 18.

Diagnosis : Prostomium with a pair of globular palps, 2 short frontal antennae and 5 longer occipital antennae having short, 3–5 ringed ceratophores and long ceratostyles. Branchiae simple beginning from setiger 18–26, continuing up to posterior end.

Remarks : Earlier records of the species from the Gangetic delta as well as from other Indian localities are only from the subtidal habitats. As the present investigation is restricted to the intertidal zones, the species has not naturally been obtained.

Distribution : Cosmopolita.

Family : EUNICIDAE Savigny, 1818

Key to Genera

1. Occipital antennae 3 *Lysidice*
 Occipital antennae 5
2. Tentacular cirri present *Eunice*
 Tentacular cirri absent *Marphysa*

39. *Eunice aphroditois* (Pallas, 1788)

1788. *Nereis aphroditois* Pallas, *Nova. Acta. Acad. Sci. Imp. St. Petersburg.* 2 : 229

Diagnosis : Prostomium bilobed, formed by partial fusion of palps; antennae smooth, longer than prostomium. Branchiae commencing from setiger 10 as simple filaments, with a maximum of 15–16 filaments in anterior and middle setigers. Setae include limbate capillaries and pectinate setae superiorly, composite falcigers and subacicular hooks inferiorly.

Remarks : As the species was not recorded during the present investigation, the diagnosis is based on earlier records.

Habitat : Lives in deep burrow in muddy substratum impregnated with fine sand, near LWM.

Distribution : Cosmopolitan.

40. *Lysidice natalensis* Kinberg, 1865

1865. *Lysidice natalensis* Kinberg, *Ofvers. K. Vetensk. Akad. Forh.*, 21 : 566.

Material : 2 exs., Naraharipur, Sagar Island, 12.6.1980.

Diagnosis : Prostomium bilobed, with 3 occipital antennae and 2 reniform eyes. Mandibles heavy; second maxillary plate with 3 teeth. Parapodia each with a bluntly conical dorsal cirrus, rounded ventral cirrus and a broad setigerous lobe. Setae include capillaries, pectinate setae, composite falcigers and subacicular hooks. Acicula black with blunt tips. Subacicular hooks from setiger 22–25 onwards.

Habitat : Lives in soft mud in zone between MTL and LWM; salinity 21‰.

Distribution : Indian Ocean.

Genus *Marphysa* Quatrefages*Key to Species*

- 1 Composite spinigers absent *M. mossambica*
- Composite spinigers present 2
2. Prostomium bilobed; acicular setae bidentate, inferior setae composite spinigers only
..... *M. sanguinea*
- Prostomium rounded; acicular setae bidentate, inferior setae capillaries and composite
spinigers *Marphysa* sp.

41. *Marphysa mossambica* (Peters, 1854)

1854. *Eunice mossambica* Peters, *Akad. wiss. Berlin*, 1854 : 612.

Material : 3 exs., Jhingakhali, Sundarbans, 12.9.1983; 1 ex., Kachuberia, Sagar Island, 26.9.80; 1 ex., Gona, Sundarbans, 4.11.88; 2 exs., Parseymari, Sundarbans, 9.11.1988.

Diagnosis : Prostomium wider than long, with a deep anterior notch and 5 smooth occipital antennae. Parapodia of prebranchial setigers each with a small transverse fold-like presetal lobe, and a broadly rounded postsetal lobe; dorsal cirri long, stout, swollen basally and ventral cirri sort, bluntly conical. Parapodia of branchial setigers each with a well developed presetal lobe having distal notch, and a triangular postsetal lobe. Branchiae commencing from setiger 15–30 in smaller specimens, 45–50 in larger forms, extending up to posterior end, with a maximum of 10 filaments. Setae include capillaries and pectinate setae only.

Habitat : Lives in deep burrow in soft mud in the zone towards LWM; salinity varies from 5‰–12‰.

Distribution : Indo-west Pacific.

42. *Marphysa sanguinea* (Montagu, 1807)

1807. *Nereis sanguinea* Montagu, *Trans. Linn. Soc. Lond.*, 11 : 20, Table 3, fig. 1.

Material : 1 ex., Sandeskhali, Sundarbans, 14.3.1975; 1 ex., An 1471/1, Gangasagar, Sagar Island, 4.9.1979.

Diagnosis : Prostomium bilobed with 5 smooth and slender occipital antennae. Presetal lobes broad and rounded on anterior setigers. Conical on posterior setigers; postsetal lobes bluntly produced, ridgelike on anterior setigers, reducing in size posteriorly. Branchiae commencing from setiger 16, extending up to posterior end, with a maximum of 4 filaments.

Habitat : Lives in soft mud at LWM; salinity 12‰.

Distribution : Cosmopolitan.

43. *Marphysa* sp.

1984. *Marphysa macintoshi* – Misra *et al.*, *Rec. zool. Surv. India*, 81 : 48. Non crossland, 1903.

Material : 1 ex., An 1470/1, Mandirtala, Sagar Island, 30.7.1974. (as *Marphysa macintoshi* by Misra *et al.*, 1984).

Diagnosis : Prostomium broad, more or less rounded, formed by almost completely fused palps; antennae 5, soomth, as long as prostomium, median one longest reaching first setiger, outer lateral pair shortest. Eyes not visible. First peristomial segment twice as long as second.

Family LUMBRINERIDAE

Genus *Lumbrineris* Blainville, 1828

Key to Species

- 1 Dorsal cirri present 2
- Dorsal cirri absent 3
2. Dorsal cirri rudimentary; hooded hooks from setiger 20–40 *L. heteropoda*
- Dorsal cirri long, strap-like; hooded hooks from setiger 40–45 *L. notocirrata*
3. Postsetal lobes narrow, conical and longer than presetal lobes in posterior setigers. *L. polydesma*
- Postsetal lobes low, reduced and subequal to presetal lobes in posterior setigers *L. bilabiata* n. sp.

44. *Lumbrineris bilabiata*, Misra

Lumbrineris bilabiata Misra, in press

Material : Holotype—An 2277/1, Kakdwip, 25.8.1980; paratype—1 ex., An 2278/1, Kachuberia, 12.6.1977; 6 exs., An 2279/i Namkhana, 7.10.1982; 1 ex., An 2282/1, Gangasagar, 4.6.1983 ; 2 exs., An 2282/1, Bakkhali, 6.3.1985.

Diagnosis : Prostomium bluntly conical, basally wider than long. Parapodia each with a short crescent-shaped presetal lobe and a broad, auricular postsetal lobe. Middle and posterior parapodia with both pre- and postsetal lobes being low, reduced and more or less subequal—slightly produced in posteriormost setigers attaining a bi-labiate condition. Setae arranged in fan-shaped bundle and of 2 kinds; limbate setae and simple hooks.

Habitat : Lives in soft clayey soil, sometimes mixed with very fine sand in MTL; salinity 14‰ to 19‰.

Distribution : Endemic in east coast of India.

45. *Lumbrineris heteropoda* (Marenzeller, 1879)

1879. *Lumbriconereis heteropoda* Marenzeller, *Denkschr. Akad. Wiss., Wien*, 41(2) : 138, pl. 6, fig. 1.

Material : 10 exs., Bhangatushkhali, 14.3.1975.

Diagnosis : Prostomium conical. Anterior parapodia with presetal lobes low and rounded, and postsetal lobes long and conical. Posterior parapodia with postsetal lobes being much longer, sometimes erect. Postsetal lobes reduced to short processes in midbody region. Dorsal cirri rudimentary. Capillaries in anterior setigers, long-bladed simple hooded hooks appearing on setiger 20–40, extending up to the posterior end. Posterior setae short-bladed and sometimes with winged capillaries.

Distribution : Indo-Pacific.

46. *Lumbrineris notocirrata* (Fauvel, 1932)

1932. *Lumbriconereis notocirrata* Fauvel, *Mem. Indian Mus.*, 12 : 156, pl. 7, fig. 1–8, text fig. 23 a–d.

Material : 10 exs., Kachuberia, 12.6.1977; Several exs., Gangasagar, 28.2.1978; 3 exs., Canning, 17.11.1982; 1 ex., Sandeshkhali, Sundarbans, 30.5.1985.

Diagnosis : Prostomium bluntly conical without eyes, antennae or any appendages. Parapodia sub-biramous; notopodia represented by small dorsal cirri supported by acicula, compressed and button-shaped on anterior setigers, but longer and strap-like from setiger 15–17 onwards. Presetal lobes short and crescent-shaped in anterior setigers, being rounded in middle and posterior setigers. Postsetal lobes flattened and auricular in anterior setigers, being longer and erect posteriorly.

Habitat : Lives in mud in the zone between MTL and LWM; salinity varies from 14‰–20‰.

Distribution : Endemic in east coast of India.

47. *Lumbrineris polydesma* (Southern, 1921)

1921. *Lumbriconereis polydesma* Southern, *Mem. Indian Mus.*, 5 : 622, pl. 26, fig. 15 A-L

Material : 3 exs., Kakdwip, 28.6.1980; several exs., Naraharipur, 25.9.1980; 10 exs., Kakdwip canal, Kakdwip, 10.3.1981; 5 exs., Canning, 17.11.1982; 5 exs., Jhingakhali, 12.9.1983; 2 exs., Muriganga creek, Sagar Island, 5.6.1984, Coll. S. Chakraborty.

Diagnosis : Prostomium bluntly conical, without eyes or any appendages. Parapodia uniramous. Presetal lobes short and rounded throughout; postsetal lobes flat and wide in anterior and middle setigers, narrow and conical in posterior setigers. Setae of 2 kinds: limbate and simple hooks. Hooks appear on setiger 30-35.

Habitat : Lives in mud, sometimes admixed with fine sand in the zone between MTL and LWM; salinity varies from 5‰-12‰.

Distribution : Endemic in India.

Family ORBINIIDAE

Subfamily ORBINIINAE

Key to Genera

Thoracic neuropodia with crenulate capillaries only, no hooks
*Leitoscoloplos*.

Thoracic neuropodia with both crenulate capillaries and hooks
*Scoloplos*.

48. *Leitoscoloplos* sp.

Material : 1 ex., Gangasagar, Sagar Island, 22.3.1981.

Diagnosis : Prostomium long conical and pointed. Thorax rounded, abdomen compressed dorsoventrally. Thorax with 19 setigers; notopodia visible from setiger 1, each with a round postsetal lamella, prominent posteriorly; neuropodia as blunt acicular projections, each with an inferior round postsetal lamella. Foot-papillae or stomach-papillae absent. Abdominal notopodia large, digitiform. Interramal cirri absent. Abdominal neuropodia oval, notched externally with papilliform inner lobe; inferior border crenulated in posterior setigers. Branchiae in the form of simple, slender filaments from setiger 21, becoming broad and lamellar.

Habitat : Lives in fine silty sand towards LWM; salinity 18‰.

49. *Scoloplos (Scolopolos) sagarensis*, Misra

Scoloplos (Scolopolos) sagarensis Misra, in press

Material : Holotype-An 2283/1. Gangasagar, Sagar Island, 12.7.1983; paratypes—3 exs., An 2284/1, other data same as above.

Diagnosis : Prostomium conical, narrowly pointed; peristomial segment 1. Eye spots absent. Thoracic setigers 18; notopodia blunt, without any lamellae in anterior setigers, postsetal lamellae as slender, digitiform lobes after setiger 10. Thoracic neuropodia broad, rounded and each with a small blunt median foot-papilla. Stomach-papillae and interramal cirri absent. Branchiae in the form of slender, digitiform lobes, extending up to the posterior end. Abdominal setigers with stout and stumpy branchiae.

Habitat : Lives in fine sand mixed with silt at LWM; salinity 15‰.

Distribution : Endemic in India.

Family SPIONIDAE

Key to Genera

1. Setiger 5 with Strongly modified setae 2
 Setiger 5 without modified setae 3
2. Setae arranged in a horseshoe-shaped pattern on setiger 5 *Pseudopolydora*.
 Setae arranged in a straight line or in a small patch on setiger 5 *Polydora*.
3. Peristomium with lateral wings; branchiae all cirriform *Minuspio*.
 Peristomium without lateral wings; branchiae fused at least anteriorly with notopodial postsetal lobes *Spio*.

50. *Minuspio cirrifera* (Wire'n, 1883)

1883. *Prionospio cirrifera* Wire'n, *VEGA-Exped. vetensk. lakttag.*, 2 : 237, fig. 134 a-d, 146.

Material : 10 exs., (Taldi near canning), 28.4.1979, Coll. N. Sarangi.

Diagnosis : Prostomium round anteriorly and narrow posteriorly, extending back to setiger 2-3 as a narrow keel. Branchiae from setiger 2, 10-12 pairs, all cirriform. First parapodial postsetal lamella small, somewhat rounded, latter ones being larger and leaf-like. Notopodial lamellae triangular—gradually decreasing in midbranchial region, extending across the dorsum as low dorsal ridges in postbranchial region.

Habitat : Lives in soft silty sediments at the bottom of the brackishwater ponds; with variable salinity.

Distribution : Cosmopolitan.

Genus *Polydora**Key to Species*

Enlarged hooks of setiger 5 slightly curved ; posterior notosetae not modified.....*P. normalis*
 Enlarged hooks of setiger 5 straight ; posterior notosetae modified, densely spinulose.....*Polydora* sp.

51. *Polydora normalis* Day, 1957

1957. *Polydora normalis* Day, Ann. Natal Mus., 14 : 97, fig. 6 f-j.

Material : 5 exs., Namkhana, 7.10.1982; 12 exs., Canning, 17.11. 1982.

Diagnosis : Prostomium deeply notched anteriorly, caruncle extending up to setiger 4. Eyes absent. Branchiae commencing from setiger 7-9 as slender filaments, continuing nearly to the posterior end. Parapodia of first setiger each with reduced notopodium in the form of a papilla and a well-developed neuropodial lamella. Parapodia of succeeding setigers each with notopodium protecting as a broad acicular lobe, neuropodium having superior and inferior presetal lamellae and a median rounded postsetal lobe.

Habitat : Lives in soft tube embedded in mud at MTL; salinity varies from 5‰ to 8‰.

Distribution : Indian Ocean.

52. *Polydora* sp.

Material : 2 exs., Naraharipur, 23.7.1982.

Diagnosis : Prostomium rounded with a small bluntly pointed tip. Caruncle extending up to setiger 5. Eyes absent. Branchiae commencing from setiger 9 as slender filaments with blunt ends, continuing nearly to the posterior end, well separated from notopodial lobes. Parapodia of prebranchial setigers with erect and blunt notopodial postsetal lamellae and short, rounded neuropodial postsetal lamellae; presetal lamellae obscured in both rami. Parapodia of branchial setigers with reduced noto- and neuropodia.

Habitat : Lives in U-Shaped burrow in solid mud at MTL; salinity 13‰.

53. *Pseudopolydora kemp* (Southern, 1921)

1921. *Polydora (Carazzia) Kemp* Southern, Mem. Indian Mus., 5 : 636, pl. 28, fig. 20 A-J.

Diagnosis : Prostomium faintly notched anteriorly with a posterior occipital papilla. Eyes 2 pairs. First setiger without notosetae. Branchiae 10-11 pairs from setiger 7. Setiger 5 with

normal notopodial capillaries, double rows of specialised setae and normal neuropodial setae. Specialised setae include an anterior row of short bilimbate capillaries with broad wings tapering rapidly and a posterior row of stout, simple hooks with curved tips. Bidentate hooded hooks from neuropodium of setiger 8. No specialised notosetae in posterior setigers. Pygidium small and saucer-like.

Remarks : As the species has not been recorded during the present investigation, the diagnosis is based on earlier reports.

Distribution : Endemic in India.

54. *Spio bengalensis* Willey, 1908

1908. *Spio bengalensis* Willey, *Rec. Indian Mus.*, 2 (4) : 389 figs. 1-6.

Diagnosis : Prostomium slightly emarginate anteriorly, being narrow posteriorly, extending back to setiger 1 as a narrow keel. Eye 2 pairs. Branchiae 12-15 pairs, cirriform, last 2 or 3 pairs smaller than others. Postsetal lamellae broad and triangular in branchial region, decreasing in prominence and becoming very inconspicuous in postbranchial region. Notosetae capillaries throughout. Neurosetae capillaries anteriorly; bidentate hooded hooks from setiger 28 onwards; one sabre seta at inferior edge of each neuropodium from setiger 12 onwards.

Remarks : The present diagnosis is based on earlier report.

Distribution : Endemic in east coast of India.

Family FLABELLIGERIDAE

55. *Pherusa bengalensis* (Fauvel, 1932)

1932. *Stylarioides bengalensis* Fauvel, *Mem. Indian Mus.*, 12 : 180, fig. 30 a-f.

Diagnosis : Surface with globular papillae. Cephalic hood horseshoe-shaped with numerous slender, filiform branchial filaments. Notosetae all capillaries, very long and stout, beautifully iridescent on third setiger. Neurosetae capillaries on anterior 6-8 setigers, neuropodial hooks starting further back on setiger 7-9. Hooks with slightly curved, pointed tips, at first small and 1-2, later enlarged and about 4-5 per setiger.

Remarks : During the present investigation, the subtidal habitats were not surveyed and the species has not been found.

Distribution : Endemic in Indian waters.

Family CAPITELLIDAE

Key to Genera

1. Thorax with 9 segments; anterior asetigerous segment absent ***Capitella***.
- Thorax with 12 segments; anterior asetigerous segment 1 2
2. First 4 thoracic setigers with capillary setae only ***Parheteromastus***.
- More than 4 thoracic setigers with capillary setae 3
3. First 5-7 thoracic setigers with capillary setae only ***Barantolla***
- All thoracic setigers usually with capillary setae only..... ***Mastobranchus***.

56. *Barantolla sculpta* Southern, 1921

1921. *Barantolla sculpta* Southern, *Mem. Indian Mus.*, 5 : 643, pl.19, fig. 24.

Diagnosis : Body widest near segments 4-5, tapering backwards; first 4 segments tessellated. Prostomium conical, without eye spots. Pharynx eversible, covered with minute papillae. Thorax with 12 segments, first segment achaetous. Setae from second segment, with narrow-winged capillaries in both rami of segments 2-7; segments 8-12 with long-handled hooks only. Abdominal setae all short-hooded hooks. Branchiae in the form of short finger-shaped lobes, appearing on segments 55-70, continuing up to posterior end. Branchiate setigers each with a membranous collar, produced into 4 shallow parapodial lobes.

Remarks : The diagnosis is based on earlier report.

Distribution : Indo-west Pacific.

57. *Capitella capitata* (Fabricius, 1780)

1780. *Lunbricus capitatus* Fabricius, *Fauna Groenlandica*, ... observations. Hafniae, p. 279.

Diagnosis : Body very small, generally varies from 30 to 40 mm in length. Prostomium conical with a pair of ventral eyes. Thorax of 9 segments, with capillaries in both rami from segments 1-6; segment 7 variable, with capillaries only or hooks only or both. In females, segments 8-9 with hooks in both rami, but in males, genital hooks replace notosetae. Abdominal segments with long-shafted hooks in both rami.

Distribution : Cosmopolitan.

58. *Mastobranchus* sp. [cf. *indicus* southern, 1921]

Material : 4 exs., Kachuberia, 12.7.1977; 2 exs., Kakdwip canal, Kakdwip, 28.6.1980; 6 ex., Bhushighata, 12.8.1982; 10 exs., Bhushighata, 18.10.1982; 2 exs., Diamond Harbour, 12.3.1983; 5 exs., Haldia, 16.3.1983; 2 exs., Patikhali, Haldia, 18.3.1983; 2 exs., Gangasagar, 12.7.1983; 5 exs., Bakkhali, 7.3.1985.

Diagnosis : Body long, cylindrical, swollen anteriorly, tessellated for anterior 6-7 segments. Prostomium short, rounded without eyes or distinct lateral sense organs. Thorax with 12 segments, first segment achaetous. First setiger complete; all thoracic setigers with capillary setae only, occasionally the last thoracic neuropodia with mixed fascicle of capillary setae and hooded hooks. First 2 or 3 abdominal setigers transitional, with capillary notoseate and neuropodial hooded hooks; succeeding setigers with hooded hooks only; mixed fascicles of capillary setae and hooded hooks appear in any one of the first 3 abdominal notopodia.

59. *Parheteromastus tenuis* Monro, 1937

1937. *Parheteromastus tenuis* Monro, *Ann Mag. nat. Hist.* (Sr. 10), **19** : 536, fig. 2a-e.

Material : 10 exs., Gangasagar creek, Gangasagar, 15.6.1978; several exs., Muriganga creek, Sagar Island, 10.3.1979, 10 exs., 10.6.1984, Coll. S. Chakraborty; 5 exs., Namkhana, 6.10.1982; 6 exs., Bakkhali creek, Bakkhali, 7.3.1985.

Diagnosis : Worms thread like; dark red in life, pale brown in spirit. Prostomium bluntly conical, without eyes. Thorax with 12 segments, first segment achaetous; setigers 1-4 with short capillaries in both rami; setigers 5-11 with long-handled hooded hooks in both rami. Abdominal hooded hooks with shorter shafts than in thorax. Branchiae absent. Pygidium with a short, median anal cirrus.

Habitat : Lives in clayey soil in the zone between MTL and LWM; salinity varies from 5‰-24‰.

Distribution : Indo-west Pacific.

Family MALDANIDAE

Subfamily MALDANINAE

60. *Asychis gangeticus* Fauvel, 1932

1932. *Asychis gangeticus* Fauvel, *Mem. Indian Mus.* 12 : 206, pl. 8, figs. 1-9.

Diagnosis : Prostomium flattened, broadly rounded in front. Nuchal grooves transversely curved. Cephalic plate rounded, slanting with a membranous rim divided into 3 parts by deep lateral notches. Cephalic keel broad, long and depressed. Notosetae of 3 kinds: long and slightly bent winged setae, slender setae with barbed tips and very slender smooth capillary setae.

Neurosetae long-shafted hooks, absent in setiger 1; subsequent setigers with a row of hooks.

Remarks : The diagnosis is based on earlier report.

Distribution : Endemic in Hoogly estuary, India.

Family OWENIIDAE

Genus *Owenia* delle Chiaje, 1841

61. *Owenia fusiformis* delle Chiaje, 1841

1841. *Owenia fusiformis* delle Chiaje, Descrizione negli anni 1822-1830, p. 31.

Material : 20 ex., Naraharipur, 23.7.1982; 10 ex., Namkhana creek, Namkhana, 7.10.1982; 5 ex., Bakkhali, 6.3.185; 1 ex., Sibgunge, 11.8.1989, Coll. B.P. Haldar & Party.

Diagnosis : Prostomium fused to achaetous buccal projection mounted on a trilobed base. Thoracic region of 3 short setigers with capillary notosetae only. Abdomen slender, first 5 setigers much longer and the rest gradually decreasing in length. Abdominal notopodia with capillaries having sparsely spinulose blades; neurosetae with minute, long-shafted hooks having 2 recurved apical teeth.

Habitat : Lives in mud mixed with fine sand towards LWM; salinity varies from 5‰ to 12‰.

Distribution : Cosmopolitan.

Family STERNASPIDAE

62. *Sternaspis scutata* (Renier, 1807)

1807. *Echinorhynchus scutatus* Renier, *Tavole per....degli animali*, Padua, p. 34.

Material : 14 exs., Banamali Khal, Jharkhali, Sundarbans, 23.9.1984 ; Coll. B.P. Haldar & party.

Diagnosis : Body swollen at both ends. Anterior 6-7 segments form an introvert; prostomium small, papillose and often retracted into introvert. First three segments with lateral rows of falcate spines. Posterior end with a pair of rhomboidal shields having 14-16 bundles of capillary setae. Branchial filaments numerous, often rolled into spirals, arise posterotermally.

Habitat : Lives in silty mud or sand in the subtidal habitat; salinity 14‰.

Distribution : Cosmopolitan.

Family SABELLARIIDAE

Key to Species

Outer paleae with denticulate margin; central terminal spine slightly produced and finely dilated
 *S. pectinata*.

Fauvel outer paleae with smooth margin; central terminal spine elongated and much densely
 spinulose *S. alcocki* Gravier.

63. *Sabellaia pectinata* Fauvel, 1932

1932. *Sabellaria pectinata* var. *intermedia* Fauvel, *Mem. Indian Mus.*, 12 : 210, fig. 35.

Material : 25 exs., Naraharipur 25.9.1980; 20 exs., Namkhana, 6.10.1982; 15 exs., Harwood Point, Kakdwip 11.9.1977.

Diagnosis : Tube made of minute sand particles, fragile. Opercular crown formed of 3 rows of golden paleae. Outer paleae long, broad, flattened, slightly curved and denticulate, 15-18 on each side, gradually increasing in size to long, sharp 5-7 spines at distal ends ; central spine longer, finely ciliated on both sides. Middle paleae spoon-shaped, short and broad, 10-12 on each side. Inner paleae spoon-shaped, elongated, 12-15 on each side, with long and sharp tips directed inwards. Branchiae on anterior 4-5 abdominal segments.

Habitat : Lives in fragile sandy tube attached to any hard object in the zone between MTL and LWM; salinity varies from 5‰ to 12‰.

Distribution : Endemic in Hooghly-Matla estuary.

64. *Sabellaria alcocki* Gravier, 1906

1906. *Sabellaria alcocki* Gravier, *Bull. Mus. Hist. nat., Paris.*, 12 : 543.

Diagnosis : Small gregarious species. Operacular crown almost at right angle to body, with a deep dorsal notch between opercular lobes. Opercular crown formed of 3 rows of golden paleae. Outer paleae broad, with smooth margin, terminating in 5-7 slender teeth of which median one elongated and barbed. Middle paleae spoon-shaped, erect, alternately long and short. Inner paleae spoon-shaped, all of same size.

Remarks : The record of this species from the Gangetic delta (India) was made by Fauvel (1932). Subsequently, the species has been reported from other localities of south India. The present diagnosis is based on earlier literature.

Distribution : Indo-Pacific and Eastern Atlantic.

Family TERESELLIDAE

Subfamily AMPHITRITINAE

Key to Genera

Branchiae 3 pairs; thoracic setigers 17; long handled uncini absent*Loimia* .

Branchiae 2 pairs; thoracic setigers 15-25; long uncini long-handled, present in anterior setigers
.....:..... *Pista* .

Genus *Loimia* Malmgren, 186665. *Loimia medusa* (Savigny, 1818)

1818. *Terebella medusa* Savigny, *Historie naturelle des animaux sans Vertebres etc.*, p. 95.

Material : 2 exs., Gangasagar, Sagar Island, 22.3.81, 1 ex., 12.7.1983.

Diagnosis : Prostomium reduced; tentacular lobe short, collar-like with long tentacles on atero-ventral surface. Buccal segment with a large, rounded foliaceous lower lip. Segments 2 and 3 fused with a large foliaceous horizontal lateral lobe and a large united ventral pad. Branchiae 3 pairs on segments 2,3, and 4; with numerous filaments arranged dichotomously.

Habitat : Adults in rigid, U-shaped tubes coated with sand, with multiple openings, forming beds in fine sandy substratum at MTL. Young ones settle in sheltered areas, particularly in canals and creeks, forming more or less U-shaped tubes made of debris and attached to under-surface of hard substratum, such as bricks, stones, etc.; salinity varies from 15‰ to 21‰.

Distribution : Cosmopolitan in temperate and tropical waters.

66. *Pista typha* (Grube, 1878)

1878. *Terebella (Pista) typha* Grube, *Mem. Acad. Sci. S. Peterb.*, 25 : 232, pl. 12, fig. 4.

Diagnosis : Small tubicolous species. Branchiae 2 pairs on segments 2 and 3; branchial filaments arranged in whorls. Semicircular lateral lobes also on segments 2 and 3. Thoracic setigers 17. Uncini of the first segment with long, slender chitinised basal shafts, reducing in size afterwards. All uncini with strongly crested heads.

Remarks : The records of the species from India are all from the subtidal levels, though the depth of occurrence at Sandheads, mouth of the Hooghly river, is not known. The species has not been recorded during the present intertidal survey.

Distribution : Indo-west Pacific.

Family AMPHARETIDAE

Subfamily MELINNINAE

Genus *Isolda* Müller, 185867. *Isolda pulchella* Müller, 1858

1858. *Isolda pulchella* Müller, *Arch. naturg. Berlin*, 24(1) :219.

Material : 2 ex., Chhotahardi, Sundarbans, 10.11.88,

Diagnosis : Prostomium snout-like; buccal tentacles smooth, arise from a horizontal shelf in the roof of the mouth. Branchiae in 2 groups of 4, each united basally; inner 2 pairs with 2 rows of long lateral lamellae. Fine acicular neurosetae on segments 3 and 5 but not on 4; stout notopodial hooks on segment 4. Small notopodial capillaries on segment 5 and 6. Thirteen uncinigerous thoracic segments starting from segment 7.

Habitat : Lives in soft muddy tubes in compact clayey soil at MTL.

Distribution : Indo-west Pacific.

Family SABELLIDAE

Subfamily SABELLINAE

68. *Potamilla leptochaeta* Southern, 1921

1921. *Potamilla leptochaeta* Southern, *Mem. Indian Mus.*, 5 : 615, pl. 31, fig. 28 A-N.

Material : 3 exs., Bakkhali creek, Bakkhali, 4.10.1982; 5 exs., Namkhana, 6.10.1982; 4 exs., Canning, 18.11.1982; 5 exs., Jhingakhali, 14.9.1983.

Diagnosis : Tentacular crown with 7–9 pairs of radioles, each with 10–14 branchial filaments. Thoracic notosetae of 2 types : narrow-winged capillary setae having long filiform tips, and bayonet-shaped spatulate setae. Thoracic neurosetae include an anterior row of companion setae, and a posterior row of avicular uncini. Uncini without prominent anterobasal swellings and posterior processes. Abdominal notosetae include avicular uncini and neurosetae all capillaries.

Habitat : Lives in soft leathery tubes embedded in soft mud at MTL; salinity varies from 6‰-10‰.

Distribution : Indian ocean, with a single record from West Pacific.

Family SERPULIDAE

Subfamily SERPULINAE

69. *Ficopomatus macrodon* Southern, 1921

1921. *Ficopomatus macrodon* Southern, *Mem. Indian Mus.*, 5 : 655, pl. 30, fig. 27 A–M.

Material : 10 exs., Namkhana, 6.10.1982; 15 exs., Jhingakhali, 14.9.1983; 12 exs., Canning, 18.11.1982.

Diagnosis : Tube white, semicircular in cross section, with a single dorsal ridge. Operculum fleshy bulb, with conical horny cap, flat or convex apically. Branchial filaments borne on paired lobes, 13–16 in number, each with 18–20 pairs of pinnules. Collar setae of 2 types.

Habitat : Lives in calcareous tubes attached to hard substrates, viz., wood, concrete piles, bricks in zones towards LWM; salinity varies from 6‰ to 14‰.

Distribution : Indian Ocean, with a single record from west Pacific.

DISCUSSION

The species composition of the polychaete fauna in the Hugli–Matla estuary belonging to different families (Table 1) shows that the errantiate polychaetes are more abundant than the sedentarians. A list of the polychaete species now studied with records of their occurrence at different zones of the estuary (Table–2) is of considerable distributional significance. It may be mentioned here that Jhingran (1983) has divided the Hugli–Matla estuary into five zones based on salinity and other physical parameters of which, the Zone I or the upper Zone stretches from Nabadwip to Konnagar, the Zone II or Middle Zone stretches from Konnagar to Dimond Harbour, Zone III or lower Zone stretches from Diamond Harbour to mouth of the estuary and entire lower Sundarbans, Zone IV includes River Rupnarayan, and Zone V includes River Matla around Port Canning. An analysis of the Table 2 shows that a majority of these species are restricted to areas located at the lower reaches (Zone III), with the number of species gradually decreasing towards the upper reaches (Zones II & I). Of the total 69 species (including five Anonymous species) of polychaetes studied by the present author, so far, 53 species have been observed to be distributed in the Zone III. Of these, 18 species were recorded only from the mouth region of the estuary. It is well-known that the fluctuations of salinity in estuaries compel their colonizers with such severe problems that a decrease in species number with increased distance from the sea is almost a certainty. Gunter (1961) stated that the number of aquatic species increased from freshwater sector of an estuary to the salt water sector where marine organisms are able to invade and survive and this is particularly true with respect to the polychaete fauna of the Hugli–Matla estuary. Kinne (1966) contended that salinity was the ecological master factor affecting the distributional patterns of estuarine

organisms. This is a normal situation in the estuary, which can be compared to the abnormal situation following the adverse effects of pollution, resulting in a decrease in the number of species and an increase in the number of the individuals (Perkins, 1974). Thus, a much lower salinity or adverse effects of pollution may be followed by a decline in the abundance of even the species able to cope with adverse conditions. The situation in the Hugli–Matla estuary is complicated as both conditions of fluctuating salinity and pollution are prevailing there.

Hundred years back the brackish-water environment formed the immediate neighbouring areas around the metropolitan city of Calcutta and some of the polychaete species were described and recorded from around Calcutta. The places, viz., Chingrighata, Barantolla, Beliaghata, Salt Lakes (north and south) from where species like, *Eteone barantollae* Fauvel, *Neanthes chingrighattensis* (Fauvel), *Neanthes glandicinca* (Southern), *Namalycastis indica* (Southern), *Barantolla sculpta* Southern, *Mastobranchus indicus* Southern and *Pseudopolydora kempfi* (Southern) were described, are now engulfed within the expanded greater Calcutta. Those old environs are totally lost and the species recorded from these areas are no more available in the area perhaps because of radical changes in the environment under the impact of irrational urbanisation. Interestingly enough, four of the above-named seven species have not been recorded from the Hugli–Matla estuary during the present investigation.

The polychaete fauna of the Hugli–Matla estuary is dominated by the brackish-water components. The most commonly occurring brackish-water species are *Talehsapia annandalei*, *Dendronereides heteropoda*, *Dendronereis aestuarina*, *Ganganereis sootai*, *Namalycastis fauveli*, *Namalycastis indica*, *Neanthes chingrighattensis*, *Neanthes meggitti*, *Nephtys oligobranchia*, *Nephtys polybranchia*, *Lumbrineris polydesma* and *Mastobranchus* cf. *indicus*. Among them, *Dendronereides heteropoda*, *Namalycastis indica*, *Namalycastis fauveli*, *Neanthes meggitti*, *Nephtys oligobranchia* and *Nephtys polybranchia* have been found to be mostly confined to the upper and middle reaches (Zones I & II) of the estuary (Fig. 1) where freshwater condition prevail almost throughout the year. It is not always easy to differentiate the brackish-water component from the marine euryhaline one. However, depending on the occurrence and nature of distribution, species like *Gattyana fauveli*, *Gaudichaudius cimex*, *Diopatra cuprea*, *Owenia fusiformis*, *Loimia medusa* and most of the glycerid and goniadid species may be considered here as marine euryhaline component.

The increasing human population of the cities and towns along the banks of the Hugli river has resulted in an increase of sewage and waste products pouring into the estuary. According to an estimate given by Jhingran and Tripathi (1977), 92 km stretch of the Hugli river near Calcutta receives over 252 million gallons daily of liquid wastes from about 161 factories comprising textile and cotton mills, tanneries, paper and pulp mills, jute mills, distilleries, etc. and storm water and domestic sewage from the towns and cities situated on either side of the river. They have no doubt contributed to the fast deteriorating environment of this largest riverine system of the country. Any future work regarding the effects of pollution should, therefore, centre around the dominant organisms those are constant component of the macrobenthos of the estuary. The

dominant polychaetes of this region mentioned earlier comprise a significant percentage of the fauna in different parts of the estuary. Any adverse effects of pollution would drastically alter not only the macrobenthos, but also the other dependant organisms such as the bottom dwelling fishes. It was observed during the present investigation that the capitellid worm *Mastobranchus cf. indicus* Southern were typically found abundantly in areas affected with sewage pollution though recorded from several localities (Fig. 2). It is, therefore, important to investigate this species further to establish it as an indicator of pollution.

An analysis of the known distribution of the polychaete species of the Hugli–Matla estuarine complex shows that the area is greatly dominated by the species occurring in the Indian Ocean only. Twenty-six species show the aforesaid type of distribution, of which 20 species have been found to be endemic in the estuaries and seas around India. Out of the rest, 19 species are known from Indo–west Pacific and another two from Indo–Pacific regions. Further, one species each has been observed to be distributed in warm and tropical waters of the Globe, warm and tropical Atlantic and Indian Oceans, Indo-west Pacific & E. Atlantic, Indo-West Pacific & N. Atlantic, Indo-Pacific & N. Atlantic and Indo–Pacific & E. Atlantic. The remaining 11 species are found to be cosmopolitan in distribution.

Works on the brackish–water polychaete fauna of India have been systematically taken up in recent years. But such works throw little light on the distributional patterns of these worms. This is largely due to the fact that many of these areas were not adequately surveyed and studied. Hitherto, a limited number of brackish-water bodies, viz., Hugli–Matla, Godavari, Vellar, Chilka and Pulicat on the east coast and Mandovi–Zuary and Cochin backwater on the west coast of India, have fairly been surveyed. A total of nearly 167 species spreading over 97 genera and 38 families have so far been reported from the brackish-water bodies of India. An analysis of distributional records (Table 3) shows that the areas, in the order of the abundance of polychaete species, may be arranged as follows : Hugli–Matla (41.3%), Godavari (33.5%), Vellar (22.7%), Mandovi–Zuary (21%), Cochin backwater (19.2%), Pulicat (15%), Chilka (14%), Mahanadi (12%), Burhabalang (10.7%) and others (less than 10%). These analytical documents for polychaete species show somewhat restricted distribution (Fig. 3). This is evident from the fact that a total of 70 species are found to be restricted to individual brackish-water bodies of India, of which 18 species are known to be confined to Hugli–Matla estuary. However, only six species, viz., *Namalycastis indica*, *Nephtys oligobranchia*, *Nephtys polybranchia*, *Lumbrineris polydesma*, *Minuspio cirrifera*, and *Diopatra neapolitana* (*Diopatra cuprea*, possibly) appear to have a very wide range of distribution and occur in most of the brackish–water bodies of India (Fig. 4).

The distributional pattern of polychaete species in different brackish-water bodies of India, as discussed above, displays very little similarity. A comparison of the presence and absence of the polychaete species at Hugli–Matla and other brackish–water bodies of India shows a dissimilarity of about 83% with Burhabalang estuary (Orissa) and more than 90% with other zones. A similar type of variation in distributional pattern has also been observed in Australian estuaries (Hutchings and Murray, 1984). Moreover, the brackish–water polychaete fauna of India is markedly different

from that occurring elsewhere. Similarly, Estcourt (1967) observed a characteristic polychaete fauna of Heathcote estuary in New Zealand, differing completely from that of the other global regions. This is probably due to the fact that the estuarine polychaete are a very diverse group.

The most characteristic feature observed during the present investigation is the high diversity of the polychaete species particularly towards the mouth of the estuary. The possible reasons for the apparent richness of polychaete species in this estuarine complex is presented below. On the basis of physiological works, Panikkar (1951) concluded that osmoregulation is easier at high temperature and that, therefore, tropical brackish-waters are richer in species than the temperate ones. Since the fauna of the marine tropical region is richer than that of the marine temperate region, it is quite logical to conclude that a comparable rate of invasion of brackish-water is the probable cause of richness in respect of brackish-water fauna in the tropics than that in the temperate zone (Casper, 1967). Hutchinson (1967) surmised the possibility of the evolution of brackish-water species in isolated and gradually freshening seas. This later type of situation has been found in the Hugli–Matla estuary as well. While dealing with brackish-water animals of the Gangetic delta, it has been pointed out by Hora (1934) that “In times past, there can be but little doubt, that this region was actually a part of the Bay of Bengal and that with the gradual extension of the delta seawards the water of the rivers and lakes gradually becomes less and less salt, though the actual process must have been extremely slow. A certain number of marine species that had established themselves within the area during the early stages of the formation of the Delta would doubtless be able to acclimatise themselves to the gradually changing conditions and thus equally be able to persist in their original habitat and form a relict fauna” While studying the fauna of the Salt Lakes, Sewell (1934) stated, “It seems possible that one predisposing factor in the gradual penetration of marine forms into freshwater is to be found in the general conditions that prevail around the mouths of these large rivers in tropical or temperate areas. The continuous outflow of large quantities of fresh water into the sea, and especially into an area such as the Bay of Bengal which is surrounded by extensive coastal barriers on three sides, necessarily results in a very considerable lowering of the salinity of the surface water, especially at the head of the Bay, down to a depth of as much as 50 fathoms;” The marine fauna of the Bay of Bengal ‘*in situ*’ consequently has got the opportunity to acclimatise themselves to fluctuating salinity conditions, thereby making them fit for penetration into the river. Annandale (1922) concluded that “the Bay of Bengal with its low salinity and gradual changes from salt water to fresh is an exceptionally favourable starting point for an immigration into freshwater on the part of marine organisms” He further stressed the importance of the fresh- and brackish-water region as “a last refuge for many marine animals whose race in the sea was nearly done” A few species of the polychaetes such as *Namalycastis indica*, *N. fauveli* and *Neanthes meggitti* have nicely adapted themselves to live comfortably in freshwater areas of the estuary as well as in freshwater ponds, which corroborates Annandale’s (1922) statement.

TABLE 1. Numerical Analysis of Polychaete species from Hugli-Matla estuary compared with that of other brackish-water bodies of India.

Sr. No.	Family	No. of Species		Sr. No.	Family	No. of Species	
		Hugli-Matla	Brackish-water			Hugli-Matla	Brackish water
1	Polynoidae	4	6	19.	Orbiniidae	2	3
2.	Polydontidae	—	2	20.	Spionidae	5	15
3.	Sigalionidae	—	2	21	Megelonidae	—	1
4.	Pisionidae	—	2	22.	Trochochaetidae	—	1
5.	Amphinomidae	1	3	23.	Poecilochaetidae	—	2
6.	Phyllodocidae	3	8	24.	Chaetopteridae	—	1
7	Tomopteridae	—	1	25.	Cirratulidae	—	1
8.	Hesionidae	1	4	26.	Cossuridae	—	2
9.	Pilargidae	2	3	27	Flabelligeridae	1	1
10.	Talehsapiidae	1	1	28.	Ophelidae	—	1
11	Syllidae	—	2	29.	Sternaspidae	1	1
12.	Nereididae	16	38	30.	Capitellidae	4	8
13.	Nephtyidae	2	4	31	Maldanidae	1	3
14.	Glyceridae	4	6	32.	Oweniidae	1	2
15.	Goniadidae	2	2	33.	Sabellariidae	2	3
16.	Onuphidae	2	4	34.	Pectinariidae	—	2
17	Eunicidae	5	9	35.	Ampharetidae	1	3
18.	Lumbrineridae	4	8	36.	Terebellidae	2	6
				37	Sabellidae	1	3
				38.	Serpulidae	1	3
		46	105			20	62

TABLE 2. Distribution of macrobenthic Polychaete species along the Hugli-Matla estuary

	Naihati	Barrackpur	Bally Khal/Uttarpara	Falta	Nurpur/Raychak	Diamond Harbour	Haldia	Kakdwip	Namkhana	Bakkhali	Sagar Is./ Mouth of R. Hugli	Haldibari/ Chhotahardi	Geonkhali	Gadiara	Port Canning/Taldi	Bhusighara	Sandeshkhali/ Bhangatushkhali	Jingakhali Chhotomollakhali	Gosaba	Jharkhali	Kishorimohanpur	Earlier Record only
	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	XIII	XIV	XV	XVI	XVII	XVIII	XIX	XX	XXI	XXII
	ZONE I		ZONE II				ZONE III						ZONE IV		ZONE V							

Family Polynoidae

Subfamily Harmothoinae

1. *Lepidonotus tenuisetosus*

+ +

+

2. *Lepidonotus sp.*

+

Subfamily Lepidonotinae

3. *Gattyana fauveli*

+

4. *Gaudichaudius cimex*

+ +

Family Amphinomidae

5. *Chloeia parva*

+

Sandheads

Family Phyllodoceidae

6. *Anaitides maderensis*

+

+

+

7. *Eteone barantollae*

+

8. *Eteone ornata*

+

Sandheads

Family Hesionidae

9. *Hesione splendida*

+

Family Pilargidae

10. *Sigambra constricta*

+

11. *Sigatargis commensalis*

+

TABLE-2 (Contd.)

	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	XIII	XIV	XV	XVI	XVII	XVIII	XIX	XX	XXI	XXII
Family Talehsapiidae																						
12. <i>Talehsapia annandalei</i>								+	+			+			+			+				
Family Nereididae																						
Subfamily Nanereidinae																						
13. <i>Namalycastis fauveli</i>	+	+	+	+	+	+	+	+			+		+			+						
14. <i>Namalycastis indica</i>	+	+	+	+			+	+		+	+		+			+						
15. <i>Namalycastis meraukensis</i>				+									+									
Subfamily Nereidinae																						
16. <i>Ceratonereis burmensis</i>																						+
17. <i>Dendronereides gangetica</i>					+						+								+			
18. <i>Dendronereides heteropoda</i>		+	+	+	+	+	+	+		+			+		+	+						
19. <i>Dendroneries aestuarina</i>									+		+						+	+				
20. <i>Dendroneries dayi</i>								+		+					+		+					
21. <i>Ganganereis sootai</i>											+							+		+		
22. <i>Lycastonereis indica</i>								+								+						
23. <i>N. anthe. chingrighattensis</i>					+	+	+				+			+								
24. <i>Neanthes glandicincta</i>																						
25. <i>Neanthes meggitti</i>			+	+	+	+	+						+									Barantolla
26. <i>Perinereis cavifrons</i>								+														
27. <i>Perinereis cultrifera</i>											+											
28. <i>Perinereis nigropunctata</i>											+				+				+			
Family Nephtyidae																						
29. <i>Nephtys oligobranchia</i>		+	+																			
30. <i>Nephtys polybranchia</i>		+	+	+									+									

TABLE-2 (Contd.)

	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	XIII	XIV	XV	XVI	XVII	XVIII	XIX	XX	XXI	XXII
Family Glyceridae																						
31. <i>Glycera convoluta</i>											+											
32. <i>Glycera lancadivae</i>											+											
33. <i>Glycera rouxii</i>											+				+							
34. <i>Glycera tessellata</i>																						
Family Goniadidae																						
35. <i>Glycinde oligodon</i>									+													Sundarbans
36. <i>Goniada emerita</i>											+	+									+	
Family Onuphidae																						
37. <i>Diopatra cuprea</i>										+	+											
38. <i>Hyalinoecia tubicola</i>																						Sandheads
Family Eunicidae																						
39. <i>Eunice aphroditois</i>											+											
40. <i>Lysidice natalensis</i>											+											
41. <i>Marphysa mossambica</i>											+										+	
42. <i>Marphysa sanguinea</i>											+										+	
43. <i>Marphysa sp.</i>											+											
Family Lumbrineridae																						
44. <i>Lumbrineris bilabiata</i>								+	+		+											
45. <i>Lumbrineris heteropoda</i>																						+
46. <i>Lumbrineris notocirrata</i>											+				+							+
47. <i>Lumbrineris polydesma</i>								+			+				+							+
Family Orbinidae																						
48. <i>Leitoscoloplos sp.</i>											+											
49. <i>Scoloplos (Scoloplos) sagarensis</i>											+											
Family Spionidae																						
50. <i>Minuspio cirrifera</i>																						+

TABLE-2 (Contd.)

	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	XIII	XIV	XV	XVI	XVII	XVIII	XIX	XX	XXI	XXII
51. <i>Polydora normalis</i>									+						+							
52. <i>Polydora sp.</i>											+											
Family Goniadidae																						
53. <i>Pseudopolydora Kempf</i>															+							
54. <i>Spio bengalensis</i>																						Chingrighata
Family Flabelligeridae																						
55. <i>Pherusa bengalensis</i>											+											Sandheads
Family Capitellidae																						
56. <i>Barantolla sculpta</i>																						Barantolla
57. <i>Capitella capitata</i>																						Matla River
58. <i>Mastobranchus cf. indicus</i>						+	+	+		+	+					+						
59. <i>Perheromastus tenuis</i>										+	+	+										
Family Maldanidae																						
60. <i>Asychis gangeticus</i>												+										
Family Oweniidae																						
61. <i>Owenia fusiformis</i>										+	+	+										
Family Sternaspidae																						
62. <i>Sternaspis scutata</i>																						+
Family Sabellaridae																						
63. <i>Sabellaria pectinata</i>								+	+		+											
64. <i>Sabellaria alcocki</i>															+							Matla River
Family Terevellidae																						
65. <i>Loimia medusa</i>												+										Sandheads
66. <i>Pista typha</i>												+										
Family Ampharetidae																						
67. <i>Isolda pulchella</i>													+									
Family Sabellidae																						
68. <i>Poltamilla leptochaeta</i>										+	+				+				+			
Family Serpulidae																						
69. <i>Ficopomatus macrodon</i>										+					+							+

TABLE 3. Distribution of Polychaete species in brackish-water bodies of India.

	Hugli Matla estuary	Burhabalang estuary	Baitarani-Brahmani estuary	Mahanadi estuary	Chilka Lake	Godavari estuary	Vishakhapatnam backwater	Vellar estuary	Madras backwater	Pulicat Lake	Cochin backwater	Mandovi-Zuary estuary	Andaman backwater
	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	XIII

Family POLYNOIDAE

1. <i>Gattyana fauveli</i>	29												
2. <i>Gaudichaudius cimex</i>	4, 29, 6, 24	4, 28				10						19	
3. <i>Harmothoe indica</i>						10							
4. <i>Lepidonotus carinulatus</i>												19	
5. <i>Lepidonotus tenuisetosus</i>	4, 6, 29			14							17		
6. <i>Lepidonotus sp.</i>	29												
7. <i>Paralepidonotus ampulliferus</i>						10			27				

Family POLYDONTIDAE

8. <i>Panthalis oerstedii</i>						10, 22					19		
9. <i>Polydontes melanonotus</i>						22							

Family SIGALIONIDAE

10. <i>Sthenalepis japonica</i>								8					
11. <i>Sthenelais boa</i>						10					17	19	

TABLE-3 (Contd.)

	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	XIII
Family PISIONIDAE													
12. <i>Pisione complexa</i>										27			
13. <i>Pisionidens indica</i>								8		27			
Family AMPHINOMIDAE													
14. <i>Chloeia parva</i>	4,6	4,6										19	26
15. <i>Eurythoe complanata</i>												19	26
16. <i>Eurythoe parvecarunculata</i>				14	6								
Family PHYLLODOCIDAE													
17. <i>Anaitides madeirensis</i>	24,29		16							27			
18. <i>Eteone barantollae</i>	4,6,29		16										
19. <i>Eteone flava</i>		16											
20. <i>Eteone ornata</i>	4,6												
21. <i>Genetyllis gracilis</i>											17		
22. <i>Mystides southerni</i>						22,23							
23. <i>Phyllodoce malmgreni</i>								11					
24. <i>Phyllodoce tenuissima</i>						10,22					19		
Family TOMOPTERIDAE													
25. <i>Tomopteris elegans</i>								8					
Family HESIONIDAE													
26. <i>Hesione intertexta</i>								8		27			
27. <i>Hesione pantherina</i>				4,6	10						9,17		

TABLE-3 (Contd.)

	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	XIII
28. <i>Hesione splendida</i>	29					22							
29. <i>Leocrates claparedii</i>						22						19	
Family PILARGIDAE													
30. <i>Sigambra constricta</i>	29				3,6			8,11,12 20	5		17		
31. <i>Sigambra parva</i>						22							
32. <i>Sigatargis commensalis</i>	29												
Family TALEHSAPIIDAE													
33. <i>Talehsapia annandalei</i>	24,29		16										
Family SYLLIDAE													
34. <i>Langerhansia cornuta</i>											17		
35. <i>Typosyllis brachychaeta</i>												19	
Family NEREIDIDAE													
36. <i>Ceratonereis burmensis</i>	29					10						19	
37. <i>Ceratonereis costae</i>						22		12,20					
38. <i>Ceratonereis erythraeensis</i>						22							
39. <i>Ceratonereis mirabilis</i>												19	
40. <i>Dendronereides gangetica</i>	29												
41. <i>Dendronereides heteropoda</i>	3,4,6,29	16,28											
42. <i>Dendronereides zululandica</i>						2	3					1	9
43. <i>Dendronereides aestuarina</i>	3,4,6,24 29						10	8			9,13,17		
44. <i>Dendronereis arborifera</i>			16			10,22						19	

TABLE-3 (Contd.)

	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	XIII
45. <i>Dendronereis dayi</i>	29						6						
46. <i>Ganganereis sootai</i>	29												
47. <i>Leonnates persica</i>			16										
48. <i>Lycastonereis indica</i>	29		21										
49. <i>Namalycastis fauveli</i>	29		21										
50. <i>Namalycastis indica</i>	3,4,6, 24 29			14	6,28	22		8	5	27	3,13,17		26
51. <i>Namalycastis meraukensis</i>	29												
52. <i>Neanthes capensis</i>						22						19	
53. <i>Neanthes chilkaensis</i>					3,4 6,28				5	27			
54. <i>Neanthes chingrighattensis</i>	4,6,24,29	16											
55. <i>Neanthes glandicineta</i>	3, 4, 6			1 4			6		5				
56. <i>Neanthes indica</i>				1 4								1 9	
57. <i>Neanthes meggitti</i>	15,29												
58. <i>Neanthes operata</i>				1 4									
59. <i>Neanthes reducta</i>					3, 6								
60. <i>Neanthes succinea</i>				1 4									
61. <i>Nereis persica</i>												1 9	
62. <i>Nereis lamellosa</i>						2 2							
63. <i>Nectoneanthes ijimai</i>						22,23							
64. <i>Perinereis aibuhitensis</i>				1 4								1 9	
65. <i>Perinereis cavifrons</i>	4,6,29										9		

TABLE-3 (Contd.)

	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	XIII
66. <i>Perinereis cultrifera</i>	24,29			14									
67. <i>Perinereis nigropunctata</i>	24,29			14	3,6							19	26
68. <i>Perinereis nuntia</i>		4										19	
69. <i>Perinereis vancaurica</i>				14									26
70. <i>Tylonereis bogoyawlenski</i>	28							11					
71. <i>Tylonereis fauveli</i>					3,6			8,20		27			
Family NEPHYIDAE													
72. <i>Nephtys dibranchis</i>							10						
73. <i>Nephtys dussumeri</i>												25	
74. <i>Nephtys oligobranchia</i>	4,6,24,29	28	16		3,6	22	6					3,6,17	
75. <i>Nephtys polybranchia</i>	4,6,29				3			8,11	5			13,17	
Family GLYCERIDAE													
76. <i>Glycera convoluta</i>	29					22		8,11,20		27		3,6,9 13,17	19,25
77. <i>Glycera lancadivae</i>	24,29	28				22							
78. <i>Glycera longipinnis</i>						10,22						17	19
79. <i>Glycera rauxii</i>	24,29	4						11					
80. <i>Glycera tessellata</i>	4,6,29	28				22							
Family GONIADIDAE													
81. <i>Glycinde oligodon</i>	29				36	22		11					
82. <i>Goniada emerita</i>	24,29												
Family ONUPHIDAE													
83. <i>Diopatra cuprea</i>	4,6,24,29	28			3								

TABLE-3 (Contd.)

	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	XIII
84. <i>Diopatra neapolitana</i>		4,16				10,22		8,11, 12,20	5,7	27	9,17	19,25	
85. <i>Hyalinoecia tubicola</i>	4												
86. <i>Onuphis eremita</i>								8	7				
Family EUNICIDAE													
87. <i>Eunice aphroditois</i>	4,6,24												26
88. <i>Eunice gracilis</i>						10							
89. <i>Eunice savigny</i>						10							
90. <i>Eunice tubifex</i>						10							
91. <i>Lysidice natalensis</i>	24,29												
92. <i>Marphysa gravely</i>					3,6	10		8	5,6,7	27	9,17		
93. <i>Marphysa macintoshi</i>				14									
94. <i>Marphysa mossambica</i>	4,24,29			14								19	26
95. <i>Marphysa sanguinea</i>	24,29										17	19	
96. <i>Marphysa sp.</i>	24,29												
Family LUMBRINERIDAE													
97. <i>Lumbrineris bilabiata</i>	29												
98. <i>Lumbrineris heteropoda</i>	4,24					10,22						19	
99. <i>Lumbrineris latreilli</i>											17		
100. <i>Lumbrineris notocirrata</i>	24,29						4,6						
101. <i>Lumbrineris polydesma</i>	24,29	16,28			3,6			8, 20	5	27			

TABLE-3 (Contd.)

	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	XIII
102. <i>Lumbrineris pseudobifilaris</i>						10						19	
103.. <i>Lumbrineris simplex</i>					3,6			8		27	9,17		
104. <i>Lumbrineris sphaerocephala</i>												25	
Family ORBINIIDAE													
105. <i>Leitoscoloplos kerkulensis</i>							6						
106. <i>Leitoscoloplos sp.</i>	29												
107. <i>Scoloplos (Scoloplos) Sagarensis</i>	29												
108. <i>Scoloplos marsupialis</i>					3,6			20				25	
Family SPIONIDAE													
109. <i>Malacoceros (Malacoceros) indicus</i>					28			20					
110. <i>Minuspio cirriferu</i>	24					10,12	6	12	5		17	19	
111. <i>Minuspio cirrobranchiata</i>						22							
112. <i>Minuspio polybranchiata</i>								8			13,17		
113. <i>Polydora ciliata</i>		4	16,28						5	27			
114. <i>Polydora hornelli</i>					3,6								
115. <i>Polydora normalis</i>	29												
116. <i>Polydora sp.</i>	29												
117. <i>Prionospio krusadiensis</i>						22				27			
118. <i>Prionospio saldhana</i>						22,23							
119. <i>Pseudopolydora kempi</i>	3,4,6					22			5		17		

TABLE-3 (Contd.)

	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	XIII
120. <i>Paraprionospio pinnata</i>						10,12	6				13,17	19,25	
121. <i>Scolecopsis squamata</i>							6	8,11,20		27		25	
122. <i>Scolecopsis indica</i>							6		5				
123. <i>Spio bengalensis</i>	2							8					
Family MAGELONIDAE													
124. <i>Magelona cincta</i>						22							
Family TROCHOCHAETIDAE													
125. <i>Trochochaeta orissae</i>											17		
Family POECILOCHAETIDAE													
126. <i>Poecilochaeta serpens</i>								20					
127. <i>Poecilochaeta johnsoni</i>						18							
Family CHAETOPTERIDAE													
128. <i>Phyllochaetopterus socialis</i>	4												
Family CIRRATULIDAE													
129. <i>Tharyx multifilis</i>			16										
Family COSSURIDAE													
130. <i>Cossura costa</i>						22					17		
131. <i>Cossura delta</i>								8,12					
Family FLABELLIGERIDAE													
132. <i>Pherusa bengalensis</i>	4,6												
Family OPHELIDAE													
133. <i>Ophelina acuminata</i>								12					

TABLE-3 (Contd.)

	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	XIII
Family STERNASPIDAE													
134. <i>Sternaspis scutata</i>					3,6	10,12		12			17		
Family CAPITELLIDAE													
135.. <i>Barantola sculpta</i>	3,4,6									27			
136. <i>Branchiocapitella singularis</i>								8		27			
137. <i>Capitella capitata</i>	1						14a						
138. <i>Dasybranchus caudacus</i>						22							
139. <i>Heteromastus similis</i>					3,6	22	6	8,12 20	5	27			
140: <i>Mastobranchus cf. indicus</i>	3,6,29							8					
141. <i>Parheteromastus tenuis</i>	29							8			17		
142. <i>Pulliella armata</i>						22							
Family MALDANIDAE													
143. <i>Asychis gangeticus</i>	4,6												
144. <i>Euclymene annandalei</i>					3,6	10		8,12 20				25	
145. <i>Euclymene insecta</i>									7	27			
Family OWENIIDAE													
146. <i>Myriochele picta</i>					3,6								
147. <i>Owenia fusiformis</i>	29												

TABLE-3 (Contd.)

	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	XIII
Family SABELLARIIDAE													
148. <i>Sabellaria cementarium</i>											17	19	
149. <i>Sabellaria pectinata</i> <i>intermedia</i>	4,6,24, 29												
150. <i>Sabellaria alcocki</i>	4,6												
Family PECTINARIIDAE													
151. <i>Pectinaria crassa</i>								8			6		
152. <i>Pectinaria (Lagis) abranchiata</i>											6		
Family AMPHARETIDAE													
153. <i>Amphicteis gunneri</i>						22, 23				27			
154. <i>Isolda pulchella</i>	29					22							
155. <i>Melina aberrans</i>							6	11					
Family TERESELLIDAE													
156. <i>Laonice socialis</i>		28											
157. <i>Loimia medusa</i>	24,29	28				10			7		17		
158. <i>Pista typha</i>	4,6												
159. <i>Eupolymnia nebulosa</i>						10							
160. <i>Terebella ehrenbergi</i>						10						19	
161. <i>Terebellides stroemi</i>						10							
Family SABELLIDAE													
162. <i>Laonome indica</i>					3,6								
								8,12 20	5	27			

TABLE-3 (Contd.)

	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	XIII
163. <i>Manayunkia spongicola</i>					3,6								
164. <i>Potamilla leptochaeta</i>	3,4,6 29						6		5	27			
Family SERPULIDAE													
165. <i>Ficopomatus macrodon</i>	4,6,29										3,6,9 17		
166. <i>Ficopomatus enigmaticus</i> ?							8				17	19	
167. <i>Hydroides norvegica</i>									5	27			

? Doubtful record. 1. Stephenson (1908) ; 2. Willey (1908) ; 3. Southern (1921) ; 4. Fauvel (1932); 5. Panikkar & Aiyar (1937); 6. Fauvel (1953) ; 7. Karishnamoorthi (1963) ; 8. Balasubrahmanyam (1964) ; 9. Cheriyan (1966); 10. Radhakrishna & Ganapati (1968) ; II. McIntyre (1968) ; 12. Ajmalkhan *et al.* (1972) ; 13. Kurian *et al.* (1975) ; 14. Julka & Rao (1976) ; 14a. Ganapati & Raman (1976) ; 15. Rao (1977) ; 16. Soota & Rao (1977); 17. Gopalkrishna Pillai (1978); 18. Srinivasa Rao & Sarma (1978) ; 19. Parulekar *et al.* (1980) ; 20. Srikrishnadhas *et al.* (1981) 21. Rao (1981) ; 22. Srinivasa Rao & Rama Sarma (1981) ; 23. Srinivasa Rao & Rama Sarma (1983) ; 24. Misra *et al.* (1984) ; 25. Harakantra & Parulekar (1984) ; 26. Das (1985) ; 27. Sunder Raj & Sanjeeva Raj (1987) ; 28 Misra *et al.* (1987) ; 29. Misra (in press).

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THE STRUCTURE AND DYNAMICS OF PLANKTONIC COPEPODS

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INTRODUCTION

The importance of copepods in the trophic dynamics of estuarine ecosystems is well known as they constitute nearly two-third of total zooplankton number and biomass throughout the year. They form the food of both larvae and adults of many commercially important estuarine and coastal water fishes whose abundance in a particular area has been directly related to the availability of either a particular species or assemblage of few copepod species. These copepod fauna of the estuarine systems consist of both, marine and freshwater forms, in addition to the 'resident species'. It appears that copepods as a group have well adapted to quickly changing conditions of the estuaries, specially to varying level of salinity, both during different seasons and at different places.

In spite of their great importance, not much work has been done on the structure and dynamics of tropical copepods as compared to enormous amount of work done in temperate regions. Earlier works on the copepods of estuarine and coastal waters of India include the taxonomic treatment by Sewell (1924) from Chilka lake, Sewell (1934) from Salt Lake, Calcutta, and Kiefer (1928, 1937), Lindberg (1940, 1947 and 1950) and Brehm (1953) from various coastal waters. Later on Chacko *et. al.* (1953) and Krishnaswamy (1953) from brackishwaters of Madras, George (1958), Pillai (1971) and Madhupratap (1978) from Kerala backwaters and Goswami (1972) and Goswami and Selvakumar (1971) from the estuaries of Goa have also dealt with several aspects of taxonomy and ecology of copepods. From Hugli–Matla estuarine system, general plankton studies were carried out by Datta *et. al.* (1954) and Shetty *et. al.* (1961) where very little information has been given on copepods. Recently, Bhunia and Choudhury (1981) and Baidya and Choudhury (1985) reported the occurrence and abundance of copepods and their relationship with some environmental factors from a limited area in the lower zone of Hugli estuary around Sagar island. As a result, there exists a great lacuna in the knowledge of copepod structure and dynamics of this ecosystem. The present paper, which is a part of the detailed investigations carried out on the biology and ecology of Hugli–Matla estuarine system, makes an attempt in this direction. The composition of copepod species, their occurrence, abundance, spatio-temporal variations and relationship with the most important environmental factor, the salinity, have been reported here.

MATERIALS AND METHODS

The studies were carried out from the entire tidal stretch of the Hugli estuary from its upper most region to the mouth in Bay of Bengal and Matla estuary below Canning, in the State of West Bengal, India (Fig. 1). The details have already been described (Khan 1993) The sampling was done

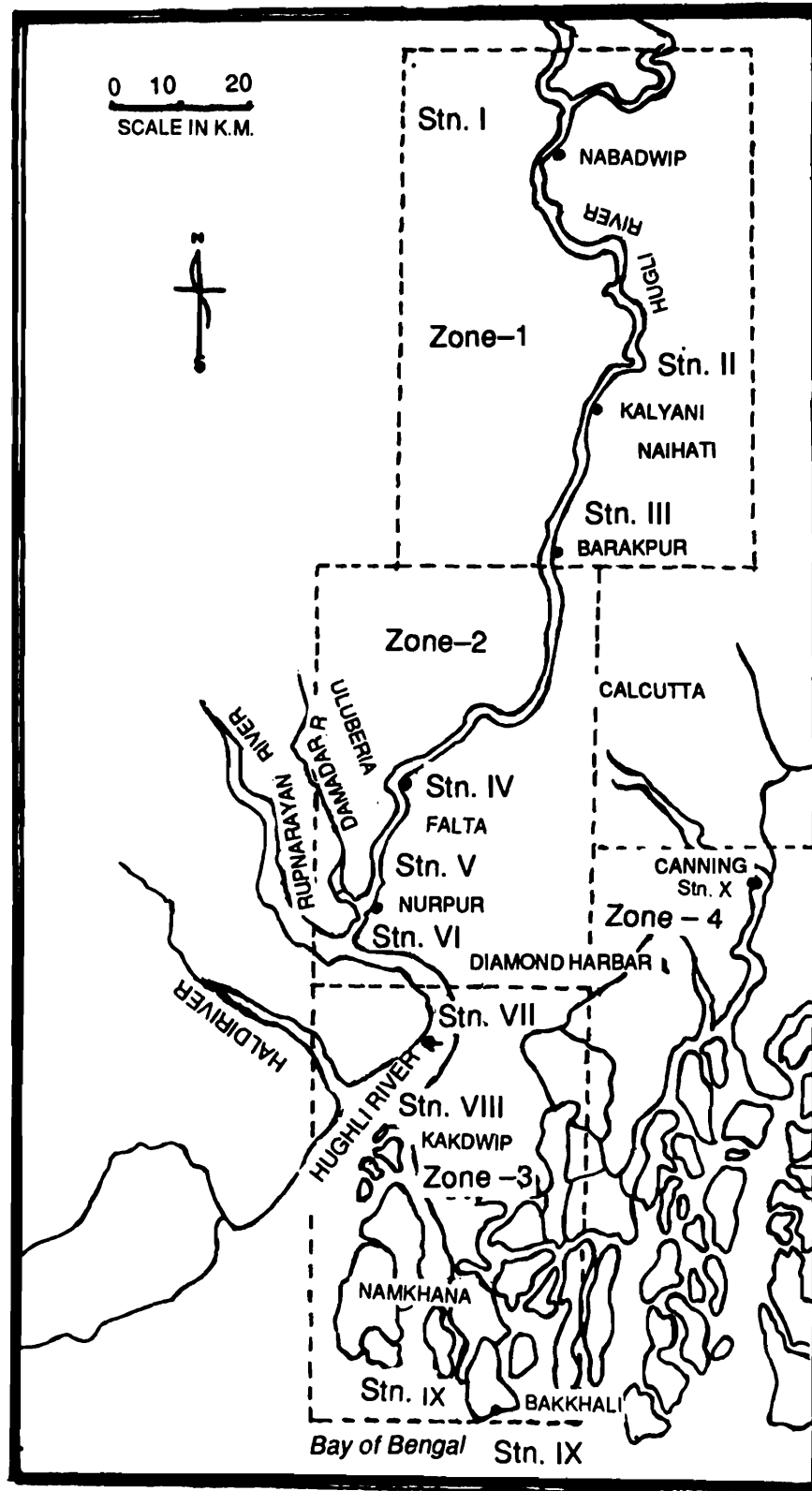


Fig-1: (Map of Hugli-Matla Estuarine Region showing different Zones and stations.)

seasonally from all the nine stations of Hugli estuary, covering Zones 1, 2, and 3 and on monthly basis from station X in Zone 4 at Matla estuary, between the period 1986-91 and the consolidated results are reported here. As already described, Zone-1 represented the freshwater, Zone-2, brackish water and Zone-3, the marine water of main river Hugli and Zone-4 marine water of Matla. Qualitative zooplankton samples were collected by placing the plankton net made of No. 25 bolting nylon against the current, both during low and high tides, for about 10 minutes. Samples for quantitative estimations were collected by filtering 200-300 liters of water through the net. Samples were preserved in 4% formaldehyde. Identification and enumeration was done as described earlier. Taxonomic characters followed were mainly those of Sewell (1924) and Kasturirangan (1963).

RESULTS

A. *Species composition and variations :*

Alltogether forty species of copepods belonging to 3 suborders, Calanoida, Cyclopoida and Herpeticoida were recorded from different zones of the estuarine system. The calanoids were by far the most important group and were represented by 31 species belonging to 17 genera and 11 families. The diversity of both, herpeticoids and cyclopoids was low. While the former was represented by only three species, each belonging to separate genera and families, the latter was composed of six species belonging to six genera and four families. The classified list of the recorded species is given below :

Order : COPEPODA

Suborder : CALANOIDA

Family : CALANIDAE

Canthocalanus pauper (Giesbrecht, 1892.)

Family : EUCALANIDAE

Eucalanus elongatus (Dana, 1862.)

Eucalanus subcrassus Giesbrecht, 1892.

Family : PARACALANIDAE

Paracalanus dubia Sewell, 1912.

Paracalanus parvus Giesbrecht 1892.

Acrocalanus similis Sewell, 1914.

Acarocalanus intermis Sewell, 1912.

Family : EUCHAETIDAE

Euchaeta marina Prestandrea (Giesbrecht, 1892).

Family CENTROPAGIDAE

Centropages dorsipinatus Thompson & Scott, 1903.

Centropages alcocki Sewell, 1912.

Family DIAPTOMIDAE

Phyllodiaptomus blanci (di Guerne, 1896)

Heliodiaptomus cinctus (Gurney, 1907)

Heliodiaptomus contortus (Gurney, 1907)

Haliodiaptomus viduus (Gurney, 1907)

Neodiaptomus strigilipes (Gurney, 1907)

Family : PSEUDODIAPTOMIDAE

Pseudodiaptomus serricaudatus (T. Scott, 1894)

Pseudodiaptomus annandalei Sewell, 1919

Pseudodiaptomus binghami Sewell, 1912

Pseudodiaptomus aurivilli Cleve, 1901

Pseudodiaptomus tollingeriae Sewell, 1919

Family : TEMORIDAE

Temora turbinata (Dana, 1952)

Family : PONTELLIDAE

Calanopia elliptica (Dana, 1952)

Lapidocera acuta (Dana, 1852)

Lapidocera minuta Geisbrecht, 1892

Lapidocera pectinata Thompson & Scott, 1903

Pontella andersoni Sewell, 1912

Family : ACRATIIDAE

Acartia (Odontacartia) spinicauda Geisbrecht, 1892

Acartia (Odontacartia) erythraea Geisbrecht, 1892

Acartia (Odontacartia) centrura Geisbrecht, 1892

Acartiella sewelli Steuer, 1934

Family : TORTANIDAE

Tortanus gracilis (Brady, 1883)

Suborder : HARPACTICOIDA

Family : ECTINOSOMIDAE

Microsetella rosea (Dana, 1852)

Family : MACROSETELLIDAE

Macrosetella gracilis (Dana, 1852)

Family : TACHIDIICAE

Euterpina acutifrons (Dana, 1852)

Suborder : CYCLOPOIDA

Family : OITHONIDAE

Oithona brevicornis Giesbrecht, 1892

Family : ONCAEIDAE

Oneaea venusta Phillipi, 1843

Family : CORYCAEIDAE

Corycaeus danae, Giesbrecht, 1892

Family : CYCLOPIDAE

Cyclops Veridus Jurine 1826

Mesocyclops leuckarti (Claus) 1857

Thermocyclops hyalinus (Rehberg)

Table 1 shows the occurrence and distribution of various copepod species in different seasons and zones of entire estuarine system. It is clearly evident that while a large number of species were recorded from Zone-2 (Brackish) and Zones 3 & 4 (marine), only few species occurred in Zone-1 (freshwater), where altogether 10 species, seven of calanoids and three of cyclopoids

TABLE - 1

DISTRIBUTION OF COPEPODS IN DIFFERENT
ZONES OF HUGLY-MATLA ESTUARINE
SYSTEM

Species	ZONE - 1			ZONE - 2			ZONE - 3			ZONE - 4		
	PRM	M	POM	PRM	M	POM	PRM	M	POM	PRM	M	POM
<i>Canthocalanus Pauper</i>	-	-	-	-	-	-	x	-	x	x	-	x
<i>Eucalanus elongatus</i>	-	-	-	x	-	-	x	-	x	x	-	-
<i>E. subcrassus</i>	-	-	-	-	-	-	x	-	x	x	-	-
<i>Peracalanus dubia</i>	-	-	-	x	-	x	x	x	x	x	-	x
<i>P. parvus</i>	-	-	-	x	-	-	-	-	x	-	-	x
<i>Acrocalanus similis</i>	-	-	-	x	-	-	x	-	-	x	-	-
<i>A. intermis</i>	x	x	x	x	x	x	x	x	x	-	x	x
<i>Euchaeta marina</i>	-	-	-	-	-	-	x	x	x	x	-	x
<i>Centropages dorsipinatus</i>	-	-	-	-	-	-	x	-	x	x	-	x
<i>C. alcocki</i>	-	-	-	x	x	x	-	x	-	x	x	-
<i>Phyllodiaptomus blanci</i>	x	x	x	-	-	-	-	-	-	-	-	-
<i>Heliodiaptomus cinctus</i>	x	x	x	-	x	x	-	-	-	-	-	-
<i>H. contortus</i>	x	x	x	-	-	-	-	-	-	-	-	-
<i>H. viduus</i>	x	x	x	-	-	-	-	-	-	-	-	-
<i>Neodiaptomus strigilipis</i>	x	x	x	-	-	-	-	-	-	-	-	-
<i>Pseudodiaptomus serricaudatus</i>	-	-	-	-	-	-	x	x	x	x	x	x
<i>P. annandalei</i>	-	-	-	x	x	x	-	x	x	-	x	x
<i>P. binghami</i>	-	-	-	x	x	x	-	x	-	-	x	-
<i>P. aurivilli</i>	-	-	-	x	-	x	x	-	x	x	-	-
<i>P. tollingerae</i>	x	-	x	x	x	x	x	x	x	-	-	-
<i>Temora turbinata</i>	-	-	-	x	-	x	x	x	x	x	x	x
<i>Calanapia elliptica</i>	-	-	-	-	-	-	x	-	x	x	x	x
<i>Lapidocera acuta</i>	-	-	-	-	-	-	x	-	x	x	x	x
<i>L. minuta</i>	-	-	-	-	-	-	x	-	x	-	-	-
<i>L. pectinata</i>	-	-	-	x	-	x	x	-	-	x	-	x
<i>Pontella andersoni</i>	-	-	-	-	-	-	x	-	-	x	-	x
<i>Acartia spinicauda</i>	-	-	-	x	-	-	-	x	x	x	x	x
<i>A. erythraea</i>	-	-	-	-	-	-	x	x	x	x	x	x
<i>A. centrura</i>	-	-	-	x	-	x	-	-	-	-	-	-
<i>Acartiella Sewelli</i>	x	-	-	x	-	x	-	-	-	-	-	-
<i>Tortanus gracilis</i>	-	-	-	-	-	x	x	x	x	x	x	x
<i>Microsetella rosea</i>	-	-	-	x	-	x	x	x	x	-	-	x
<i>Macrosetella gracilis</i>	-	-	-	-	-	-	x	-	x	x	-	x
<i>Euterpina acutifrons</i>	-	-	-	x	-	x	x	x	x	x	x	x
<i>Oithona brevicornis</i>	-	-	-	x	x	x	-	x	-	x	x	-
<i>Oncaea venusta</i>	-	-	-	-	-	x	x	x	x	x	x	x
<i>Corycaeus danae</i>	-	-	-	-	-	x	-	x	x	x	x	x
<i>Cyclops viridis</i>	x	x	x	-	x	-	-	-	-	-	-	-
<i>Mesocyclops leuckarti</i>	x	x	x	-	-	-	-	-	-	-	-	-
<i>Thermocyclops hyalinus</i>	x	x	x	-	-	-	-	-	-	-	-	-

x present - absent

PRM—Premonsoon, M—monsoon, POM—postmonsoon

formed the total copepod population. Out of this, six were exclusively confined to freshwater and four were common to both, Zones 1 and 2. Maximum number of species were recorded from Zone-2 which comprised seven resident species, 16 species common to Zones 2, 3 and 4 and four species common to Zones 1 and 2. A large number of species were also recorded from marine Zones 3 & 4, which in addition to abovestated 16 species of brackish-marine nature, also contained eight exclusively marine species. Not much differences were noticed in the qualitative composition of the species between Zones 3 & 4. Species diversity was lowest in Zone-1 and highest in Zone-3.

Maximum number of species belonged to Calanoida which were represented by 11 families. Species of the family Centropagidae were predominately marine, collected mainly from Zones 3 & 4. Diaptomids were basically freshwater group recorded mainly from Zone-1 and also Zone-2 during low salinity periods. *Pseudodiaptomus* were mostly confined to brackishwater Zone-2, having wide range of salinity tolerance. Out of five species recorded, only one (*P. tollingeriae*) ventured into freshwater and other (*P. annandalei*) into marine waters of Zones 3 and 4. The family Calanidae was represented by only one species, *Canthocalanus pauper* which was confined to marine Zones 3 & 4. The members of the family Eucalanidae, also basically marine, were represented by two species only. While *Eucalanus subcrassus* remained confined to marine Zones 3 & 4, the other one *Eucalanus elongatus* was also recorded from Zone-2 during comparatively higher salinity period. The members of the family Paracalanidae, represented by six species, were characteristic of brackishwater Zone-2, with few species entering into marine waters. Family Temoridae recorded its presence by one species, *Temora turbinata* from Zones-2, 3 & 4. Family Pontellidae was basically comprised of marine species with few species entering brackishwater Zone-2 during comparatively higher salinity period. Acartiidae was again a dominant group of brackish water Zone-2 with several species moving to and from marine waters. *Acartiella sewelli* was the species with wider distribution, also occurring in freshwater Zone-1 during premonsoon season. *Acartia spinicauda* was the most common species and occurred in all zones except Zone-1. *Euchaeta marina* was the single species representing family Euchaetidae and was restricted to Zones 3 & 4. Similarly, Tartanidae was also represented by single marine species, *Tartanus gracilis*.

The herpetocoids were both, qualitatively and quantitatively of little importance to planktonic copepods. They were represented altogether by three species belonging to three different families—The family Ectinosomidae included the species *Macrosetella rosea* from lower zones, Family Microsetillidae was represented by the species *Microsetella gracilis* from brackish and marine zones and Family Tachidiidae by *Euterpina acutifrons*, both from marine and brackish waters. The species diversity of Cyclopoida was also very low. Out of the six species recorded, three were exclusive residents of freshwater Zone-1. The other three, viz., *Oithona brevicornis* (Family Oithonidae), *Oncaea venusta* (family Oncaeidae) and *Corycaeus danae* (family Corycaeidae) were abundant mainly in brackish water zone and also marine waters during low salinity periods. The freshwater species *Mesocyclops leuckarti*, *Thermocyclope hyalinus* and *Cyclops viridis* constituted the main species of Zone-1.

B. Seasonal cycle of total copepod population :

Copepods comprised the bulk of total zooplankton fauna throughout the year in the entire estuarine system. The seasonal variations in total zooplankton and copepod numbers have been shown in Fig. 2. The contribution of copepods to total zooplankton in brackish and marine zones varied between 71.7% and 82.0% in Zone-2, between 88.0% and 91.5% in Zone-3 and between 88.6% and 91.8% in Zone-4. The contribution was lowest in freshwater Zone-1 (48.5 to 55.5%), where two other groups, Rotifera and Cladocera also shared the zooplankton composition substantially. Seasonal variation analysis revealed lowest values of population number of copepods during monsoon months from all stations and Zones. The pre-monsoon season was characterised by higher densities. Zonewise analysis revealed highest density in Zone-3, where it varied between 2090/m³ to 8635/m³ and lowest in Zone-2 where the variations were between 811/m³ and 2729/m³. The contribution of copepods was also less in freshwater Zone-1.

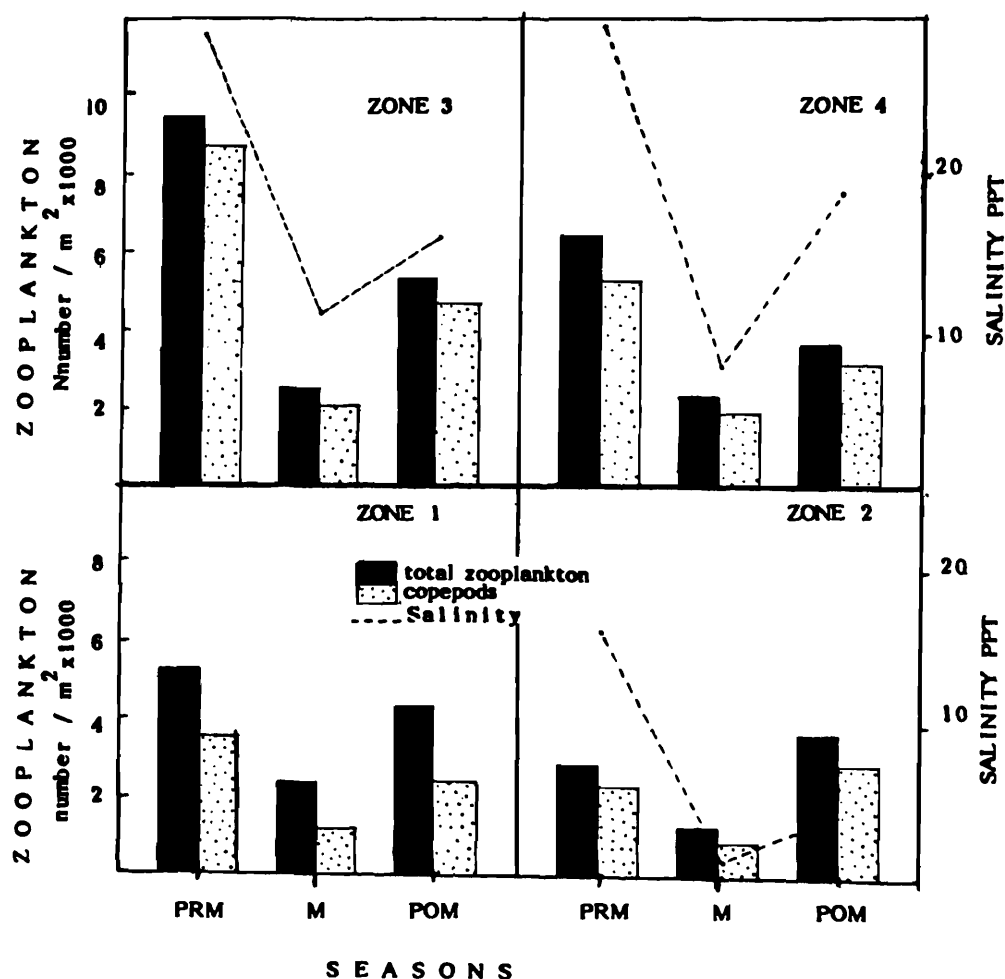


Fig-2 : Seasonal variations in the numbers of total zooplankton, copepods and salinity in different zones.

The seasonal variations in the abundance of copepods in relation to total zooplankton based on intensive data at Station X in Zone-4 revealed a bimodal pattern of variations of both, copepods

and total Zooplankton. (Fig. 4). Two peaks were recorded, first in pre-monsoon month of April and second in post-monsoon month of December. Soon after the monsoon was over the copepod

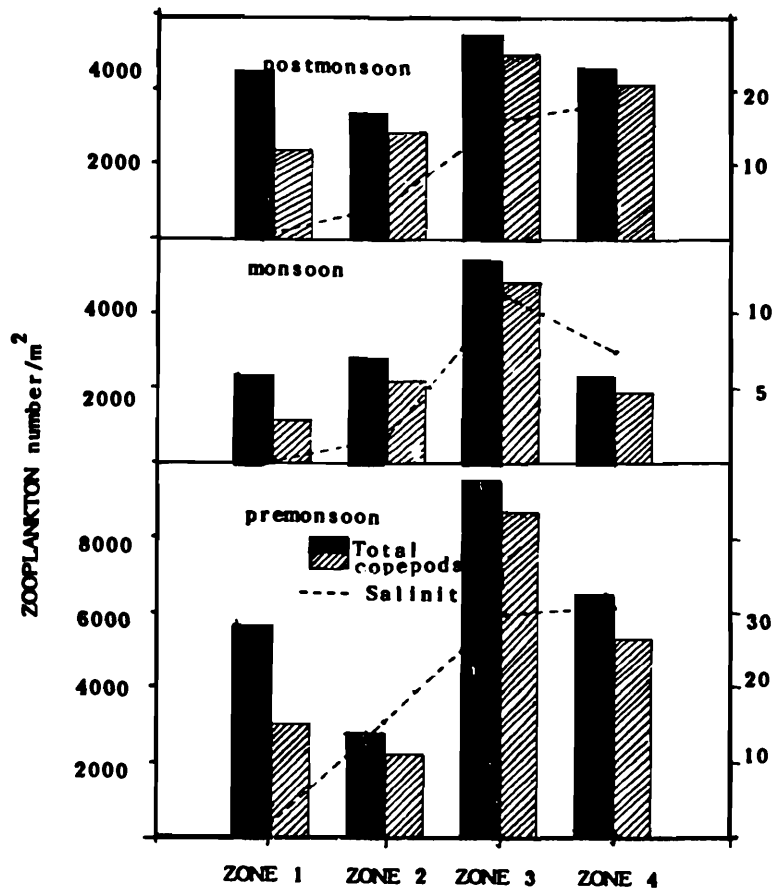


Fig-3 : Zonewise variations in the numbers of total zooplankton, copepods and salinity during different seasons.

population started to increase gradually from October onwards and reached to first peak level during December ($6118/m^3$). The values fell sharply during January only to rise again from February onwards which culminated into the major peak of the year during April ($7671/m^3$). Lowest values were recorded during monsoon months of August ($1267/m^3$). It is also evident from the figure that the pattern of copepod population fluctuation followed the pattern of salinity variations. Increased population density was recorded during high salinity period.

C. *Dynamics of numerically abundant species :*

Out of above mentioned 40 species recorded during different seasons and from different zones, only few species were numerically abundant in each zone and constituted the bulk of population number and biomass (85 to 95%). The others were of nominal values. Each zone was characterized by a specific set of numerically abundant species. The details of their spatio-temporal variations were analysed.

In Zone-1, (Fig. 5) only four species viz., *Heliodiaptomus contortus*, *Heliodiaptomus viduus*, *Thermocyclops hyalinus* and *Mesocyclops luckarti* were abundant and constituted nearly

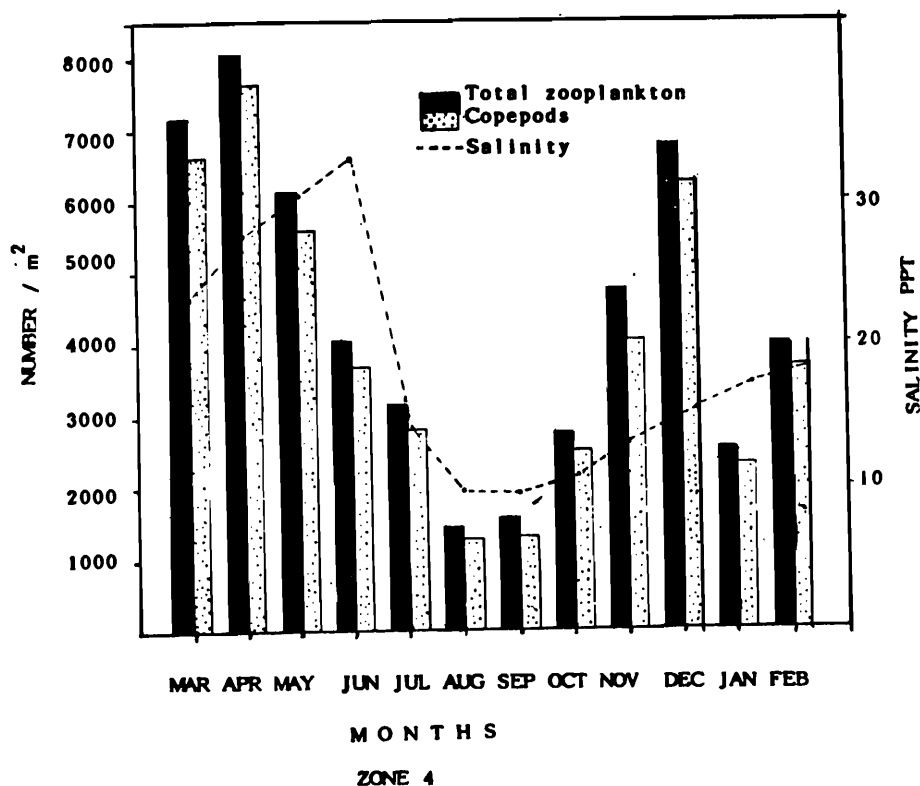


Fig-4 : Monthly variations in the numbers of total zooplankton copepods and salinity in Zone-4.

90% (86–93%) of the total copepod density, in terms of numbers. Highest contribution of *H. contortus* was observed during pre-monsoon (34%) followed by post-monsoon season (20%). *H. viduus* was found to dominate during post-monsoon period (31%) followed by monsoon (20%) and pre-monsoon (17%). The periods of abundance of the two species of *Heliodiaptomus* differed from each other. Similarly, two species of cyclopoids, *Mesocyclops luckarti* and *Thermocyclops hyalinus* also alternated in their abundance. While the former was dominant during premonsoon season (23%), the latter was the chief contributor of postmonsoon months (26%).

The numerically abundant species of Zone-2 (Fig. 6) were *Pseudodiaptomus annandalei*, *Acartiella sewelli*, *Oithona brevicornis*, *Pseudodiaptomus tollingerae*, *Acartia spinicauda*, *Pseudodiaptomus binghami*, *Acrocalanus intermis*, *Paracalanus dubia*, *Temora turbinata* and *Euterpina acutifrons* in the order of their abundance. They together constituted about 90% (88–94%) of the total copepods concentration. While *Pseudodiaptomus annandalei* and *Acartia spinicauda* were abundant during pre-monsoon months (20% each), *P. annandalei* (25%), *P. tollingerae* (18%) and *Acartiella sewelli* (22%) contributed mainly during monsoon season. The post-monsoon season was characterised by the abundance of *Oithona brevicornis* (24%), *Temora turbinata* (19%) and *Paracalanus dubia* (12%).

The pattern of abundance was entirely different in marine Zone-3, where mostly coastal water species were found to flourish during major part of the year (Fig. 7). The group of

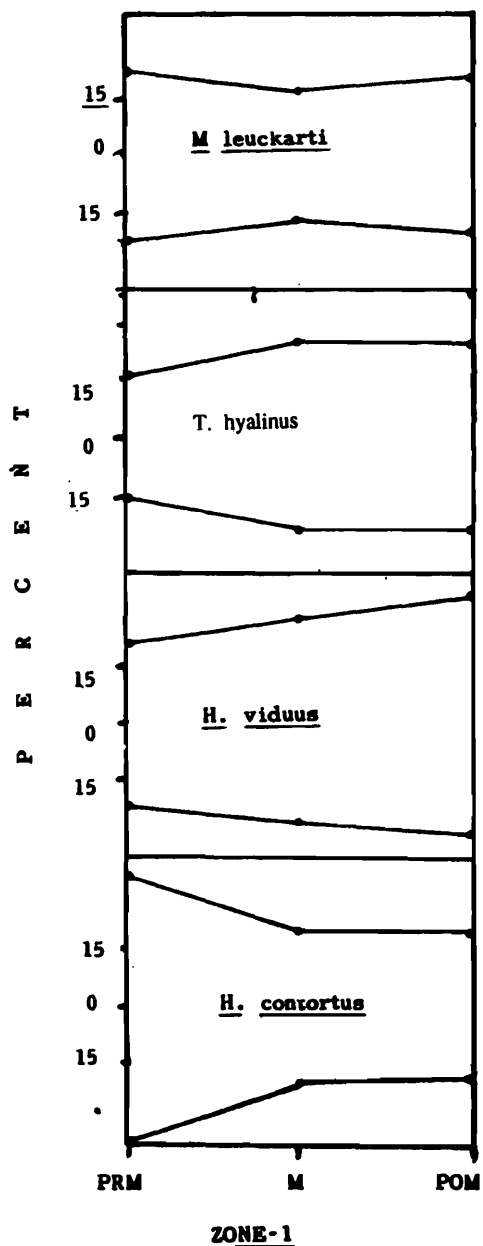


Fig-5 : Variations in the composition of numerically abundant species of zone-1.

numerically abundant species was comprised of 10 species viz., *Paracalanus dubia*, *Acrocalanus intermis*, *Euchaeta marina*, *Acartia erythraea*, *Centropages dorsipinatus*, *Labidocera acuta*, *Eucalanus subcrassus*, *Canthocalanus pauper*, *Macrosetella gracilis* and *Oncaea venusta* in the order of abundance. During pre-monsoon high salinity period, *C. dorsipinatus*, *E. subcrassus*, *P. dubia* and *Oncaea venusta* were abundant. During monsoon season *P. dubia*, *A. intermis* and *M. gracilis*

formed the bulk of copepod population. The post-monsoon season was dominated by *Euchaeta marina*, *Acartia erythraea*, *Labidocera acuta* and *Canthocalanus pauper*.

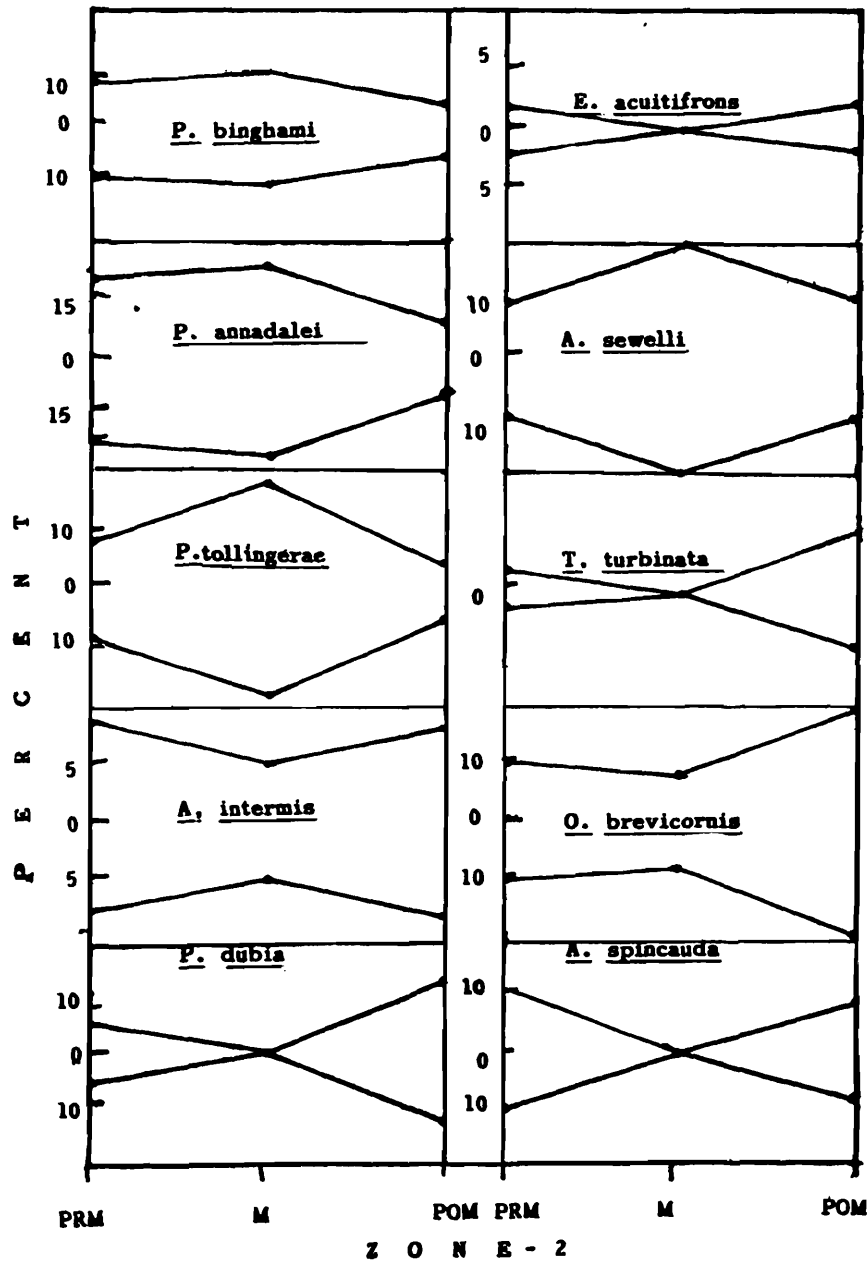


Fig-6 : Variations in the composition of numerically abundant species of zone-2..

In Zone-4, all the species of Zone-3 were present, and in addition to that three more species *Pontella andersoni*, *Pseudodiaptomus serricaudatus* and *Oithona brevicornis* (Fig. 8) also contributed to numerically abundant group of species. This zone was characterised by somewhat uniform pattern of distribution of different species as compared to other zones. Abundant species, computed on annual average basis, were *pseudodiaptomus serricaudatus*, *Acartia erythraea*, *Macrosetella gracilis*, *Euchaeta marina*, *Labidocera acuta*, *Pontella andersoni*, *Centropages*

dorsipinatus, *Oncaea venusta*, *Oithona brevicornis*, *Acrocalanus intermis* and *paracalanus dubia*, in the order of abundance. During pre-monsoon season *Centropages dorsipinatus*, *Pontella andersoni*,

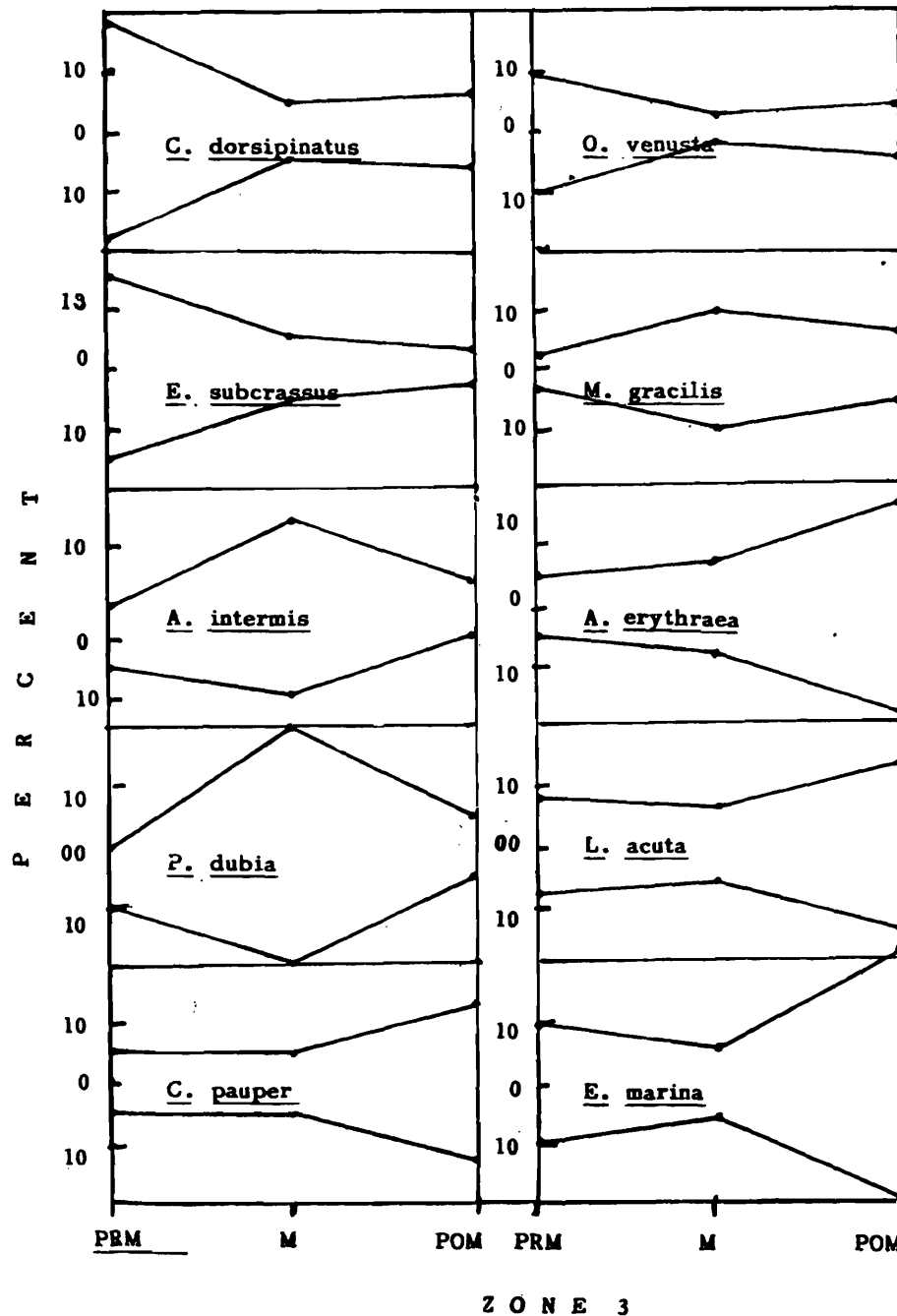


Fig-7 : Variations in the composition of numerically abundant species of zone-3.

Euchaeta marina and *Acrocalanus intermis* were the main component. During monsoon *Pseudodiaptomus serricaudatus*, *Acartia erythraea* and *Oithona brevicornis* were common. In post-monsoon season the copepod species which gained peak were *Labidocera acuta*, *Acartia erythraea*, *Pseudodiaptomus serricaudatus* and *Euchaeta marina* (Fig.8).

The detailed monthwise analysis of the cycle of different species in Zone—4 also revealed pattern similar to seasonal variations (Fig. 9).

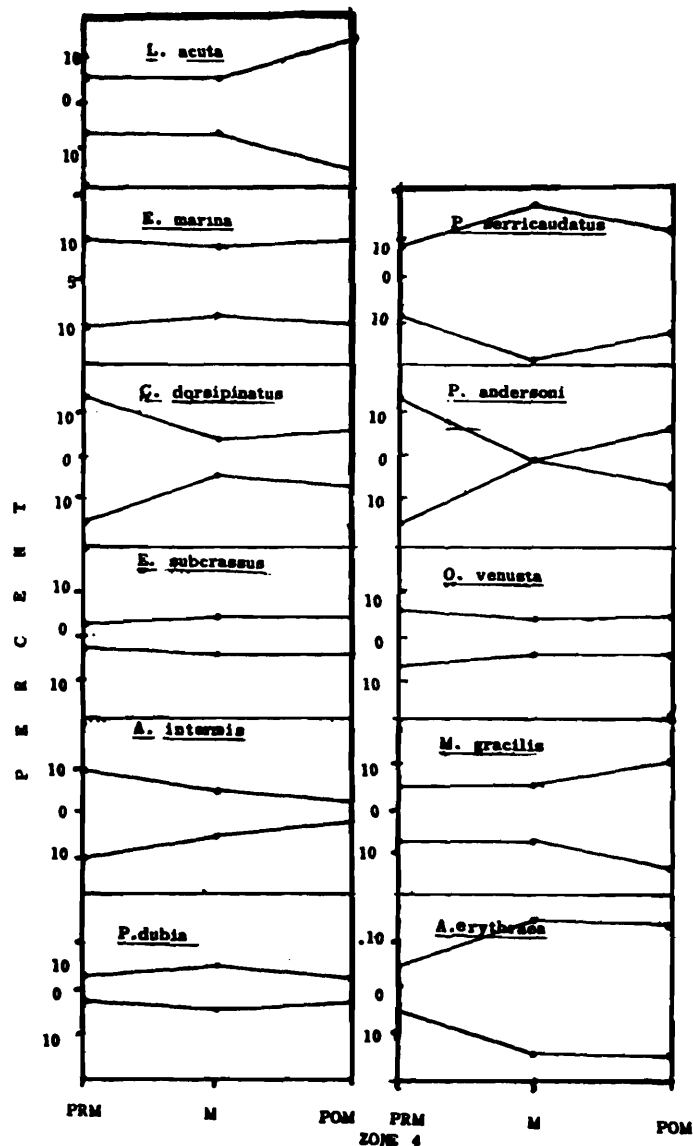


Fig-8 : Variations in the composition of numerically abundant species of zone-4.

The relationship between the mean population density of different numerically abundant species and salinity was worked out by analysing the correlation coefficients (Table 2). It was observed that most of the species were significantly related to salinity, either directly or inversly. Four species which showed inverse relationship were *Pseudodiaptomus annandalei*, *P. binghami*, *P. tollingeriae* and *Acartiella sewelli*. No significant relationship of salinity was observed with any of the fresh water species of Zone-1. The herpecticoid, *Euterpina acutifrons* also did not show any significant relationship. Rest of the species were significantly and positively related either at 1% or 5% level (Table 2).

TABLE – 2

RELATIONSHIP BETWEEN SALINITY AND COPEPODS POPULATION
DENSITY (Numerically abundant species)
IN HUGLY–MATLA ESTUARINE SYSTEM

Species	Degree of Freedom	Correlation coefficient (r) value	Level of significance
<i>Canthocalanus Pauper</i>	22	0.62	1%
<i>Eucalanus subcrassus</i>	22	0.58	1%
<i>Paracalanus dubia</i>	22	0.56	1%
<i>Acrocalanus intermis</i>	22	0.59	1%
<i>Euchaeta marina</i>	22	0.45	5%
<i>Centropages dorsipinatus</i>	22	0.61	1%
<i>Heliodiaptomus contortus</i>	22	0.32	NS
<i>Haliodiaptomus viduus</i>	22	0.27	NS
<i>Pseudodiaptomus serricaudatus</i>	22	0.48	5%
<i>Pseudodiaptomus annandalei</i>	22	– 0.46	5%
<i>Pseudodiaptomus binghami</i>	22	– 0.50	5%
<i>Pseudodiaptomus tollingeriae</i>	22	– 0.43	5%
<i>Temora turbinata</i>	22	0.45	5%
<i>Pontella andersoni</i>	22	0.50	5%
<i>Lapidocera acuta</i>	22	0.58	5%
<i>Macrosetella gracilis</i>	22	0.46	5%
<i>Euterpina acutifrons</i>	22	0.28	NS
<i>Oithona brevicornis</i>	22	0.47	5%
<i>Oneaea venusta</i>	22	0.52	5%
<i>Thermocyclops halinus</i>	22	0.27	NS
<i>Mesocyclops leukarti</i>	22	0.32	NS
<i>Acartia spinicauda</i>	22	– 0.49	5%
<i>A. erythraea</i>	22	0.44	5%
<i>Acartiella sewelli</i>	22	– 0.51	5%

Significant at 1% or 5%

NS—Not significant

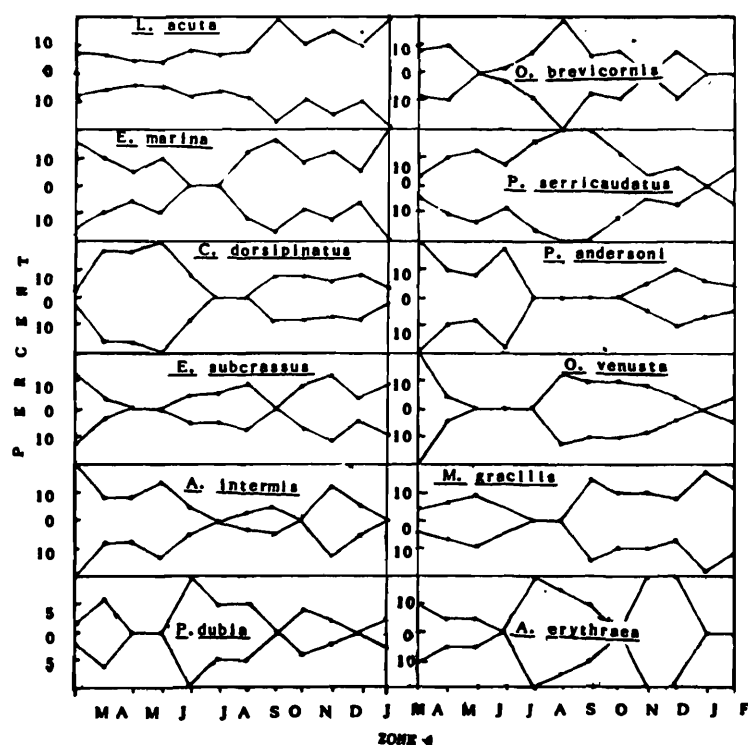


Fig-9 : Monthly variations in the composition of numerically abundant species of zone-4.

On the basis of their occurrence in different zones of Hugli–Matla estuarine system, each having distinct salinity ranges, the copepod species were divided into five ecological categories as per gradation from marine to freshwaters. These are : Marine, Marine–Brackish, Brackish, Brackish–Freshwater and Freshwater. The preference of each species has been shown in Table 3. Eight species were attributed to the first category of purely marine zone. A large number of species (16) showed their preference for Marine–Brackish zones. The resident brackish water group included only six species and the number of species common to brackish and freshwater was only four. The freshwater group included six species, which were permanent resident of this zone.

Further, based on the salinity ranges, under which numerically abundant species occurred in the sample, their salinity tolerance limits were worked out, which have been depicted in Fig 10. It is evident that barring few freshwater species and still fewer marine species, in general, the numerically abundant species of the Hugli–Matla estuarine system were able to occur under wide range of salinity. While the species of Pseudodiaptomidae, Acratidae and Oithonidae were able to tolerate wide ranges of salinity, the diaptomids were generally intolerant to higher levels of salinity. Similarly, many marine forms were also not found to withstand lower salinity levels.

DISCUSSION

The copepod fauna of the Hugli–Matla estuarine system were moderately rich, both qualitatively and quantitatively, as compared to other Indian estuaries. Forty species, consisting of 31 calanoids, 6 cyclopids and 3 herpeticoids were recorded during the present investigations which also included eight species of freshwaters. Baidya and Choudhury (1985) while working on lower zone of the Hugli estuary near Sagar island, where nearly marine situation exists, reported the

occurrence of 42 species but their list did not contain any freshwater species. Somewhat similar number of species have been reported from other estuaries of the country too. Goswami and Selvakumar (1971) reported the occurrence of 47 species from the estuaries of Goa and Pillai (1971) listed 42 species of Calanoids from Cochin backwaters. However, Nair and Abdul Azis could find only 23 species from the Ashtmundi estuary. As compared to coastal waters from where a large number of species have been reported (Sewell 1929, 1932, Kasturirangan, 1963), the copepod fauna of the estuarine system were poor. This may be due to unstable conditions in the estuaries which might have restricted the distribution of many species and allowed only those who could adapt to the fluctuating conditions, at least to some degrees.

TABLE - 3

OCCURRENCE OF COPEPOD SPECIES UNDER DIFFERENT ECOLOGICAL CATEGORIES.

MARINE	MARINE-BRACKISH	BRACKISH	BRACKISH-FRESHWATER	FRESHWATER
<i>Canthocalanus pauper</i>	<i>Paracalanus dubia</i>	<i>Pseudodiaptomus annandalei</i>	<i>Heliodiaptomus cinctus</i>	<i>Heliodiaptomus viduus</i> <i>Phyllodiaptomus</i>
<i>Eucalanus subcrassus</i>	<i>Paracalanus parvus</i>	<i>Pseudodiaptomus binghami</i>	<i>Heliodiaptomus contortus</i>	<i>blancei</i>
<i>Centropages dorsipinatus</i>	<i>Acrocalanus similis</i>	<i>Pseudodiaptomus serricaudatus</i>	<i>Pseudodiaptomus tollingeræ</i>	<i>Neodiaptomus strigilipes</i>
<i>Euchaeta marina</i>	<i>Acrocalanus intermis</i>	<i>Centropages alcocki</i>	<i>Acartiella sewelli</i>	<i>Cyclops viridis</i>
<i>Calanopia elliptica</i>	<i>Eucalanus elongatus</i>	<i>Acartia spinicauda</i>		<i>Mesocyclops leukarti</i>
<i>Lapidocara acuta</i>	<i>Pseudodiaptomus aurivilli</i>			<i>Thermocyclops hyalinus</i>
<i>Lapidocera minuta</i>	<i>Temora turbineta</i>	<i>Oithona brevicornis</i>		
<i>Macrosetella gracilis</i>	<i>Pontella andersoni</i>			
	<i>Lapidocera pectinata</i>			
	<i>Acartia erythraea</i>			
	<i>Acartia centura</i>			
	<i>Tartanus gracilis</i>			
	<i>Microsetella rosea</i>			
	<i>Euterpina acuitifrons</i>			
	<i>Onecaea venusta</i>			
	<i>Corycaeus danae</i>			

One of the most important features of copepods in this estuarine system was the contrast in the occurrence and abundance of species between two phases of the annual cycle, monsoonal and intermonsoonal, similar to some other estuaries (Madhupratap 1978, Rao *et. al.*, 1981). A very

poor fauna occurred in the estuarine system during monsoon months, as compared to pre- and post-monsoon seasons. The maximum differences between the number of species recorded during monsoon and pre-monsoon seasons were found in Zone-2, the brackishwater Zone. Only 10 species were recorded during monsoon as compared to 21 during pre-monsoon. The differences in Zones 3 & 4 and also in Zone-1 were of lesser magnitude. Such small differences indicated almost stable condition of the environment in marine and freshwater zones and large differences were due to unstable conditions in the brackish water leading to wide fluctuations. Repopulation commenced soon after the monsoon when salinity started increasing gradually, facilitating many species of marine origin to migrate upwards. It is also quite possible that species of higher salinity thresholds, which did not migrate during low saline period, might have gone into quiescent stages (Haridas *et. al.* 1977) and reactivated when favourable conditions returned. Khan (1981) while working on the ecology of calanoid, *Heliodiaptomus viduus* under quickly changing environmental conditions of temporary pond ecosystem, observed the possibilities of formation of resting eggs before the complete desiccation of the pond. These resting eggs activated quickly on the onset of favourable conditions during next monsoon.

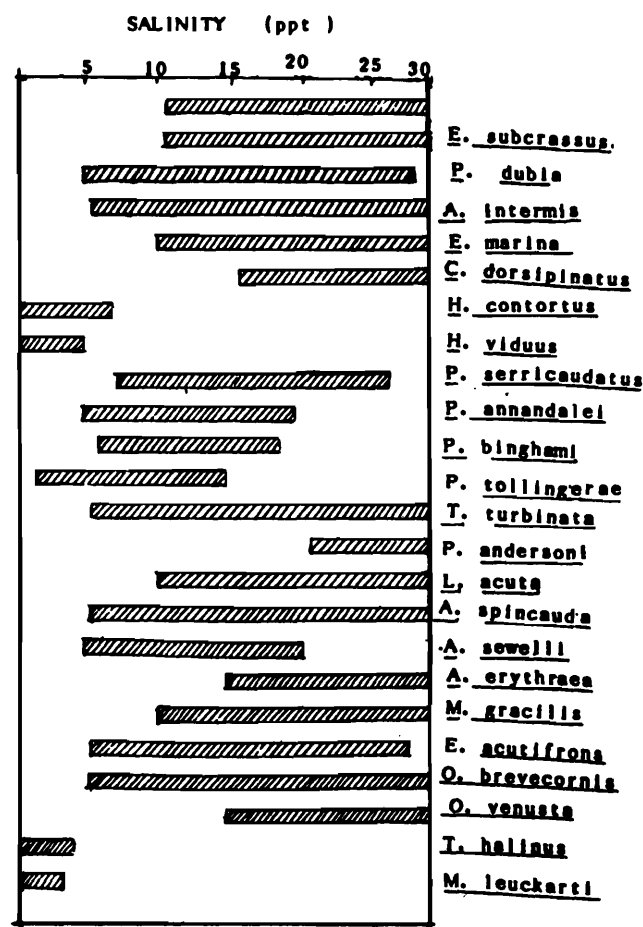


Fig-10 : Monthly variations in the composition of numerically abundant species of zone-4.

During high saline premonsoon months more species entered the estuary, both in lower and middle zones. The extension of the distribution of freshwater species was considerably restricted, which was probably due to their high sensitivity to salinity. The marine species which entered in

brackishwater during high salinity period were *Eucalanus elongatus*, *Centropages dorsipinatus*, *Paracalanus dubia*, *Pseudodiaptomus aurivilli* and *Temora turbinata* etc. The species which entered only into Zones 3 & 4 were *Canthocalanus pauper*, *Acrocalanus similis*, *Calanopia elliptica*, *Labidocera minuta* and *Microsetella rosea*, etc.

The bimodality in the pattern of seasonal abundance of copepods, as observed during the present course of investigations, seems to be the characteristics of estuaries of the country in general (Pillai, 1971; Subharaju and Krishnamurthi, 1972 etc). While the period of peak occurrence varied from estuary to estuary, the fluctuations were generally governed by monsoon, which reduced their density drastically. In this estuarine system the late pre-monsoon season (April–May) was characterised by the occurrence of major peak of abundance. The post-monsoonal peak (Nov.–Dec.) was of smaller extent. Baidya and Choudhury (1985) also observed similar periods of abundance. However, Shetty *et. al.* (1961) found the occurrence of major peak during November to February and a minor one in July in lower zone only. The considerable dominance of copepods over other groups of zooplankton (sometimes to the extent of more than 90%), appears to be the characteristics of this estuarine system as also observed by Shetty *et. al.* (1961) and Baidya and Choudhury (1985).

Out of 40 species recorded from the estuarine system only 24 were of some consequence as far as zooplankton biomass and production are concerned since the bulk of total biomass was constituted by these numerically abundant species. Each zone contained a set of few such species who could exploit fully the resources of the zone under specific conditions.

The classification of the species according to ecological categories revealed that large number of species belonged to marine-brackish category (16) followed by marine (8) and brackish (6). The present observation is somewhat different from the earlier observations of Baidya and Choudhury (1985) who placed only 4 species under Marine-Brackish category. They placed a large number either under marine (19) or brackish (16) categories. In fact, estuaries, in general, contain mainly marine elements which adapt themselves to certain level of environmental fluctuations. They remain in the brackish water as long as they are able to tolerate the fluctuations and retreat back to their original zone during adverse conditions. The number of such 'opportunistic' species is ought to be more as they explore wider areas for their fortunes as compared to those who have settled in the brackish water by enhancing their adjustment capabilities. Pillai (1971) also observed greater number of species under Marine-Brackish category than either under Brackish or Marine category.

The salinity tolerance spectrum of many species of Hugli-Matla estuarine system tallied well with those observed from other estuaries (Pillai 1971, Nair and Abdul Azis, 1987). While species of Pseudodiaptomidae, Acartidae, Temoridae and Oithonidae exhibited wide range of salinity tolerances, the members of family Diaptomidae were quite susceptible to higher salinity level. Similarly, many marine species also possessed very little flexibility in their salinity thresholds.

The direct statistical relationship between the population number and salinity of a large number of species, either directly or inversely, further confirmed the role of salinity in the dynamics of copepods. It will be worthwhile to mention here that no other factor, either physico-chemical or biological including food supply was ever limiting in the estuarine system for copepod survival

and growth. In fact, the population maxima of copepods always followed the abundance of diatoms. Besides, phytoplankton, detritus supply was also sufficient throughout the year. The oxygen supply, pH and temperature were also moderate (Khan, 1993). Hence, it may be concluded that the salinity was the single most important factor, which governed the dynamics of the copepods in the estuarine system.

SUMMARY

1. The occurrence, abundance and spatio-temporal variations of the planktonic copepods of Hugli–Matla estuarine system, along with their relationship with salinity were studied covering the entire stretch of the main Hugli estuary (demarcated into three Zones, 1, 2 & 3, from freshwater to marine) and Matla estuary below Canning (Zone 4).

2. The copepod fauna comprised of 40 species, 31 calanoid, 6 cyclopoid and 3 herpeticoïd. The species composition differed considerably between different zones. Zone–1, exhibiting freshwater conditions, contained mostly species intolerant to higher salinity, Zone–2, representing brackishwater, harboured species with wide salinity tolerances and Zone–3 (marine) included most of the species of Zone-2 with some additional marine species. Zone–4 almost resembled Zone–3 both in physico-chemical conditions and copepod composition. Drastic alteration in the composition and abundance of copepod species was observed during monsoon months in all zones.

3. Copepods comprised the bulk of total zooplankton number and biomass which in turn was formed by few 'numerically abundant' species. Bimodal pattern of seasonal variations in the total copepod population was observed with major peak during pre-monsoon (April–May) and minor during post-monsoon (Nov.–Dec.) seasons.

4. On the basis of their occurrence and abundance in different zones of the estuarine system, each with specific salinity range, the copepod species have been classified into five ecological categories. Maximum number of species belonged to Marine-Brackish category, followed by Marine and Brackish Categories.

5. Analysis of salinity tolerance limits of different species revealed that while the species of Pseudodiaptomidae, Acartiidae and Oithonidae were able to tolerate wide range of salinity, Diaptomids were generally intolerant to higher levels. Similarly, many marine forms were also not found to withstand lower salinity levels.

6. The abundance of most of the species of copepods was either directly or inversely related to salinity, showing their close relationship with the factor. No other factor, abiotic or biotic including food supply was ever limiting for the survival and growth of copepods.

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STOMATOPODA : CRUSTACEA

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INTRODUCTION

Stomatopods are primarily marine inhabitants extending from coastal inshore to offshore areas to about 760m. However, a number of species have been recorded in recent years from brackish water zones with mud bottoms and less salinity.

The Hoogli and Matla rivers break up into a number of tributaries, shallow water creeks and canals on their southward journey before reaching the sea. These, together with the vast mangroove swamps of the Sundarbans constitute an unique biota for a number of brackish water organisms including stomatopods.

Wood-mason (1895), Kemp (1913) and chopra (1934) together reported nine species of stomatopods, all from sandheads, the Hugli river mouth. Much later Tiwari and Biswas (1952) described the first brackish water stomatopod, *Cloridopsis bengalensis* from Salt-Lake area near Calcutta. Subsequently, Tiwari and Ghosh (1975) recorded the extension of range of the species from the present study area.

The author in a recent paper (in press) on the Stomatopoda of West Bengal listed 22 species including one new species from off Digha. Of these, only 12 species distributed into 3 families and 7 are genera are from the study area.

The present study is based on material of stomatopods collected by parties of the Zoological Survey of India in recent years, named and registered material present, and available literature. A brief taxonomic account of all the 12 species together with keys, diagnostic characters and Zoogeographical distribution has been provided.

SYSTEMATIC ACCOUNT

LIST OF STOMATOPODA OF HUGLI-MATLA ESTUARY

Class : CRUSTACEA
Order : STOMATOPODA
Family 1 : HARPIOSQUILLIDAE
Genus (1) : *Harpiosquilla*

- (1). *Harpiosquilla raphidea*
 Family II : SQUILLIDAE
 Genus 2 : *Alimopsis*
- (2). *Alimopsis supplex*
 Genus 3 : *Carinosquilla*
- (3). *Carinosquilla multicarinata*
 Genus 4 : *Clorida*
- (4). *Clorida decorata*
- (5). *Clorida latreillei*
 Genus 5 : *Cloridopsis*
- (6). *Cloridopsis bengalensis*
- (7). *Cloridopsis immaculata*
- (8). *Cloridopsis scorpio*
 Genus 6 : *Oratosquilla*
- (9). *Oratosquilla interrupta*
- (10). *Oratosquilla nepa*
- (11). *Oratosquilla Wood-masoni*
 Family III : NANNOSQUILLIDAE
 Genus 7 : *Acanthosquilla*
- (12). *Acanthosquilla multifasciata*

Keys to Families of stomatopoda of Hugli-Matla Estuary

Propodi of posterior three maxillipeds broad, beaded or ribbed ventrally; telson without distinct median carina; proximal end of uopodal endopod with strong fold on outer margin
 NANNOSQUILLIDAE.

Propodi of posterior three maxillipeds slender, not beaded or ribbed ventrally; telson with distinct median carina; proximal end of uropodal endopod without fold on outer margin 2

2. Posterior margin of carapace with deep excavation, propodus of raptorial claw with erect spines on opposable margin HARPIOSQUILLIDAE.

Posterior margin of carapace without deep excavation; propodus of raptorial claw pectinate on opposable margin SQUILLIDAE.

Family HARPIOSQUILLIDAE Manning, 1980

The family Harpiosquillidae can be distinguished by the key cited above and is represented in the present study by a single species *Harpiosquilla raptidia*.

Genus 1. *Harpiosquilla* Holthuis, 1964

Diagnosis : Eye large, T-shaped and cornea bilobed.; Carapace with deep posterolateral excavation. Dactylus of raptorial claw with teeth; upper margin of propodus with row of erect spines and intervening smaller spines. Abdomen broad. The genus includes the largest known stomatopods measuring up to 335 mm.

1. *Harpiosquilla raphidea* (Fabricius)

1798. *Squilla raphidia* Fabricius, *Ent. Syst. Supp.* : 416

1969. *Harpiosquilla raphidea* : Manning, *Smithson Contr. Zool.*, No. 36 : 9.

Material examined : 3 (M) (TL-120-235mm), Ganga Sagar S. 24-Parganas, K.N.Reddy, 23.12.1978. 1 (F) (TL 143 mm); Bakkhali; S. 24-Parganas; K.N.Reddy, 21.12.1978. 4 (M) (TL 90-211 mm); 2 (F) (TL 95-120 mm); Frasergunja, S. 24-Parganas; K.V.Surya Rao; 9.12.1965.

Diagnosis : Rostral plate longer than broad, with a slender apical projection. Raptorial dactylus with 8-teeth, outer margin with sharp angular projection in adult males. 5th thoracic somite with a sharp lateral spine. Ventral keel on 8th thoracic somites rounded. Abdominal carinae spined as follows : submedian 6, intermediate 1-5, lateral 1-6, marginal 1-5. Telson with a broad median carina and 3 pairs of marginal teeth.

Distribution : India : West Bengal : S. 24-Parganas; Orissa and Maharastra. *Elsewhere* : East Coast of S. Africa to Indonesia.

Remarks : Of the three species of *Harpiosquilla* found in the West Bengal Coast only *H. raphidia* is found in the estuarine waters of the study area. The other two species *H. harpax* and *H. annandalei* are restricted to deeper waters in the Sandheads, off the Hugli River Mouth.

Family : SQUILLIDAE Latreille, 1803

The family squillidae can be distinguished by the key given above and is represented in the present study by ten species distributed into five genera.

Key to genera of Squillidae

1. Eye large; cornea strongly bilobed, broader than stalk 2.
Eye small, cornea feebly bilobed, slightly broader than stalk 4.
2. Lateral process of 6th and 7th thoracic somites bilobed 3.
Lateral process of 6th and 7th thoracic somite not bilobed *Alimopsis*.
3. Carapace, abdomen and telson with numerous longitudinal carinae..... *Carinosquilla*.
Carapace, abdomen and telson with normal compliment of carinae *Oratosquilla*.
4. Ocular scales separate, submedian teeth of telson with fixed apices *Cloridopsis*.
Ocular scales medially fused, submedian teeth of telson with movable apices.....
..... *Clorida*.

Genus 2. *Alimopsis* Manning, 1977

The genus *Alimopsis* can be distinguished by the key presented above and is represented in the present study by a single species, *Alimopsis supplex*.

2. *Alimopsis supplex* (Wood-Mason)

1895. *Squilla supplex* Wood-Mason, *Proc. As.Soc. Bengal* : 232.

1977. *Alimopsis supplex* : Manning, *Proc. Biol. Soc. Wash.* 90 (2) : 421.

Material examined : 10 (M) (TL 64 mm); Jambudwip, Sundarbans, S. 24-Parganas, H.C.Ghosh, 11.2.1980.

Diagnosis : Rostrum with short carina. Mandibular Palp present. Carapace with long anterolateral spines. Dactylus of raptural claw with teeth, outer margin with a bulge basally. 5th thoracic sumite laterally bilobed anterior lobe produced into an anteriorly directed spine, 6th and 7th single and laterally rounded. 1st to 5th abdominal somites with distinct median carinae. Uropodal protopod with a small lobe in the middle in the longer arm

Distribution : India : West Bengal : S. 24-Parganas; Tamilnadu and Maharastra.

Remarks : The species is endemic to the Indian waters and is represented by a single male specimen from the study area. Appears to be rare.

Genus 3. *Carinosquilla*, Manning, 1968

The genus *Carinosquilla* is represented in the present study by a single species.

3. *Carinosquilla multicarinata* (White)

1848. *Squilla multicarinata* White, *Proc. Zool. Soc.* : 144, Figs., 1, 1a.

1968. *Carinosquilla multicarinata* : Manning, *Bull. mar. sci. Gulf-Carrib*, 18 (1) : 136.

Material examined : 1(M) (TL 79 mm); Sundarban, S. 24-Parganas; R.S.Pillai; 12.7.1977.

Diagnostic : Rostrum elongated, with 5 longitudinal carinae. Dactylus of raptorial claw with 5-teeth. Carapace with numerous longitudinal carinae. 5-7 thoracic somites bilobed, 5th somite with transverse carinae and anterior lobe produced into an anteriorly directed spine. All six abdominal carinae lined with longitudinal carinae. Telson lined with longitudinal carinae, median strong with a sharp posterior spine. Proximal segment of uropodal exopod with four entire longitudinal carinae and distal segment with two raised longitudinal carinae.

Distribution : India : West Bengal : Sundarban, S. 24-Parganas;

Remarks : *Carinosquilla multicarinata* is so far reported from the study area alone. Appears to be rare.

Genus 4. *Clorida* Eydoux and Souleyet, 1842.

The genus *Clorida* is represented in the study area by only two species as keyed below.

Key to species of genus Clorida

1. Lateral spine of 5th thoracic somite anteriorly directed. Submedian carinae of 1-5th abdominal somites strongly divergent *C. decorata*
- Lateral spine of 5th thoracic somite laterally directed. Submedian carinae of 1-5th abdominal somites parallel *C. latreillei*

4. *Clorida decorata* Wood-Mason

1875. *Clorida decorata* Wood-Mason, *Proc. As. Soc. Bengal* : 131.

1968. *Clorida decorata* : Manning, *Bull. mar. sci. Gulf-Caribb*, 18 (1) : 123.

Material examined : 2 (F) (TL 75 and 83mm); Bakkhali, S. 24-Parganas; B.P.Halder, 5.3.1988.1 (F) (TL 59mm); Frasergunje; S. 24-Parganas; K.V.Surya Rao; 9.12.1965.

Diagnosis : Eyes very small, cornea bilobbed, stalk greatly expanded. Rostrum broader at base, apex rounded. Carapace strongly narrowed anteriorly, anterolateral angles with short inwardly curved spines. Dactylus of raptorial claw with 5 teeth, outer margin with strong angular projection. Lateral processes of thoracic somites single lobed, 5th produced into an anteriorly directed spine. Telson broader than long, dorsal surface with tubercles. Bifurcated process of uropodal protopod with a broad rounded lobe on outer margin.

Distribution : India : West Bengal : S. 24-Parganas; and Andamans. *Elsewhere :* Burma and Thailand.

Remarks : Only female specimens of the species have so far been reported from the study area. Compared to other species appears to be rare.

5. *Clorida latreillei* Eydux and Souleyet

1841. *Clorida latreilla* Eydoux and Souleyet, *Voy de la Bonite Zool. 1-Crust.* : 265, pl 5, figs. 2-5.

1968. *Clorida latreillei* : Manning, *Bull. mar. sci. Gulf-caribb*, **18** (1) : 123.

Material examined : 1 (F) (TL 40mm); Jambudwip, Sundarban, S. 24-Parganas, H.C.Ghosh; 10.12.1980.

Diagnostic : Eyes very small, cornea bilobed, stalk greatly expanded. Rostrum triangular, apex rounded. Carapace strongly narrowed anteriorly, anterolateral angles with sharp outwardly directed spine. Dactylus of raptorial claw with 4 teeth, outer margin with angular projection. Thoracic somites laterally single lobed, 5th produced into laterally directed spine. Telson broader than long, dorsal surface with irregular ridges.

Distribution : India : West Bengal : S. 24-Parganas, Maharashtra, Tamil Nadu, Andhra Pradesh and Orissa. *Elsewhere :* From Red sea to Japan.

Remarks : Presence of 4 teeth on the raptorial dactylus and a laterally directed spine on the lateral process of the 5th thoracic somite will distinguish *C. latreillei* from *C. decorata*.

Genus 5. *Cloridopsis* Manning, 1968

Three species of *Cloridopsis* occur in the study area and all are brackish water forms. They may be differentiated by means of the key given below.

Key to species of Cloridopsis

1. Lateral process of 5th thoracic somite without a large black spot 2.
- Lateral process of 5th thoracic somite with a large black spot *C. scorio*.

2. Raptorial dactylus with 5 teeth*C. immaculata*.
 Raptorial dactylus with 6 teeth*C. bengalensis*.

6. *Cloridopsis bengalensis* (Tiwari and Biswas)

1952. *Squilla bengalensis* Tiwari and Biswas, *Rec. Indian Mus.*, **44** : 352.

1973. *Cloridopsis bengalensis* : Tiwari and Ghosh, *Proc. Zool Soc. Calcutta*, **26** : 33, figs. 1a, b, c, d.

Material examined : 1(F) (TL 69 mm); Gosaba, S. 24-Parganas; N.C.Gayen; 17.9.1983. 1(M) (TL 122 mm); Jharkhali, S. 24-Parganas, B.P.Halder; 22.5.1985.

Diagnosis : Eyes small, cornea bilobed, set obliquely on stalk. Rostrum with a median carina, apex rounded. Anterolateral spines of carapace with a rounded ventral lobe. Raptorial dactylus with 6 teeth. Lateral process of 5th thoracic somite produced into an anteriorly directed spine, those on 6th and 7th rounded. Telson broader than long, with three pairs of marginal teeth, prelateral lobe present, denticles large and rounded.

Distribution : *India* : West Bengal : S. 24-Parganas; Orissa and Andhra Pradesh. *Elsewhere* : Thailand.

Remarks : The adult males of this species differ from adult females in a number of characters. Male-female characters are dealt by Tiwari and Ghosh (1975)

7. *Cloridopsis immaculata* (Kemp)

1913. *Squilla scorpio* var. *immaculata* Kemp, *Mem. Indian Mus.* **4** : 45

1968. *Cloridopsis immaculata* : Manning, *Bull. mar. sci. Gulf-Caribb*, **18** (1) :

Material examined : 1(M) (TL 7 mm), Sajinakhali, S. 24-Parganas, B.P.Halder, 12.1.1984. 2(M) (TL 51 and 58 mm), 3(F) (TL 53-63 mm); Gosaba, S. 24-Parganas; H.C.Ghosh; 1981. 1(M) (TL 60 mm); Jhingakhali, S.Biswas; 13.9.1983. 1(M) (TL 70 mm), 2 (F) (TL 59 and 70 mm); Chota Mullakhali, B.P.Halder; 13.1.1984 15(TL 60-80 mm), 9(F) (TL 62-75 mm); Matla river, T.Roy, 12.3.1985. 1(F) (TL 80 mm), Raimangal river, B.P.Halder, 8.9.84.

Diagnosis : Eyes small, cornea bilobed and broader than long Rostrum with median carina. Anterolateral angles of carapace produced into slender spines. Dactylus of raptorial claw with 5 teeth. Lateral process of 5th thoracic somite produced into anteriorly directed spine. Telson broader than long, denticles large and rounded.

Distribution : *India* : West Bengal : S. 24-Parganas and Orissa. *Elsewhere* : Karachi, Arakan coast, Singapore and Thailand.

Remarks : *C. immuculata* is most common and more abundantly available than the other two members of the genus from same area.

8. *Cloridopsis scorpio* (Latreille)

1825. *Squilla scorpio* Latreille, *Encycl. Method*, 10 : 472

1968. *Cloridopsis scorpie* Manning, *Bull. mar. sci. Gulf-caribb*, 18 (1)

Material examined : 1(M) (TL 41mn) ; Frazerganj, Sundarban ; B. Prasad ; 14.12.1917.

Diagnostic : Eyes small, cornea bilobed, broader than. stalk Rostrum with median carina on anterior half, apex truncate. Carapace narrowed anteriorly, anterolateral spines strong, each spine with a rounded ventral lobe. Raptorial dactylus with 5 teeth, outer margin with a swallow proximal notch. Lateral process of 5th thoracic somite with a large and black spot and produced into an anteriorly directed spine. Outer margin of inner spine of basal prolongation of uropod with a large rounded lobe.

Distribution : *India* : West Bengal : S. 24-Parganas, *Elsewhere* : Indo-West Pacific.

Remarks : *C. scorpio* is easily distinguished from the other two members of the genus in the presence of a permanent large black spot on the lateral process of the 5th thoracic somite. So far the species is known by a single specimen from the study area and as such appears to be very rare.

Genus 6. *Oratosquilla* Manning, 1968

Of the six species of *Oratosquilla* known from the coastal waters of West Bengal only three species are so far reported from the study area. They may be distinguished by the key given below.

Key to species of *Oratosquilla*

1. Median carina of carapace interrupted at base of bifurcation 2.
Median carina of carapace uninterrupted at base of bifurcation *O. nepa*
2. Anterior bifurcation of median carina of carapace wellmarked, arms of bifurcation not lined with dark spots, submedian carinae of 5th abdominal somite parallel *O. interrupta*
Anterior bifurcation of median carina of carapace not wellmarked, arms of bifurcation lined with dark spots, submedian crina of 5th abdominal somite slightly divergent
.....*O. woodmasoni*.

9. *Oratosquilla Interrupta* (Kemp)

1911. *Squilla interrupta* Kemp, *Rec. Indian Mus*, 6 : 98

1913. *Squilla interrupta* Kemp, *Mem. Indian Mus.* 4 : 72, pt. 5. figs. 60-62.

1968. *Oratosquilla interrupta* : Manning, : *Bull. mar. sci. Gulf-caribb*, 18 (1) :

Material examined : 4(F) (TL- 56 87 mm); Jumbudwip, S. 24-Parganas. H.C.Ghosh, 11.12.1980. 4(F) (TL 69-80 mm), 4(M) (TL 75-118) ; Bakkhali, S. 24-Parganas, H.C.Ghosh 10.12.1980. 2(F) (TL 80 and 96 mm). Gangasagar, S. 24-Parganas, H.C.Ghosh, 13.12.1980.

Diagnosis : Eye large, cornea bilobbed, set obliquely on stalk. Lateral margin of rostrum upturned, apex truncate. Anterior bifurcation of median carina of carapace interrupted at base of bifurcation. Dactylus of raptorial claw with 6 teeth, dorsal ridge of carpus of claw with two tubercles. Telson broad, with three pairs of sharp marginal teeth. Lobe on outer margin of inner spine of basal prolongation of uropodal protopod rounded and outer margin convex.

Distribution : *India* : West Bengal : S. 24-Parganas; Maharashtra, Andhra Pradesh and Orissa. *Elsewhere* : Indo-West Pacific region.

Remarks : Interruption at the base of bifurcation of median carina of carapace and a rounded lobe with a convex outer margin on the inner spine of basal prolongation of uropodal protopod are characteristic of the species. Abundantly available in the study area.

10. *Oratosquilla nepa* (Latreille)

1825. *Squilla nepa* latreille, *Encycl. Method.*, 10 : 471.

1968. *Oratosquilla nepa* : Manning, *bull. mar.sci. Gulf-Caribb*; 18 (1) : 134

Material examined : 1(F) (TL 49 mm); Jumbudwip, S. 24-Parganas, H.C.Ghosh, 10.12.1980.

Diagnosis : Eyes small, cornea bilobed. Rostrum subquadrate, apex rounded, margins upturned. Anterior bifurcation of median carian of carapace uninterrupted. Dactylus of raptorial claw with 6 teeth, outer margin sinuous. Anterior lobe of lateral process of 5th thoracic somite produced into an anteriorly directed spine. Telson as long as broad, denticles large and rounded.

Distribution : *India* : West Bengal : S. 24-Parganas, Orissa, Andhra Pradesh, Tamilnadu and Maharashtra. *Elsewhere* : Indo-West Pacific region.

Remarks : Compare to *O. interrupta* and *O. wood masoni*, *O. nepa* seems to be rare along the West Bengal coast. The small eyes and uninterrupted median carina of carapace will distinguish *O. nepa* from other members of the genus from West Bengal.

11. *Oratosquilla Woodmasoni* (Kemp)

1911. *Squilla woodmasoni* Kemp, *Rec. Indian Mus.*, 6 (2) : 99

1878. *Oratosquilla woodmasoni* : Manning *Smithson. Contr. zool.* No. 272 : 36.

Material examined : 7(M) (TL 66-92 mm), 5(F) (TL 71-85 mm); Sagar Island, S. 24-Parganas; H.C.Ghosh, 23.12.1978.

Diagnosis : Eyes large, cornea bilobed and set obliquely on stalk. Rostrum broader than long, apex truncate. Anterior bifurcation of median carina of carapace indicated by dark dots. Dactylus of raptorial claw with 6 teeth, outer margin sinuous, dorsal ridge of carpus of claw with 2-3 tubercles. All three exposed thoracic somites bilobed. Submedian carina on 5th abdominal somites slightly divergent.

Colour : Dorsal surface with dark brown chromatophores. Posterior margins of thoracic and abdominal somites dark.

Distribution : *India* : W. Bengal : S. 24—Parganas; TamilNadu and Pandichery. *Elsewhere* : Indo-West Pacific region.

Remarks : The indistinct bifurcated process of the median carina of carapace and presence of 2-3 tubercles on the dorsal ridge of carpus of raptorial claw will distinguish the species from the other two members of the genus from W. Bengal. It appears to be abundant along the West Bengal Coast.

Genus 7. *Acanthosquilla* Manning 1963

Only three species of *Acanthosquilla* are known from West Bengal coast of which, only *A. multifasciata* is known from the study area by a single male specimen.

12. *Acanthosquilla multifasciata* (Wood-Mason)

1895. *Lysiosquilla multifuscista* Wood-Mason, *Figs. and Desc. nine squillidae*, : 1, pl. 1, figs. 4-7.

1963. *Acanthosquilla multifasciata* : Manning, *Bull. mar. sci. Gulf-Caribb.*, 13 (2) : 319.

Material examined : 1 (M) (TL 62 mm); Sundarban, S. 24-Parganas; R.S.Pillai; Date not recorded.

Diagnosis : Eyes small, cornea subglobular. Antennal scale short, antenal prosopod with one dorsal and one ventral papilla. Rostrum subquadrate, apical spine slender. Dactylus of raptorial claw with 5 teeth, outer margin with two basal lobes. Telson broader than long with 2 pairs of fixed marginal teeth submedian denticles 12, movable and arranged in a transverse row., dorsal surface with a fan shaped row of five spines above posterior margin. Uropodal endopod with strong fold on outer margin.

Colour : Rostrum pitted with dark dots. Carapace with three dark transverse bands. Thoracic and abdominal somites with dark and broad transverse bands. Telson with a pair of dark bands below anterior margin. Uropodal endopod pitted with dark dots.

Distribution : *India* : West Bengal : S. 24-Parganas; TamilNadu; Andaman; Maharashtra.

Elsewhere : Indo-West Pacific from Red Sea to Japan.

Remarks : *A. multifaciata* can be distinguished from *A. acanthocarpus* in having 5 teeth on the dactylus of raptorial claw and arrangement of submedian denticles of telson in a transverse row and from *A. dighaensis*, (in press) in having 2 pairs of fixed marginal teeth on telson. The record of only two male specimens from West Bengal coast indicates its rarity in the area.

SUMMARY

Of the 22 species of stomatopods so far known from the coastal waters of West Bengal 10 are purely marine and exclusive to deeper waters at the sandhads, the Hugli River Mouth including one from off Digha Coast and the rest 12 are purely brackish waters forms restricted to the Hugli-Matla estuaries. A brief taxonomical account of all the 12 brackish water species from the Hugli-Matla estuaries is dealt with in this paper along with keys to families genera and species.

ACKNOWLEDGMENTS

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ISOPODA : CRUSTACEA

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INTRODUCTION

Isopods (Families Sphaeromatidae, Cymothoidae and Cirolandiae) occur in diverse ecological niches of marine, estuarine and brackish water environment. The Hugli-Matla estuarine complex having a luxuriant growth of mangrove forests has a faunistic community quite rich in variety and abundance, of which the isopods constitute one of the important crustacean components. The present study is based on the named and unnamed material available in the Zoological Survey of India as well as material collected by various survey parties from the Hugli-Matla estuarine area.

Perusal of literature reveals that Stebbing (1911) initiated the study of Indian isopods. The works of Chilton (1924), Hale (1926), Barnard (1936), Tiwari (1952 & 1953), Pillai (1964) and Ghatak and Misra (1984) may be mentioned in this context. However, information about this group in Hugli-Matla estuary is rather meagre being limited to notes published by the aforesaid workers.

Material of this group was collected during 1978-1989 from the Hugli-Matla estuarine belt. Altogether seven species belonging to three families and four genera have been worked out. The present paper deals with the diagnostic characters, distribution, colour, host and keys for identification of the species hitherto reported from this area. It also furnishes the material and methods for collection and preservation of this group. Synonymies have been reduced to avoid repetition and is restricted to the original and most recent references.

MATERIAL AND METHODS

The floating isopods were collected by using trownet and plankton net made of botting silk or nylon. Parasitic isopods were collected with a small forcep and mounting needle. Some parasitic isopods were also collected along with their hosts. For sand and mud-dwelling forms, a commercial bottom grab sampler was used.

After collection specimens were left in 70% alcohol for storage. The preservative was changed after returning to the laboratory. The labels containing total number of examples colour, date, locality, name of the host (in case of parasitic forms) and name of the collector were placed inside the container for the purpose of study.

SYSTEMATIC ACCOUNT

Class	CRUSTACEA
Order	ISOPODA
Suborder	FLABELLIFERA

- Family I. SPHAEROMATIDAE
- Genus (1) *Sphaeroma* (Bosc)
1. *Sphaeroma tristi* Heller
- Genus (2) *Exosphaeroma* (Stebbing)
2. *Exosphaeroma parva* Chilton
- Family II. CYMOTHOIDAE
- Genus (3) *Nerocila*
3. *Nerocila phaeopleura* Bleaker
4. *Nerocila serra* Sch. & Mein
5. *Nerocila madrasensis* Ramakrishna & Venkata Ramaniah
- Genus (4) *Cymothoa* Fabricius
6. *Cymothoa indica* Sch. & Mein
- Family III. CIROLANIDAE
- Genus (5) *Cirolana* (Leach)
7. *Cirolana parva* Hansen

Keys to The Families of Isopoda

1. Pleon composed of three or less visible segments 2
 Pleon composed of one free segmentSPHAEROMATIDAE
2. All paraeopods prehensileCYMOTHOIDAE
 ALL paraeopods ambulatory.....CIROLANIDAE

Family : SPHAEROMATIDAE

Diagnosis : Body oval in shape, quickly roll into a ball; all pleon somites fused, usually three sutures; pleon formed with the fusion of six pleon somites; pleopods of two to three usually fleshy or membranous and more or less translucent; coxal plates of paraeon 2-7 fused with somite; uropod lateral and endopod rigidly fused with peduncle; exopod moveable.

Key to *Genera*

Endopods of pleopods fleshy and folded*Exosphaeroma* Stebbing

Endopods of pleopods not fleshy and floded*Sphaeroma* (Bosc)

Genus (1) *Sphaeroma* (Bosc)1. *Sphaeroma triste* Heller

1868. *Sphaeroma triste* Heller, *Novara Reise Zool.*, 2 : 142.

1961. *Sphaeroma triste* : Pillai, *Proc. zool. Soc. Lond.*, 2 : 379.

Material examined : Many examples, Hugly-Matla estuary, Coll. B.P. Haldar and N. Bairagi, 21.xii. 1987-1988.

Host : Unknown.

Colour : Straw coloured with black scattered spots.

Diagnosis : Surface of head and first peraeon segment granulated and one prominent tubercle present in middle of head; a setiferous rounded tubercle on the anterior and posterior lateral margins; exopod of endopod subequal in length.

Distribution : West Bengal : South 24 Parganas; Camorta Is., Nicobars; Rameswaram.

Remarks : The species is recorded for the first time from this area.

Genus (2) *Exosphaeroma* Stebbing2. *Exosphaeroma parva* Chilton

1916. *Exosphaeroma parva* Chilton, *Mem. Indian Mus.* 5 : 890-891.

Material examined : 20 exs., Bakkhali, 21. xii. 1978, Coll: K.N. Reddy.

Host : Unknown.

Colour : Dark straw colour.

Diagnosis : Body dorsoventrally flattened, the last body segment broadly rounded; dorsal surface smooth; mouth parts, limbs and pleopods present but not distinct; uropod branches not exactly subequal in length.

Distribution : *India* : West Bengal : South 24 Parganas; Orissa : Maludai Kuda Island, Off Samal Island, Rambha. *Elsewhere* : Absent.

Remarks : The species is recorded for the first time from this area.

Family II. CYMOTHOIDAE

Diagnosis : Antennae short and reduced, without clear distinction between peduncle and flagellum; palp of maxillepedes always two jointed and the last joint long and narrow.

Key to Genera

- Postero-lateral angles of peraeonal somite prominently reduced
 *Nerocila* Leach
- Postero-lateral angles peraeonal somite not produced at all
 *Cymothoa* Fabricius

Genus (3) *Nerocila* Leach

3. *Nerocila phaeopleura* Bleaker

1857. *Nerocila phaeopleura* Bleaker, *Verh. nat. Ver. Nedrl. Indie*, 2 : 25.

Material examined : 20 exs., Canning, 22. ii. 1986, Coll. N. Bairagi.

Host : *Istiophrous platypterus* (Shaw and Noddar).

Colour : Brown or pale brown.

Diagnosis : Head quadrate, eyes distinct; first and second antenna composed of nine and ten articles; pleonic appendages with setae; inner margin of endopod of uropod not serrated.

Distribution : *India* : West Bengal : South 24 Parganas; Bay of Bengal. *Elsewhere* Absent.

Remarks : This is the first record from this area.

4. *Nerocila serra* Sch and Mein.

1881. *Nerocila serra* Sch and Mein, *Naturh. Tidsskr.*, (3) 13 : 18.

1936. *Nerocila serra* : Barnard, *Rec, Indian Mus.*, 38 : 163.

Material examined : 20 exs., Canning, 7. iv. 1987, Coll A. Misra.

Host : Unknown.

Colour : Straw colour.

Diagnosis : Head almost quadrate, cephalon broader than long, eyes distinct but small; first and second antennae composed of eight and nine articles; first five pleon segments subequal in length.

Distribution : *India* : West Bengal : Medinipur; Orissa, Andhra Pradesh. *Elsewhere* : South Africa; East Indies; Queensland.

Remarks : This species is recorded for the first time from this area.

5. *Nerocila madrasensis* Ramakrishna & Venkata Ramaniah

1978. *Nerocila madrasensis* Ramakrishna and Venkata Ramaniah, *Bull. zool. Surv. India*, 1:177-180.

1984. *Nerocila madrasensis* : Ghatak and Misra, *Bull. zoo. Surv. India*, 5 : 21-25.

Material examined : 7 exs., Sagar Island, Coll B.P. Haldar, 23. xii. 1987.

Host : *Strongylura strongylura* Van Hasselt

Colour : Yellowish with black stripes.

Diagnosis : Head triangular; eyes distinct and small; first and second antennae composed seven and nine articles; coxal plates well developed; endopod of uropod reaching beyond the apex of telson and margin of its ramus very finely serrate.

Distribution : *India* : West Bengal : South 24 Parganas; Orissa. *Elsewhere* : East Indies.

Remarks : This species is recorded for the first time from this area and found in abundance.

Genus (4) *Cymothoa* Fabricius

6. *Cymothoa indica* Sch and Mein.

1884. *Cymothoa indica* Sch and Mein, *Naturh. Tidsskr.*, 16 : 230.

1924. *Cymothoa indica* : Chilton, *Mem. Indian Mus.*, 5 : 887.

Material examined : 10 exs., Canning, 7. iv. 1984, Coll B.P. Haldar.

Host : *Glossogobius giuris* Hamilton

Colour : Dark brown

Diagnosis : Head subovate; eyes obscure; first and second antennae subequal in length and composed of eight and nine articles; uropod reaching almost to the level of hinder margin of telson; pleon abruptly narrower than peraeon.

Remarks : *Cymothoa indica* is closely resembles *Cymothoa limbata* in shape and size but it differs from the latter by its anterior margin of the telson not being truncate. This species is common.

Genus (5) *Cirolana* Leach

7. *Cirolana parva* (Hansen)

1890. *Cirolana parva* Hansen, *Vidensk. selsk Skr.*, 6 : *Rakke naturvidens, ogmathen Afd.*, 5 : 340-341.

1924. *Cirolana parva* : Chilton, *Mem. Indian Mus.*, 5 : 883.

Material examined : 10 exs., Kalnaghat, 13. iv. 1989; 30 exs., Majerchar, 7. i. 1989; 35 exs., Shibjange, 31. iii. 1989; 12 exs., north of Gadiwara, 31. iii. 1989, Coll B.P. Haldar and N. Bairagi.

Colour : Yellowish white.

Host : Unknown.

Diagnosis : Dorsal surface of the body smooth and pigmented; terminal segment not rounded; outer ramus of uropod slightly shorter and much narrower; all paraeopods ambulatory not prehensile.

Distribution : *India* : West Bengal : South 24 Parganas, Nadia, Hugli, Bardhaman; Orissa. *Elsewhere* : Sri Lanka; Gulf of Mexico; West Indies; Red Sea; East Indies.

Remarks : This species is recorded for the first time from this area and found in abundance.

SUMMARY

The present paper deals with seven species of isopods from the Hugli-Matla estuary, of them only *Nerocila madrasensis* Ramakrishna and Venkata Ramaniah, was reported earlier from this area. Remaining six species are recorded for the first time from this area. The diagnostic characters and key for identification of the genera and species of this group have been provided.

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HERMIT CRABS (CRUSTACEA : DECAPODA)

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INTRODUCTION

Hermit Crabs from Hugli-Matla Estuarine Complex find their mention in the publication of Alcock (1905) which is an earliest available monographic work on Indian hermit crabs. He reported six species from this area. Later publications on this group do not contain any mention of hermit crabs from this area. Hence, the present report assumes significance as it is based on over a thousand examples, collected subsequently from this area by different survey parties of Zoological Survey of India, Calcutta, and deposited in the Crustacea Section of the department. The present study added eight more species bringing the total to 14 species known from this area.

The present study area is at the head of Bay of Bengal and is traversed by River Hugli and its distributaries and is crisscrossed by big back water channels from the sea called by different names such as Matla River and includes a part of Sundarbans. A few sand heads are also found off the mouth of River Hugli. Material was collected from the banks of the river courses in the estuary, from the intertidal area near the river mouths and from sand heads found off the river mouths. Material from the adjoining beaches of Junput and Digha, where the influence of the estuary is felt to a large extent was also included to make the information as complete as possible.

List of Species Reported

Class	: CRUSTACEA
Order	: DECAPODA
Sub-Order	: PLEOCYEMATA
Infra Order	: ANOMURA
Super Family	: COENOBITOIDEA
Family	: DIOGENIDAE

1. *Clibanarius clibanarius* (Herbst)
- *2. *Cl. infraspinatus* Hilgendorf
3. *Cl. padavensis* de Man
- *4. *Cl. olivaceus* Henderson
5. *Diogenes diogenes* (Herbst)

6. *D. custos* (Fabricius)
 *7. *D. affinis* Henderson
 *8. *D. planimanus* Henderson
 *9. *D. avarus* Heller
 10. *D. costatus* Henderson
 *11. *D. investigatoris* Alcock
 *12. *Dardanus hessii* (Miers)
 Family : COENOBITIDAE
 *13. *Coenobita cavipes* Stimpson
 Super Family : PAGUROIDEA
 Family : PAGURIDAE
 14. *Spiropagurus spiriger* (de Haan)
 * New to the Hugli—Matla Estuarine Complex.

SYSTEMATIC ACCOUNT

Key to the Superfamilies and Families of hermit crabs from Hugli-Matla Estuarine Complex.

1. Bases of third maxillipeds not separated by any sternal plate.....
**Superfamily-Coenobitoidea**
 a) Antennular flagella end in a filament.....**Family-Diogenidae**
 b) Antennular flagella end abruptly and bluntly.....**Family-Coenobitidae**
2. Bases of third maxillipeds widely separated by a sternal plate
**Superfamily-Paguroidea**

Super Family : COENOBITOIDEA Dana, 1851

Family : DIOGENIDAE Ortmann, 1892

Key to the genera of the family, Diogenidae

1. Fingers of chelipeds opening and closing horizontally.....**Clibanarius**
 — Fingers of chelipeds opening and closing obliquely or nearly vertically.....2

- 2. Finger tips of chelipeds corneous, balckened and somewhat spooned.....*Dardanus*
- Fingertips of chelipeds calcareous and white, left cheliped vastly the larger, rostrum replaced by a moveable spine or lamina.....*Diogenes*

Genus : *Clibanarius* Dana, 1852

Key for the identification of *Clibanarius* species

- 1. Eyestalks shorter than the antennular peduncles2
- Eyestalks as long as the antennular peduncles3
- 2. Inner lower border of merus of chelipeds simply serrulate without any denticle or tooth*clibanarius*
- A strong tooth at the proximal end of the inner border of the merus of the chelipeds.....*infraspinatus*
- 3. Hands rough with spinules; red longitudinal stripes present on eyestalks, walking legs, though less distinct and sinuous on chelipeds*padavensis*
- Hands comparatively smooth with less no. of spinules ; red longitudinal stripes absent on eyestalks, walking legs and chelipeds.....*olivaceus*

1. *Clibanarius clibanarius* (Herbst)

1791. *Cancer clibanarius* Herbst, *Krabben*, 2 (i) : 20, pl. 23, fig. 1.

1905. *Clibanarius clibanarius* : Alcock, *Cat. Indian Decapod Crust.*, pt 2 (1) : 43, pl. 4, fig. 1

1989. *Clibanarius clibanarius* : Thomas, *J. mar. biol. Ass. India*, 31 (1 & 2) : 62

Material : 1 ex., Reg. No. 7922/9, Sandheads, Hugli River mouth, Pilot Milner. 1 ex., Reg. No. C-2808/1, Bank of River Hugli near Royal Botanical Gardens, Shibpur, Howrah ; K. C. Biswas. 4 exs., (12 mm. each) Reg. No. C-4327/2, Junput beach, 8. iii. 1966, K. V. Rama Rao.

Diagnostic characters : Eyestalks shorter than the antennular peduncles, reaching half or more than half of the last segment of the antennular peduncle but as long as the anterior border of the carapace or as the antennal peduncle.

Chelipeds equal, similar and their fingers opening and closing horizontally ; the carpus and chela have the inner border serrulated and the outer surfaces including fingers with tubercles ; tufts of bristles arise from the bases of these tubercles ; the merus has the upper and inner borders serrulate with tubercles on its outer surface.

Second and third pairs of legs with dactylus longer than propodus by one-third to half.

Colour : Spirit preserved specimens with reddish yellow or orange colour on carapace and legs ; faint stripes of reddish brown on legs and eyestalks.

Distribution : India—It is reported from the mouth of River Hugli, Sandheads and Junput (West Bengal) ; Kakinada (Andhra Pradesh) ; and Madras, Pondicherry, Cuddalore and Porto Novo (Tamilnadu). *Elsewhere* : It is reported from different coastal areas from West and South east coast of Africa to Philippines.

2. *Clibanarius infraspinatus* Hilgendorf

1869. *Clibanarius infraspinatus* Hilgendorf, V. D. Decken's *Reisen Ost Afr.* 3 (1) : 97

1905. *Clibanarius infraspinatus* : Alock, *Cat. Indian Decapod Crust.*, pt. 2 (1) : 44

1989. *Clibanarius infraspinatus* : Thomas. *J. mar. biol. Ass. India*, 31 (1 & 2) : 63

Material : 14 exs., Reg. No. C-4348/2, Digha, 3. ix. 1964, A. K. Dutta. 7 exs., (12-20 mm), Reg. No. C-4328/2, Digha, 6. ix. 1964, A. K. Dutta 4(F) (11-22mm) and 5(M) (13-19.5 mm), Reg. No. C-4329/2, Junput, 8. iii. 1966, K. V. Rama Rao. 8 exs., (13.5-18.5 mm), Reg. No. C-4349/2, Lykanikhal, E. of Digha Ghat, 6. viii. 1976, K. N. Reddy. 9 exs., (12-16.5 mm), Reg. No. C-4350/2, Junput, 7. viii. 1976, K. N. Reddy. 1(F) (10.5 mm), Reg. No. C-4351/2, West of Digha Ghat, 8. viii. 1976, K. N. Reddy. 1 ex., Reg. No. C-4331/2, Bakkhali, 11. iv. 1978, G. C. Rao. 2 exs., (5mm each), Reg. No. C-4330/2, Bakkhali, 11. xii. 1980, H. C. Ghosh.

Diagnostic characters : Eyestalks shorter than the antennular peduncles, antennal peduncles and also the anterior breadth of carapace.

Chelipeds equal ; merus with a strong tooth at the proximal end of the lower inner border, distal upper margin serrated ; carpus with three strong spines in a row on upper inner margin and with a few scattered spines on the rest of the upper surface.

Second and third pair of legs with dactylus longer than propodus. Outer surface of propodus of third left leg flatter than in *Cl. clibanarius*.

Colour : In spirit preserved specimens the carapace, chelipeds and pereopods brownish yellow with brownish red stripes on eystalks and walking legs.

Distribution : India—It is reported from the mouth of River Hugli, Junput and Digha (West Bengal) ; Waltair (Andhra Pradesh) ; Madras, Vellar estuary-Porto Novo, Palk Bay and Gulf of Mannar (Tamilnadu) and Beyt Island near Okha (Gujarat). *Elsewhere* : It is reported from different coasts from Red Sea to Australia.

3. *Clibanarius padavensis* de Man

1888. *Clibanarius padavensis* de Man *J. Linn. Soc. (Zool)*, 22, 1887-1888 : 242, pl. 16. fig. 1.

1989. *Clibanarius padavensis* : Thomas *J. mar. biol. Ass. India*, 31 (1 & 2) : 65

Material : 6 exs., Reg. No. 1853, Port Canning, Matla River, Sundarbans, J. Wood-Manson. 15 exs., Reg. No. 9170/10, Port Canning, Matla River, Sundarbans, Dec. 1914, N. Annadale. 13 exs. Reg. No. 5255/10, Port Canning, Matla River, Sundarbans, R. Hodgart. 2 exs., Reg. No. C-2809/1, Port Canning, Sundarbans, 8.3.1918, B. Prashad. 3(F) (17.3-18.8mm), Reg. No. C-4332/2, Canal Junction, Belgachia, Calcutta, 21.6.1917, S. C. Mondal. 3 exs., (10.5-22.5 mm), Reg. No. C-4336/2, Sajnekhali, Sundarbans, 7. viii. 1955, A. K. Mukherjee. 3 exs. (9-16.5 mm.), Reg. No. C-4337/2, Sajnekhali, Sundarbans, 22. iii. 1958, H. C. Ray. 30 exs., (8-16 mm.) Reg. No. C-4338/2, Lykani Khal, East of Digha Ghat, 6. viii. 1976, K. N. Reddy. 1(F) (8.5 mm.) Reg. No. C-4339/2, West of Digha Ghat, 8. viii. 1976, K. N. Reddy. 5 exs., (10-15mm) Reg. No. C-4340/2, Shola, West of Junput, 8. xi. 1977, K. N. Reddy. 1 ex., Reg. No. C-4341/2, Bakkhali, 11. iv. 1978, G. C. Rao, 5 exs., Reg. No. C-4342/2, Mandirtala, Sagar Id., 12. iv. 1978, G. C. Rao, 5 exs., Reg. No. C-4343/2, Kachuberia, Sagar Id., 13. iv. 1978, G. C. Rao. 25 exs., Reg. No. C-4344/2, Chemaguri Creek, Sagar Id., 14. iv. 1978, G. C. Rao. 2 exs., (13 & 18 mm), Reg. No. C-4345/2, Bakkhali, 21. xii. 1978, K. N. Reddy. 5 exs., Reg. No. C-3198/2, Arbesi Block, Sundarbans, 16. ix. 1983, A. K. Hazra, STRAS. * 3 exs., Reg. No. C-3199/2, Jhingakhali, Sundarbans, 13. ix. 1983, S. Biswas & A. Misra, STRAS. 2 exs., Reg. No. C-3200/2, Block-4, Matla Id., Sundarbans, 12. ix. 1983, N. C. Gayen, STRAS. 8 exs., Reg. No. C-3201/2, Block-4, Gosaba, Sundarbans, 14. ix. 1983, S. S. Saha, STRAS. 2 exs., Reg. No. C-3202/2, Bangadhuni Id., Kedo Block, Sundarbans, 18. ix. 1983, C. K. Misra, STRAS. 10 exs., Reg. No. C-3203/2, Baghmara, Sundarbans, 14-17. ix. 1983, S. R. Dey Sarkar. STRAS. 15 exs., Reg. No. C-4333/2, South Parghumti, Sundarbans, 9. ix. 1984, B. P. Halder. 5 exs. Reg. No. C-4334/2, Chhota Mollakhali, Sundarbans, 12. ix. 1984, B. P. Halder. 4 exs., Reg. No. C-4335/2, Gosaba, Sundarbans, 17. ix. 1984, B. P. Halder. 4 exs., Reg. No. C-3629/2, Canning, 10. iii. 1985, T. Roy. 4 exs., Reg. No. C-3630/2, Bhangon-Kalighat, Sundarbans, 11. iii. 1985, T. Roy. 9 exs., Reg. No. C-3631/2, Rajarhat Village, Sundarbans, 12. iii. 1985, T. Roy. 2 exs., Reg. No. C-3632/2, Durgaduani River, Gosaba, Sundarbans, 14. iii. 1985, T. Roy.

Diagnostic characters : Eystalks as long as the antennular peduncles but about one-sixth longer than the anterior border of the carapace.

Chelipeds equal, similar ; merus with 1 or 2 spinules at the distal end of the outer lower border ; carpus with a distinct spine at the distal end of the dorsal inner border.

Colour : In live specimens body yellowish green. Crimson coloured longitudinal stripes on chelipeds, walking legs, antennular peduncles and eystalks. In spirit preserved specimens the body becomes yellow and the stripes become red in colour.

Distribution : India—It is reported from the mouth of River Hugli , Sundarbans, Junput and Digha (West Bengal) ; Chilka Lagoon (Orissa) ; Waltair (Andhra Pradesh) ; and Adyar River mouth, Madras, Madras beach, Vellar estuary-Porto Novo, Athankarai estuary, $\frac{1}{N}$ Palk Bay, Rameswaram and Tuticorin (Tamilnadu). *Elsewhere* : It is reported at different coasts from South and Eastcoast of Africa to Australia.

4. *Clibanarius olivaceus* Henderson

1915 *Clibanarius olivaceus* Henderson, *Rec. Indian Mus.*, 11 : 26, figs. 3.

1935. *Clibanarius olivaceus* : Reddi, *Curr. Sci.*, 3 : 561.

Material : 34 exs., (4-7mm), Reg. No. C-4352/2, Lykanikhal, East of Digha Ghat., 6. viii. 1976, K. N. Reddy. 7 exs., Reg. No. C-4383/2. Mandirtala, West coast of Sagar Id., 12. iv. 1978, G. C. Rao. 1 ex., (10 mm), Reg. No. C-4353/2, Lykanikhal, East of Digha Ghat, 26. vi. 1983, A. K. Mondal. 1 ex., Reg. No. C-4346/2, Chhoto Mollakhali, Sundarbans, 13. ix. 1984, B. P. Halder. 1 ex., Reg. No. C-4347/2, Gosaba jetty, Sundarbans, 17. ix. 1984, B. P. Halder. 2 exs., (7.5 mm), Reg. No. C-4354/2, Junput, 24. ii. 1988, D. R. K. Sastry.

Diagnostic characters : Eystalks as long as the antennular peduncles but distinctly longer than the anterior border of the carapace.

Chelipeds sub-equal and similar. The hand with a few scattered granular tubercles and free of setae in comparison to *Cl. padavensis*. No spines on the entire palmar surface. The fingers rougher becoming spinous towards the tips and more setose than the palm. The length of the hand including the fingers is almost twice its breadth.

Colour : Spirit preserved specimens yellowish with the chelipeds and walking legs olive green. Eystalks with three pale red lines on the inner, upper and outer surfaces. No stripes on walking legs.

Distribution : India—It is reported from the mouth of Hugli River, Sundarbans, Junput and Digha (West Bengal); Chilka Lagoon (Orissa); Madras and Vellar estuary—Porto Novo (Tamilnadu) and Andamans.

Genus : *Diogenes* Dana, 1852

Key for the identification of *Diogenes* species

1. Rostrum is a narrow lamina, with the free edge spinose distally.....2
- Rostrum is a slender non-serrated spinule.....5
2. Antennal acicle bifurcate, inner branch reaches about halfway along the penultimate joint of the peduncle, outer branch just reaches or well beyond the base of the terminal joint of the peduncle3
- Antennal acicle obscurely bifurcate, the outer branch does not reach the base of the terminal joint of the peduncle.....4
3. Outer surface of the hand of the left cheliped with claw-shaped spines.....*diogenes*
- Outer surface of the hand of the left cheliped closely and finally granulous.....*custos*
4. Palm of the left cheliped higher than long.....*affinis*
- Palm of the left cheliped as long as high, the lower part of its outer surface flattened*planimanus*
5. Fixed finger of left cheliped deflexed.....6
- Fixed finger of left cheliped not deflexed, a single longitudinal row of spinules on upper part of outer surface of left palm. Antennal and antennular peduncles of equal length*investigatoris*
6. Eyestalks extending beyond the base of the terminal joint of the antennular peduncle, wrist and hand of left cheliped remarkably elongate.*avarus*
- Eyestalks hardly reach the base of the terminal joint of the antennular peduncle, a single obliquely-longitudinal crest on the outer surface of the left palm.*costatus*

5. *Diogenes diogenes* (Herbst)

1791. *Cancer diogenes* Herbst, *Krabben*, 2 (1) : 17, pl. 22. fig. 5.

1905. *Diogenes diogenes* : Alcock, *Cat. Indian Decapod Crust.*, pt. 2 (1): 62, pl. 15 fig. 3.

1989. *Diogenes diogenes* : Thomas, *J. mar. biol. Ass. India*, 31 (1 & 2) ; 71

Material : 1 ex., Reg. No. 8000/9, Sandheads, Hugli River mouth, Pilot, J. Daly. 1 ex., Reg. No. C-5495/1, Sandheads, Hugli River mouth, Jan., 1928, P. V. Lady Fraser.

Diagnostic characters : Rostrum long, about one-third the length of the eyestalks, with its distal half spinose. Antennular peduncle exceeds the length of anternal peduncle by about half of its terminal joint. Antennal acicle bifurcate, the opposed edges of the fork spinulose ; the outer prong barely reaches the base of the terminal joint, the inner prong reaches about mid way along the penultimate joint of the peduncle.

Chelipeds bear claw-shaped spines on the outer surface of the palm, edges of their joints spinose and setose, fingers of the smaller cheliped and the dactyli of 2nd and 3rd legs thickly plumose.

Distribution : India—It is reported from Sandheads—off the mouth of River Hugli (West Bengal) ; Orissa coast ; Waltair and Kakinada (Andhra Pradesh) ; Ennur, Madras, Cuddalore, Porto Novo, Nagapattinam, Point Calimere, Rameswaram, Krusadai Id., and Tuticorin (Tamilnadu) ; Mangalore (Karnataka) ; and Calicut and Azhicode (Kerala). *Elsewhere* : It is reported from Periya Paar on Sri Lanka's coast from Gulf of Mannar.

6. *Diogenes custos* (Fabricius)

1798. *Pagurus custos* Fabricius, *Ent. Syst. Suppl.* : 412.

1905. *Diogenes custos* : Alcock, *Cat. Indian Decapod Crust.*, pt. 2 (1) : 64, pl. 6, fig. 1.

1989. *Diogenes custos*: Thomas, *J. mar. biol. Ass. India*, 31 (1 & 2) : 73.

Material : Reg. No. 3157/5 Sandheads, mouth of River Hugli, Pilot J. Barnett. Regd. No. 8003/9 Sandheads, mouth of River Hugli, J. Barnett. Reg. No. 7912-21/9 Sandheads, mouth of River Hugli, Pilots Milner, Daly & West. Regd. No. 7980/9 Sandheads, mouth of River Hugli, Pilots Milner, Daly & West. Regd. No. 4361-2/10 Sandheads, mouth of River Hugli, Pilots Milner, Daly & West. 9 exs., Reg. No. C-5415/1 Sandheads, mouth of River Hugli, 1926-27, P. V. Lady Fraser. 20 exs., Reg. No. C-5472/1 Sandheads, mouth of River Hugli, 11. i. 1926, P. V. Lady Fraser. 24 exs., Reg. No. C-5490/1, Sandheads, mouth of River Hugli, 11. i. 1923, P. V. Lady Fraser. 5 exs., Reg. No. C-5473/1 Sandheads, mouth of River Hugli, Aug-Sept., 1927, P. V. Lady Fraser. 1 ex., Reg. No. C-5497/1, Sandheads, mouth of River Hugli,

26-viii.1922, P. V. Lady Fraser. 1 ex., Reg. No. C-5493/1, Sandheads, mouth of River Hugli, Jan., 1928, P. V. Lady Fraser. 2(M) (12 & 22.2 mm), Reg. No. C-4355/2, Digha, 7.iii, 1966, K. V. Rama Rao. 7 exs., (11.5-16.5 mm.) Reg. No. C-4356/2, Digha, March, 1980. A. Misra. 3 exs., (11-21.5 mm.) Reg. No. C-4357/2, Digha, 15-23. vii. 1982, G. C. Rao. 1 ex., Reg. No. C-4358/2, Lykani Khal, Digha, 20.ii. 1988, D. R. K. Sastry.

Diagnostic characters : Rostrum about half the length of the eyestalks with its free edge spinose. Antennular and antennal peduncles of equal length. Antennal acicle bifurcate, the outer prong extends well beyond the base of the terminal joint of the peduncle.

Chelipeds and exposed surface of legs finely granular ; borders of segments of chelipeds as well as the interior border of the four terminal joints of the 2nd and 3rd legs spinose. The granules on the outer surface of the propodus of 2nd and 3rd legs arranged in transverse rows.

Distribution : India—It is reported from Sandheads off the mouth of River Hugli and Digha (West Bengal) ; Waltair (Andhra Pradesh) ; Madras, Cuddalore, Porto Novo, Nagapattinam, Palk bay and Rameswaram (Tamilnadu), and Andamans. *Elsewhere* : It is reported from East Africa to S. E. coast of Australia and N. Pacific.

7. *Diogenes affinis* Henderson

1893. *Diogenes affinis* Handerson, *Tr. Linn. Soc. Zool.*, (2) 5 : 415, pl. 39, fig. 1,2.

1905. *Diogenes custos* var. *affinis* : Alcock, *Cat. Indian Decapod Crust.*, pt. 2 (1) : 65, pl. 6. fig. 2.

1972. *Diogenes custos* var. *affinis* : Sarojini & Nagabhushanam, *Rec. Zool. Surv. India.* 66 (1-4) : 259-261, text. fig. 3.

Material : 2(M) (10 mm each), Reg. No. C-4377/2, Sandheads, Mouth of River Hugli, Dec., 1940, Lt. Chas H. Potten, RINR. 1(M) (8 mm.), Reg. No. C-4378/2, Digha beach, 10. iii. 1966, K. V. Rama Rao. 2 exs., (3 & 11 mm), Reg. No. C-4379/2, Lykanikhal, East of Digha Ghat, 6. viii. 1976, K. N. Reddy.

Diagnostic characters : Rostrum shorter, but slightly longer than ophthalmic scales. Antennular peduncle shorter than the antennal peduncle. Antennal acicle indistinctly bifurcate and the outer prong does not reach the base of the terminal joint of the peduncle. Antennal flagellum thickly setose. In the left cheliped, the palm is broader than long.

Distribution : India—It is reported from Sandheads-off the mouth of River Hugli and Digha (West Bengal) ; Orissa coast ; and Madras (Tamilnadu). *Elsewhere* : It is reported from Burmese coast and from Madagascar (E. Africa).

8. *Diogenes planimanus* Henderson

1893. *Diogenes planimanus* Henderson, *Tr. Linn. Soc. Zool.* (2) 5 : 416, pl. 39, figs. 5 & 6.

1905. *Diogenes custos* var. *planimanus* : Alcock, *Cat. Indian Decapod, Crust.* pt. 2(1) : 66, pl. 6, fig. 3.

1972. *Diogenes custos* var. *planimanus* : Sarojini & Nagabhushanam, *Rec. Zool. Surv. India*, 66 (1-4) : 261, text fig. 3, fig. 4.

Material : 1(M) (10.7 mm) Reg. No. C-4380/2, Sandheads, Mouth of River Hugli, Dec., 1940, Lt. Chas H. Potten RINR. 1 ex., (6 mm), Reg. No. C 4381/2, Digha, 18. xi. 1964, P. K. Maity.

Diagnostic characters : Rostrum short, slender and slightly exceeding the ophthalmic scales. The palm of left cheliped as long as broad, lower portion of its outer surface flattened which is bounded posteriorly by a short ridge running parallel with the carpal articulation.

Distribution : India—It is reported from Sandheads—off the mouth of River Hugli and Digha (West Bengal) ; Orissa coast ; Waltair (Andhra Pradesh) ; and Madras and Rameswaram (Tamilnadu).

9. *Diogenes avarus* Heller

1865. *Diogenes avarus* Heller, *Novara Crust.*, 183, pl. 7, fig. 2.

1905. *Diogenes avarus* : Alcock, *Cat. Indian Decapod Crust.*, pt. 2(1) : 68, pl. 6, fig. 6.

1989. *Diogenes avarus* : Thomas, *J. mar. biol, Ass. India*, 31 (1 & 2) : 74.

Material : 12 exs., (7.3 mm. largest), Reg. No. C-4368/2, Digha, 6. ix. 1964, A. K. Dutta. 11 exs., (2-6 mm), Reg. No. C-4369/2, Digha, 18. xi. 1964, P. K. Maity. 6 exs., (3-6 mm), Reg. No. C-4370/2, Lykani Khal, East of Digha Ghat, 6. viii. 1976, K. N. Reddy. 90 exs., (2-6 mm.), Reg. No. C-4371/2, West of Digha Ghat, 8. viii. 1976, K. N. Reddy. 1 ex., (4mm), Reg. No. C-4372/2, Lykani Khal, East of Digha Ghat, 20. ii. 1988 D. R. K. Sastry. 200 exs., (7.3 mm, largest), Reg. No. C-4373/2, Junput, 8. iii. 1966, K. V. Rama Rao. 29 exs., Reg No. C-4374/2, Junput, 7. viii. 1976, K. N. Reddy. 238 exs., Reg. No. C-4375/2, Ganga Sagar, Sagar Id., 12. iv. 1978, C. C. Rao. 13 exs., Reg No. C-4376/2, Bakkhali, 10. iv. 1978, G. C. Rao.

Diagnostic characters : Eyestalks stout, reaching the middle third of the last segment of the antennular peduncles. Rostrum slender, shorter than ophthalmic scales. Antennal peduncles slightly shorter than antennular peduncles. Antennal acicle straight, barely reaching the base of the terminal joint of the peduncle.

Left cheliped stouter and vastly larger than the right, about two and half times the length of the carapace ; segments granulous, more finely on hand. Carpus longer than merus and palm. Palm one and half times as long as broad, its outer surface longitudinally carinated near the middle line, the carina gradually fading away before it reached the finger cleft. The fixed finger deflexed, dactylus less than half the length of palm.

Distribution : India—It is reported from the mouth of River Hugli, Junput and Digha (West Bengal) ; Chilka Lagoon (Orissa) ; Waltair (Andhra Pradesh) ; Ennur, Madras, Vellar estuary-Porto Novo, Rameswaram, Mandapam, Athankarai, Krusadai Id., and Kundugal (Tamilnadu) and Nicobar Is. *Elsewhere* : It is reported from the coasts of persian Gulf, Mergui (Burma), Philippines and Queensland (Australia).

10. *Diogenes costatus* Henderson

1893. *Diogenes costatus* Henderson, *Tr. Linn. So. Zool.*, (2) 5 : 418, pl. 39, figs. 7,8.

1905. *Diogenes costatus* : Alcock, *Cat. Indian Decapod Crust.*, pt. 2 (1) : 70, pl. 6, fig. 7.

1989. *Diogenes costatus* : Thomas, *J. mar. biol. Ass. India*, 31 (1 & 2) : 74

Material : 1 ex., (5 mm) Reg. No. C-5489/1, Sandheads, Hugli River mouth, II.i.1923, P. V. Lady Fraser 9 exs., Reg. No. 3150/5, Sandheads, Hugli River mouth, A. J. Milner. 1 ex., Reg. No. C-4359/2, West of Digha Ghat, 8. viii. 1976, K. N. Reddy. 7 exs., (2-5 mm), Reg. No. C-4360/2, Lykani Khal, East of Digha Ghat, 20. ii. 1988, D. R. K. Sastry.

Diagnostic characters : Rostrum slender and spine like, shorter than the ophthalmic scales, which are spinulose anteriorly.

Eyestalks hardly reach the base of the terminal joint of the antennular peduncle, but slightly surpass the same point in the antennal peduncle.

Left cheliped vastly larger than the right, fixed finger deflexed, the dactylus constituting a little more than two-thirds the total length of the hand ; all the borders of the merus and inner, anterior and lower borders of the carpus strongly serrated ; both borders of the palm straight, the upper border being strongly serrated, the lower border being serrated only in its proximal half ; upper edge of the dactylus serrated, the lower edge of the fixed finger smooth ; the outer surface of the palm traversed by a ridge which beginning at the lower proximal angle, runs up parallel with the carpal articulation and then curving continues upto the finger-cleft.

Distribution : India—It is reported from Sandheads—off the mouth of River Hugli and Digha (West Bengal) ; Waltair (Andhra Pradesh) and Porto Novo, Mandapam and Rameswaram (Tamilnadu).

11. *Diogenes investigatoris* Alcock

1905. *Diogenes investigatoris* Alcock, *Cat. Indian Decapod Crust.*, pt. 2 (1) : 71, pl. 6, fig. 9.

1906. *Diogenes investigatoris* : Southwell, Report Pearl Oyster Fisheries Gulf of Mannar, pt. 5 (35) : 211

Material : 7 exs., Reg. No. C-4361/2, Digha, 6. ix. 1964, A. K. Dutta. 13 exs., (2-5.5 mm) Reg. No. C-4362/2, Digha, 18. xi. 1964, P. K. Maity. 1 ex. Reg. No. C-4363/2, West of Digha Ghat, 8. viii. 1976. K. N. Reddy. 60 exs., (2-6 mm.) Reg. No. C-4364/2, Lykani Khal, East of Digha Ghat, 20.ii.1988, D. R. K. Sastry. 15 exs., (2-6 mm.) Reg. No. C-4365/2, Junput, 7. Viii. 1976, K. N. Reddy. 20 exs., Reg. No. C-4366/2, Gangasagar, Sagar Id., 12. iv. 1978, G. C. Rao. 5 exs., Reg. No. C-4367/2, Bakkhali, 11. iv. 1978, G. C. Rao.

Diagnostic characters : Very near to *D. costatus*. Antennal and antennular peduncles of equal length. Ophthalmic scales spinose throughout the free edge. Eystalks just reach the base of the terminal joint of the antennular peduncle as well as that of the antennal peduncle. Antennal flagellum thickly setose and the antennal acicle does not reach the base of the terminal joint of its peduncle.

Both the chelipeds thickly setose. Left cheliped short and stout, merus with a distinct spine at the proximal end of the lower inner border and with indistinct denticles on the lower outer border ; palm higher than long and the fixed finger not deflexed. A longitudinal row of spinules on the upper part of the outer surface of the palm.

Distribution : India—It is reported from the mouth of Hugli River, Junput and Digha (West Bengal) ; Visakhapatnam (Andhra Pradesh) ; Palk Bay and Gulf of Mannar (Tamilnadu) ; and Okha (Gujarat).

Genus *Dardanus* Paulson, 187512. *Dardanus hessii* (Miers)

1884. *Pagurus hessii* Miers, *Zool. H. M. S. Alert*, : 185,264, pl. 28, fig. A.

1905. *Pagurus hessii* : Alcock, *Cat. Indian Decapod Crust.* pt. 2 (1): 93 pl. 8., fig. 4

1989. *Dardanus hessii* : Thomas, *J. mar. biol. Ass. India*, 31 (1 & 2) : 69.

Material : 1 ex., Reg. No. C-5499/1, Sandheads, mouth of River Hugli, Jan., 1928, P. V. Lady Fraser, 1 ex., Reg. No. C-5500/1, Sandheads, mouth of River Hugli, April-May, 1922, P. V. Lady Fraser, 1 ex., Reg. No. C-5501/1, Sandheads, mouth of River Hugli, 26. viii. 1922, P.

V. Lady Fraser, 1 ex., Reg. No. C-5502/1, Sandheads, mouth of River Hugli, 11. i. 1925, P. V. Lady Fraser, 3 exs., Reg. No. C-5503/1, Sandheads, mouth of River Hugli, Feb-Mar, 1928, P. V. Lady Fraser, 1 ex., Reg. No. C-5504/1, Sandheads, mouth of River Hugli, Aug-Sept., 1927, P. V. Lady Fraser, 1ex., Reg. No. C-5507/1, Sandheads, mouth of River Hugli, 11.i. 1923, P. V. Lady Fraser, 2 exs., Reg. No. C-5508/1, Sandheads, mouth of River Hugli, Jan., 1928, P. V. Lady Fraser. 1(M) (27mm), Reg. No. C 4382/2, Sandheads, Mouth of River Hugli, Nov. Dec., 1940, Lt. Chas H. Potten, RINR.

Diagnostic characters : Eyes reniform. Eye stalks depressed, broad distally, reaching upto the middle of the terminal joint of the antennular peduncle, or as long as the anternal peduncle.

Chelipeds hairy and similar on both sides ; inner lower border of merus, inner upper borders of merus, carpus, propodus and dactylus of both the chelipeds with conspicuous claw-shaped spines ; outer surface of these joints with distinct spines arranged in 3 or 4 longitudinal rows.

Second and third legs look alike on both sides ; upper border of carpus and propodus with claw-shaped spines which continue less conspicuously on dactylus. Outer surface of the distal ends of dactylia thickly setose.

Distribution : India—It is reported from Sandheads—off the mouth of River Hugli (West Bengal) ; Orissa coast ; Visakhapatnam and Kakinada (Andhra Pradesh) ; and Porto Novo and Mandapam (Tamilnadu). *Elsewhere* : It is reported from Maldives to Philipines and in between from Burmese coast, Malaysian coast, Celebes Sea and Arafura Sea of Indonesia.

Family : COENOBITIDAE Dana, 1852

Genus : *Coenobita* Latreille, 1826

13. *Coenobita cavipes* Stimpson

1859. *Coenobita cavipes* Stimpson, *Proc. Acad. Nat. Sci. Philad.* : 245

1905. *Coenobita cavipes* : Alcock, *Cat. Indian Decapod Crust.* pt. 2 (1) : 146 pt. 14, fig. 1

1950. *Coenobita cavipes* : Barnard, *Ann. South African Mus.*, 38 : 470

Material : 1 ex., (35 mm), Reg. No. C-4239/1, Sea face of Sundarbans, Mr. Shaw. 1 ex., Reg. No. C-3204/2, Arbesi Block, Sundarbans, 16. ix. 1983, A. K. Hazra, STRAS * 2 exs., Reg. No. C3205/2, Chhota Hardi Block, Sundarbans, 13. ix. 1983, S. S. Saha, STRAS. 3 exs., Reg. No. C-3206/2, Bangadhuni Id., Sundarbans 18. ix. 1983, C. K. Misra, STRAS. 3 exs.,

Reg. No. C. 3207/2, Baghmara, Sundarbans, 11. ix 1983, S. Chattopadhyay, STRAS. 1 ex.,
Reg. No. C-3208/2, Mechua Khal, Sundarbans, 13. ix. 1983, S. Chattopadhyay, STRAS.

Diagnostic characters : Eye stalks compressed, dorsally punctate, reaching the base of the terminal joint of the antennular peduncle and nearly to the middle of the last joint of the antennal peduncle. Ophthalmic scales narrow and acute.

Antennal acicle fused with the second joint of the peduncle. Chelipeds and legs relatively smooth. Upper part of the outer surface of the left palm without any oblique file of upright laminar teeth (stridulating mechanism, a characteristic feature of *C. rugosus*) but studded with vesicular granules with Corneous tips ; the lower part quite smooth. Meri of both the Sundarban Tiger Reserve Area Survey chelipeds finely rugulose, the carpi punctate, the upper part of their outer surface and the right palm with some vesicular corneous tipped granules. A thick brush of long hairs on the upper part of the inner surface of both palms.

In the 3rd left leg, the outer surface of the propodus nearly flat and not separated from the anterior surface by a crest, the dactylus somewhat compressed and its outer surface flat. Coxae of the 5th pair of legs slightly prominent on the left side than on the right more so in males than in females.

Distribution : India—It is reported from the southern Part of Sundarbans (West Bengal) ; Chilka Lagoon (Orissa) ; Madras, Porto Novo and Krusadai Id. (Tamilnadu) and Andaman & Nicobar Is. *Elsewhere* : It is reported from east coast of Africa, Red Sea, Indo-Pacific to West Coast of America.

Super Family : PAGUROIDEA Latreille, 1803

Family : PAGURIDAE Latreille, 1803

Genus : *Spiropagurus* Stimpson, 1858

14. *Spiropagurus spiriger*. (de Haan)

1849. *Pagurus spiriger* de Haan, *Faun. Japon Crust.*, 206, pl. 49, fig. 2

1859. *Spiropagurus spiriger* : Stimpson, *Proc. Acad. Nat. Sci. Philad.*, : 248

1905. *Spiropagurus spiriger* : Alcock, *Cat. Indian Decapod Crust.* pt. 2 (1) : 118 pl. 13, fig. 1.

Material : 15 exs., Reg. Nos. 3156/5, 7911/9, Sandheads, mouth of River Hugli, Pilots Barnett and Milner.

Diagnostic characters : Eyes large, reniform. Eyestalks short, broad with transverse ciliated lines dorsally, reaching the base of the last joint of the antennular as well as the antennal peduncles. Dorsal surface of the antennal peduncles squamose in appearance. Antennal acicles setose and curved away from the eyes.

Chelipeds slender, fingers opening horizontally, joints covered with squami form ciliated markings ; carpus spinose in the distal half of the inner border and with a row of spines on the distal part of the outer surface.

Second and third legs with some what broader joints of merus, carpus and propodus having ciliated squamiform markings on the outer face. These markings on propodus and carpus run obliquely. Gills Phyllobranchiate.

No paired abdominal appendages in both sexes, but males with three and females with four appendages on left side only. In males the left vas deferens, relatively enormous in size and forms a coil of two nearly complete turns.

Distribution : India—It is reported from Sandheads off the mouth of River Hugli (West Bengal); Orissa coast; and Madras and Porto Novo (Tamilnadu).

Elsewhere it is reported from the coasts of Red Sea, Sri Lanka, Indonesia, Philippines, China and Japan.

Observations : Hermit crabs are mostly marine forms and a very few can tolerate the estuarine conditions and none the purely fresh water conditions. Out of the 14 species known from this area one species, *Coenobita cavipes* with its terrestrial habits is confined to the southern islands in the estuary, while another species, *Clibanarius padavensis* which could tolerate extreme fluctuation in salinity established itself throughout the estuary and it is followed by *clibanarius olivaceus*. Another three species *Clibanarius infraspinatus*, *Diogenes avarus*, and *D. investigatoris* could be collected in the muddy-sand areas near the river mouths.

Distribution of the species in the three distinct zones of Hugli-Matla Estuarine Complex viz., Estuary proper including Sundarbans, Sandheads found off the mouth of River Hugli and the beach area of Junput and Digha found west of the mouth of River Hugli is given in the table.

Good accounts of hermit crabs from the brackish waters of Chilka Lagoon and Vellar estuary-Porto Novo are available from the literature. Henderson (1915) and Kemp (1915) reported seven species from Chilka Lagoon. Of them three species *Clibanarius padavensis*, *Cl. longitarsus*, and *Cl. olivaceus* were considered as permanent inhabitants of the lagoon as they are found in the main body of the lagoon throughout the year. Another three species, *Diogenes avarus*, *Coenobita cavipes* and *C. rugosus* were found as casual visitors in the outer channel which connects the mainbody of the lagoon with the sea, where conditions were more of saline during major part of

DISTRIBUTION OF THE SPECIES IN THE THREE DISTINCT ZONES OF HUGLI-MATLA
ESTUARINE COMPLEX

Sl. No.	Name of the species	Hugli-Matla Estuary proper	Sandheads	Junput & Digha beach
1.	<i>Clibanarius clibanarius</i> (Herbst)		x	x
2.	<i>Cl. infraspinatus</i> Hilgendorf	x		x
3.	<i>Cl. padavensis</i> de Man	x		x
4.	<i>Cl. olivaceus</i> Henderson	x		x
5.	<i>Diogenes diogenes</i> (Herbst)		x	
6.	<i>D. custos</i> (Fabricius)		x	x
7.	<i>D. affinis</i> Henderson		x	x
8.	<i>D. planimanus</i> Henderson		x	x
9.	<i>D. avarus</i> Heller	x		x
10.	<i>D. costatus</i> Henderson		x	x
11.	<i>D. investigatoris</i> Alcock	x		x
12.	<i>Dardanus hessii</i> (Miers)		x	
13.	<i>Coenobita cavipes</i> Stimpson	x		
14.	<i>Spiropagurus spiriger</i> (de Haan)		x	

the year but have extreme fluctuation in salinity in certain part of the year. The latter two species with their terrestrial habits crawl on the shores and are less affected by the salinity fluctuations of the water. One species, *Diogenes miles* was found on the sea shore near the lagoon.

Ajmal Khan & Natarajan (1984) reported 20 species from Porto novo waters. Of them, the following six species were found to be estuarine and were collected from Vellar estuary proper.

Clibanarius padavensis

Cl. longitarsus

Cl. olivaceus

Cl. infraspinatus

Diogenes avarus

Coenobita cavipes

The remaining 14 species were collected from the nearby coastal waters of Porto Novo.

In all the above brackish water areas, four species viz., *Clibanarius padavensis*, *Cl. olivaceus*, *Diogenes avarus*, *Coenobita cavipes* were found to be common. *Clibanarius longitarsus* found at Chilka Lagoon and Vellar estuary is not encountered in the Hugli-Matla estuary. *Cl. infraspinatus* found at Hugli-Matla Estuary and Vellar Estuary was not encountered at Chilka Lagoon. *Coenobita rugosus*, a hermit crab with terrestrial habits found at Chilka Lagoon was not encountered at Hugli-Matla Estuary and Vellar Estuary.

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CRUSTACEA : XANTHIDAE

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INTRODUCTION

The earliest works on the Indian crabs dates back to 1884, when Wood-Mason studied these animals from Bengal. Studies were continued by Alcock (1894-1910) which culminated in the publication of six volumes of Carcinological Fauna.

Kemp (1915-1924) worked on the crabs of the rivers of lower Bengal (Hugli, Matla, Piyali, Vidyadhari), Chopra (1933-1935) worked on the material brought by Bengal Pilot Service from the mouth of river Hugli, Sandheads and Hora (1933-1935) dealt with estuarine crabs of lower Bengal.

In 1960 Banerjee, Published one paper on Grapsid crab of the Snellius expedition XVIII. Contributions have also been made by Deb. (1972-1990) on this group (12 papers + 4 papers in press). Choudhury *et al* (1981-1992), Nandi and Ghatak (1985), Bairagi and Misra (1988) made some contributions to this group in recent years.

The study of these animals is far from complete and there is much scope to study as they form additional source for protein.

In the present communication 13 species of 9 genera of crabs belonging to the family Xanthidae have been dealt. One species is newly recorded.

List of Xanthidae Crabs from Hugli Matla estuary—

Class : CRUSTACEA
Order : DECAPODA
Sub Order : BRACHYURA
Family : XANTHIDAE

Diagnosis : Carapce as long as or broader than long; variously shaped, may be broadly oval or hexagonal or subquadrate or small, thin subcircular. Antennules fold transversely or obliquely. Anterior boundary of buccal cavity sharp and raised, so the external maxillipeds shut close against that raised ridge. Front broad, not like spiny rostrum of prawns. Appendages used for walking and picking food but stout cheipeds are also used for fighting with enemies and self protection.

1. *Eurycarcinus bengalensis* Deb
2. *Erycareinus grandidieri* Edw.
3. *Erycarcinus maculatus* Edw.
4. *Heteropanope neolavis* Deb
5. *Heteropanope Indica* de Man
6. *Galene bispinosa* (Herbst)
7. *Galene granulata* Miers
8. *Halimede tyche* (Herbst)
9. *Parapanope hextii* (Alcock)
10. *Myomenippe hardwickii* (Gray)
11. *Menippe rumphii* (Fabr.)
- * 12. *Heteropilumnus ciliatus* Stimpson
13. *Liagore rubromaculata* De Haan

Key to the genera of Xanthidae crabs of river Hoogly-Matla estuary.—

1. Ridges of efferent branchial channel faint, never reach to the anterior boundary of buccal cavity 2
 Ridges of efferent branchial channel not faint, extend up to the anterior boundary of buccal cavity 6
2. Abdomen of adult male 7 jointed 3
 Abdomen of adult male 5 or 6 jointed 4
3. Small, hexagonal crab, surface granular, hairy, front narrow, square cut; regional lobules well outlined, wrists and palms of chelae covered with raised flattened tubercles ***Halimede***
 Small subcircular hairy crab, middle of carapace crossed by two transverse parallel rows of short granular hairy ridges, four acuminate anterolateral teeth, outer surface of chelipeds smooth.....
***Heteropanope***.
4. Antero-lateral sides of carapace without teeth or spines: smooth, convex broadly oval crab***Liagore***
 Antero-lateral sides of carapace dentate 5

5. Three antero-lateral uniform tubercles or spines present; minutely granular dorsal surface of convex crab *Galene*
- Last antero-lateral tooth laterally directed; large spine; thin, depressed, hexagonal leaf-like crab *Parapanope*
6. Strongly convex, large minutely granular brown crab, stout unequal chelae, fingers dark; four sharp antero-lateral teeth 7
- Small convex or flat crab surface smooth or hairy or transverse granular ridges present on carapace 8
7. Front with 4 teeth *Menippe*
- Front with 6 teeth *Myomenippe*
8. Smooth, broad oval crab, four low antero-lateral teeth *Eurycarcinus*
- Small, subquadrilateral, hairy crab, hairs silky long, yellow on front part of edges; two or three antero-lateral spinules present *Heteropilumnus*

Genus I. *Heteropanope* Stimpson

1858. *Heteropanope* Stimpson, *Proc. Acad. Nat. Sci. Phil* 10 : 35;

1898. *Heteropanope* : Alcock 1898 : 207; Sakai 1976 : 502; Deb. 1994; (in press)

Diagnosis : Small, convex crab, subcircular or slightly broader shape; regions faintly indicated; surface often adorned with short pieces of transverse granular, hairy ridges; front one third to one-fourth of maximum width of carapace, bilaminar, free edge entire, sharp; chelipeds unequal, colour of fingers dark or white; male abdomen seven jointed.

Key to Species of *Heteropanope*

- 1 Four antero-lateral teeth, spine-like *H. indica*
- Last two antero-lateral teeth, spine like *H. neolaevis*

1. *Heteropanope indica* de Man

1887. *Heteropanope indica* de Man, *J. Linn. Soc. Zool.*, : 53; Alcock 1898 : 208

Material examined : 1 ex., Matla river 1915, S.W. Kemp.

Diagnosis : Dark brown, small, scantily hairy crab, sub-circular in shape, two-thirds as long as wide; granular hairy small ridges in two parallel rows crossing the carapace transversely, rising from the base of third and fourth antero-lateral teeth which are four in number; Front convex, bilobed, outer angle dentiform, well separated, chelipeds markedly unequal, only outer-surface of the smaller chela granular; leg joints hairy.

Remarks : This mud crab can easily be separated from its nearest allies for the presence of two parallel, discontinuous, transverse, granular, hairy ridges on mid-dorsal surface of carapace. Status : Rare.

Distribution : *India* : West Bengal : Hugli-Matla; Sandhead Salt Lake, east and west coast of India; Andamans. *Outside India* : Mergui; Japan.

2. *Heteropanope neolaervis* Deb

Heteropanope nedaervis Deb, State Fauna Series of West Bengal, pt....(in Press) :

Material examined : 50 exs, Matla river, S.W. Kemp, 1915; lex, Kachuberia, 16.vi.1976, A Misra.

Diagnosis : Crab small, dark brown convex, broadly hexagonal in shape, surface covered with minute granules and short hairs, front bilobed, horizontal, sharp edged, smooth, rounded outer corners; antero-lateral teeth 4 in numbers, 1st & 2nd teeth low, edges crenulate, last two teeth spine-tipped, a granular transverse raised ridge extend on middle of carapace from the last tooth; chelipeds marked by unequal outer surfaces of smaller hand granular.

Distribution : *India* : West Bengal : Matla river, Sundarban area.

Remarks : Anteriorly the crab is very broad owing to its horizontal first antero-lateral teeth, posterior edge is almost half of the anterior edge. *Markedly unequal chelipeds*, cutting edges of fingers of larger chela is dentate.

Genus II. *Eurycarcinus* A. Milne-Edwards

1867. *Eurycarcinus* A. Milne Edwards, *Ann. Soc. Entomol. France*, Vii : 276.

1987-88. *Eurycarcinus* de Man *J. Linn. Soc. Zool.*, 22:43; *Deb in State Fauna of West Bengal*. (in press)

Diagnosis : Very common during low tide, accessible at mid-littoral zone in the mangrove patch, living in burrows on the ground or on decomposed logs; carapace smooth; small, dark brown, very convex, thick crabs, leg joints with few lank hairs only; chelipeds markedly unequal. front low straight, square; antero-lateral teeth low, four in number.

Key to Species of genus *Eurycarcinus*

1. Fingers with larger teeth on their cutting edges.....
 A large tooth present at base of cutting edge of thumb of larger cheliped only
 *E. maculatus*
 Cutting edges of both the Fingers with one larger and few smaller teeth
 *E. bengalensis*
2. Cutting edges of Fingers without larger teeth..... *E. grandidieri*

3. *Eurycarcinus maculatus* (A.M. Milne-Edwards)

1867. *Pilumnopus maculatus* A Milne Edwards, *Ann Soc. Entomo France*, 1 : 277

1994. *Eurycarcinus maculatus* Deb. State Fauna. West Bengal (In press)

Material examined : 8 exs., Jharkhali, 4-ii-1986, B.P. Halder; 11 exs., Sagar Is., 24-xii-1987, B.P. Halder, 6 exs., Bakkhali beach, 3-iv-87 and 18-xii-87, B.P. Halder.

Diagnosis : Carapace 10mm long, 13 mm wide, front 4 mm, convex thick and smooth but few minute granules may be present near the periphery; of the four antero-lateral teeth, 1st one low, 2nd one angular, 3rd & 4th teeth spinelike; present one minutely granular transverse ridge from last antero-lateral teeth-obliquely forward on carapace; Front faintly bilobed and low; chelipeds unequal, smooth.

Remarks : Small, thick, brown, smooth crab with oblique transverse low granular ridges present on mid dorsal surface arc sufficient enough to separate *E. maculatus* at a glance.

Distribution : *India* : West Bengal : Hugli Estuary, Sundarbn; East coast of India; Goa. *Outside India* : Mergui and Zanzibar.

Status : This species occur in abundance near estuarine and river mouth only.

4. *Eurycarcinus grandidieri* A. Milne Edwards

1867. *Eurycarcinus grandieieri* A. Milne Edwards, *Ann. Soc. Entom. France*, VII : 277.

1986. *Eurycarcinus grandidieri*, Chakrabarty, Choudhury & Deb, *J. Bengal Nat. Hist. Soc.*, 5 : 64.

Material examined : 4 males and 3 females, Sagar Is., Luthian Is. & Prentice Is. S.Chakrabarty in 1981-85; 8 exs., Canning 18-V-85; B.P. Halder; 5 exs. Champatala, Sagar Is. 7.xi.1975. A. Misra; Few exs. Sajnakhali Basanti, 21.vi.86, B.P. Halder; 3 exs. from Matla river, Launch Jetty, Canning 12-iii-85, T. Roy.

Diagnosis : Small, dirty brown colour, convex (16mm wide, 12mm long) Crab. Front square cut, 5 mm. Supra-orbital edge entire, lower edge finely crenulate; four antero-lateral teeth, edges being little thickened; chelipeds unequal, perfectly smooth, inner angle of wrist bluntly angular, thumb of cheliped without any enlarged tooth at its base. Except larger palm entire body covered with short dense fine soft hairs; or (algae) both the fingers brown coloured.

Remarks : *E. grandidieri* specimens lack the oblique mid-dorsal granular ridge from last antero-lateral teeth and the large tooth at the base of thumb of larger chela.

Status : Very common in mud and mangrove swamps.

Distribution : *India* : West Bengal : Sundarbn-West Bengal coast ; Nicobar. *Outside India* : From East Africa and Red Sea to Japan; Tahiti and New Zealand.

5. *Eurycarcinus bengalensis* Deb

1994. *Eurycarcinus bengalensis* Deb, State Fauna: West Bengal (In press).

Material examined : 5 exs., Matla river, Dec. 1916, S.w.Kemp.; 1 ex.. Sundarban, 10-xii-1917, B.Prashad; 1 ex. Sundarban, Sta. 20, 20-vii-1918, B.Prashad, 3 exs.Champatala, 7-xi-1975, A. Misra; 1 ex. Tiger Project Jetty, Gosaba, 25-v-1975, B.P. Halder; 3 exs., Matla river, 12-iii-1985, T.Roy; 8 exs., Canning Launch Ghat, 18-v-1985; 2 exs., Jharkhali Launch Ghat, 4-ii-1986 and 1 ex. Jharkhali fish firm, 1 ex., Baghmara, S.R.Day Sarkar.

Diagnosis : Dark brown fingers of unequal chelipeds, crabs broadly oval, convex, light brown, covered always with velvety hairs, thick; surface smooth; teeth low, obscure, four in numbers on antero-lateral sides; free frontal edge entire, sharp and faintly concave.

Distribution : *In India* : West Bengal : Sundarban *Outside India* : Absent.

Remarks : The crabs are much broader and longer than *E.maculatus*, lacks the oblique ridge on carapace and its fingers are dark brown coloured.

Genus III *Galene* De Haan

1833. *Galene* De Hann : *Fauna Japonica* : 19; Alcock 1898: 136; : 441; Deb, State Fauna West Bengal (in Press).

Diagnosis : Broad, thick, granular crab, roughly quadrilateral in shape; regions ill defined; last two or three antero-lateral teeth tubercular or little elongate; front narrow, bilobed or four dentate; chelipeds stout, unequal in both the sexes, smooth or rough, finger tips pointed; male abdomen seven jointed, separate and distinct.

Key to Species of *Galene*

Mid-dorsal surface of carapace smooth*G.bispinosa*

Entire carapace profusely granular*G. granulata*

6. *Galene bispinosa* (Herbst)

1834. *Cancer bispinosus* Herbst, *Krabben*, 1 : 144

1994. *Galene bispinosa* Dcb, State Fauna : West Bengal (in Press)

Material examined : 9 exs., from Matla river and Sandhead. 1923, Coll. Lady Fraser.

Diagnosis : Carapace broad, convex, thick somewhat pentagonal in shape; surface smooth only mid dorsally; antero-lateral sides with four tubercles, 1st tooth obsolete; unequal chelipeds either smooth or rough.

Remarks : Mid-dorsal surface of carapace is smooth. Last two or three teeth on the antero-lateral sides prominent and tubercular, 1st tooth obsolete.

Distribution : *India* : West Bengal Coast, Waltair. *Outside India* : Hongkong, Japan and Tenasserim.

Status—Rare

7. *Galene granulata* Miers

1848. *Galene granulata* Miers, "A lert Crustacea" : 208.

1935. *Galene granulata*, Chopra. *Rec. Ind. Mus.* 37 : 510.

1994. *Galene granulata* Dcb, *State Fauna, West Bengal* (in Press)

Material examined : 2 females from Sandhead, Coll. Lady Fraser in 1925, 1928.

Diagnosis and Remarks : Very close to *G. bispinosa* but for the followings (a) Profusely granular surface of crab, (b) Three distinct teeth on antero-lateral sides and (c) Of four frontal teeth inner pair more prominent.

Distribution : *In India* : West Bengal ; Sandhead; Mouth of River Hugli. *Outside India* : Singapore, Port Darwin in N.Australia.

Status : Rare

Genus IV *Halimede* De Haan

1835. *Halimede* De Haan : 35; ref. *Deb in State Fauna, West Bengal* (In press)

1900. *Litochira* Alcock : 313

Diagnosis : Carapace hexagonal in shape, slightly convex medially, regions well outlined; front narrow, bilaminar, of the four antero-lateral teeth first tooth obsolete, last two teeth prominent; chelipeds unequal in both the sexes, upper and outer surfaces of wrists and palms covered with raised flattened tubercles. leg joints hairy.

8. *Halimede tyche* (Herbst)

1801. *Cancer tyche* Harbst, *Crabben and Kerbse*, 3 : 35.

1994. *Halimede tyche*, Deb. West Bengal State Fauna (In Press).

Material examined : One male from Sandhead, Lady fraser, March 1928.

Diagnosis : Small, hexagonal, flalish, thin crab, surface granular, hairy; front bilaminar, free frontal edge crenulate ; of the three antero-lateral teeth first tooth smaller, third tooth largest; chelipeds subequal, outer surfaces of wrists and palms covered with raised flattered tubercles.

Remarks : Surface granules are large, tubercular.

Distribution : *In India* : Sandheads, Krusadi Island, Tuticorin. *Outside India* : Gult of Siam and Hongkong.

Status : Rare

Genus V *Parapanope* De Man

1895. *Parapanope* De Man, *Zool. Jb (Syst)* 8 : 513.

1898 *Hoploxanthus* Alcock, *J. Asia. Soc. Bengal*, 67 (11 : 1) 67-223

Diagnosis : Broad carapace, hexagonal in shape owing to its large, spine like last tooth of antero-lateral side, moderately convex, regions clearly outlined, covered with short, soft hairs and often granules.

9. *Parapanope hextii* (Alcock)

1898. *Hoploxanthus hextii* Alcock : 126.

1985. *Parapanope hextii* Guinot, *Bull Mus. Natn. Hist. Nat. Paris*, 4 : 683.

Material examined : 3 exs. Sandheads, mouth of river Hughly;1923, *Coll.* Lady Fraser.

Diagnosis : Thin, hexagonal and moderately broad convx crab; regions distinct, their summits finely granular under soft hairs. front bilaminar, square; antero-lateral sides thin, four lobed, lastlobe large, horizontal long spine like; chelipeds slightly uncqual.

Distribution : In India : Sandheads, Nicobar Islands. Outside India : Malacca Strait; Indian Ocean; Java and China Sea.

Status : Occasional and rare.

Remarks : Hexagonal shape. granular regional summits, nature of antero-lateral teeth are very distinctive.

Genus VI *Menippe* De Haan

1833. *Menippe* De Haan, *Fauna Japon. Crust* : 21.

1898 *Menippe* Alcock : 178; *Deb, State Fauna, West Bengal (In Press)*.

Diagnosis : Large, convex, transversely oval crab; four acuminate antero-lateral teeth present; chelipeds very stout, slightly unequal, dark fingers stout, pointed at tips; abdomen of male with all seven joints distinct.

10. *Menippe rumphii* (Fabr.)

1793. *Cancer rumphi* Fabricius, *Suppl. Entom. Syst.* : 572.

1994. *Menippe rumphii* Deb, *West Bengal, State Fauna (In Press)*.

Material examined : Several large brown crabs from Sandheads and Bay of Bengal, coast of West Bengal, Coll. P.V. Lady Frase, 1923-1925.

Diagnosis : Broad, large thick convex crab, proto and mesogastric areas well outlined; front 1/5 of the greatest width of carapace, two rounded lobes, teeth like, with tubercular outer angles. Four sharp antero-lateral teeth, last two teeth prominent; chelipeds very stout slightly unequal, fingers dark brown coloured, short and stout.

Remarks : Presence of only four frontal teeth.

Distribution : In India : Sandheads, Bay of Bengal, Tamil Nadu. Outside India : Karachi; Persian Gulf; Srilanka, Laccadives; Penang; Tavoy and Mergui.

Status : Common in Bay of Bengal.

Genus VII *Myomenippe*, Hilgendorf

1878. *Myomenippe* Hilgendorf, *MB. Ak. Berl.* : 795; Alcock 1898 : 179

Diagnosis : A close ally of *Menippe*, but, differs (1) in the orbits being a close cavity, hence the antennary flagellum is quite excluded from the orbit, and (2) front six lobate.

11. *Myomenippe hardwickii* (Gray)

1831. *Myomenippe hardwickii* Gray, *Zool. Misc.* London : 39

1984. *Myomenippe hardwickii* Serene, *Crust. Decap. brach* : 307.

Material examined : Several specimens, Sandheads, Bay of Bengal Coll. P. V. Lady Fraser in 1892; one Juvenile specimen, Sagar Is. 1984. A. Misra.

Diagnosis : Crab, Large, brown, thick, subcircular or little broader than long; only granular protogastric and mesogastric areas outlined. epibranchial region rugose; four antero-lateral sharp angular teeth. front bilobed, each lobe three denate ; cheliped as in *M. runghii*.

Remarks : Presence of six frontal teeth and completely closed orbital cavity of the crab differentiate it from *M. runghii*.

Distribution : *In India* : Sandheads, Bay of Bengal, Port Okha. *Outside India* : Akyab Harbour; Arakan; Mergui; Diamond Is and Singapor.

Status : Rare.

Genus VIII *Liagore* De Haan

1833. *Liagore* De Haan *Fauna Japonica* : 19; Alcock 1898 : 93; Deb State Fauna, West Bengal (In Press).

Diagnosis : Carapace, smooth Convex, broad, regions not indicated, no antero-lateral teeth; chelipeds equal in both the sexes, finger tips pointed. male abdomen five jointed, 3-5 joints fused

12. *Liagore rubromaculata* De Haan

1833. *Cancer (Liagore) rubromaculata* De Haan, *Fauna Japan crista* : 49.

1994. *Liagore rubromaculata* Deb, State fauna, West Bengal (In Press).

Material examined : Two females, Sandhead, Nov. 1923 Lady Fraser.

Diagnosis : Quadrilateral or broad, transverse, oval thick crab, surface smooth; freshly preserved specimen in spirit yellowish brown, with many red symmetrical spots; antero lateral sides of carapace sharp, entire, faintly four lobed, front bilobed; chelipeds equal, slender, smooth; leg joints long narrow, bare.

Remarks : Squarish shape, surface smooth, with red, symmetrical small spots in fresh condition are the main distinguishing features of the species.

Distribution : In India : West Bengal : Sandheads, Outside India : Irrawaddy delta, Persian Gulf; Hongkong; China and Japan.

Status : Rare.

Genus IX *Heteropilumnus* De Man

1895. *Heterpilumnus* De Man. *Zool Jb. (Syst)* 8 : 527: Deb. State Fauna West Bengal (In Press).

1900. *Litochira* Alcock : 313 *J. Asia. Soc. Bengal* 67 (11 : 1) 67-233.

Diagnosis : Small squarish crab, appendages thickly hairy; regions not indicated. antero-lateral teeth 2 or 3 small or spiny. front narrow, bilobed, rounded. chelipeds sub equal; leg joints compressed; male abdomen occupies the whole space between the last pair of legs.

13. *Heteopilumnus ciliatus* (Stimpson)

1833. *Pilumnoplax ciliatus* Stimpson. *Proc. Acad. Nat. Sci. Philad.* 10 : 91

1933. *Heteropilumnus ciliatus* Sakai, *Crabs of Japan & Adjacent Seas* : 492.

Material examined : One ex; Sundarban, Coll. C. De, 1979, Measuring width 12 mm.

Diagnosis : Small, hairy, subquadrilateral crab, anterior-third broad, convex, posterior half of carapace flat, depressed. Post frontal ridge and antero-lateral sides of crab fringed with very long yellow silky hairs, other parts covered by short valvety hairs ; front obliquely bilobed, outer angle rounded; anterolateral sides of carapace four lobed; chelipeds and leg joints thickly fringed with very long fine yellow silky hairs.

Remarks : Subquadrilateral, profusely hairy, posterior half of carapace flat and depressed, all these are unlike the other allied species.

Distribution : In India : West Bengal : Canning and Sundarbans, Andamans.

Outside India : China; Korea; Japan and Simoda.

Status : Rare.

SUMMARY

Present paper deals with the 13 species including one new record of Brachyura crabs belonging to the family Xanthidae from Hugli-Matla estuary. Crab fauna of coastal West Bengal comprises 116 species fresh-water and hill stream crabs are 11 species only and some of these crabs

are common in Hugli-Matla areas also as stated in my previous papers entitled "*Crab fauna of West Bengal*" (In Press).

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CRUSTACEA : DECAPODA : GRAPSIDAE

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INTRODUCTION

Earlier works on this group are based on the collections of Indian Marine Survey Ship by Alcock (1900), the crabs of Travancore by Pillai (1951), crabs of Maharashtra (Bombay) State by Chhapgar (1957), crabs of Andaman & Nicobar Is. by Sankarankutty (1961), crabs of Sundarbans by Chakraborty, Choudhury & Deb (1986).

As a result, 49 species under 15 genera of the family Grapsidae have been reported from India and out of them 12 species endemic to Indian water. Family Grapsidae of Sundarbans is dealt mainly by Alcock (1900) and Chakraborty, Choudhury & Deb (1986) who reported 20 species under 7 genera.

The present work is based on the recent survey material as well as unnamed collections from different areas of the Hugli-Matla Estuarine belt. The study reveals 24 species under 9 genera, of which 4 species are being reported for the first time from the study area. Most of the species are not only estuarine and brakish water but also freshwater forms. All the species inhabit close to water body or haunting the intertidal bed under stone, bricks, mud etc.

The paper deals with key to the family, genera and species along with details of the material examined, diagnosis and distribution in India and abroad.

MATERIAL AND METHODS

Crabs can be easily collected with stout forceps by placing a bait near the mouth of burrow. Two-net can be used for swimming crabs and hand-net in case of land and freshwater crabs. After collection specimens are killed in formalin, then washed in water and permanently transferred to 70-90% alcohol. Care should be taken to place the appendages together with the specimens.

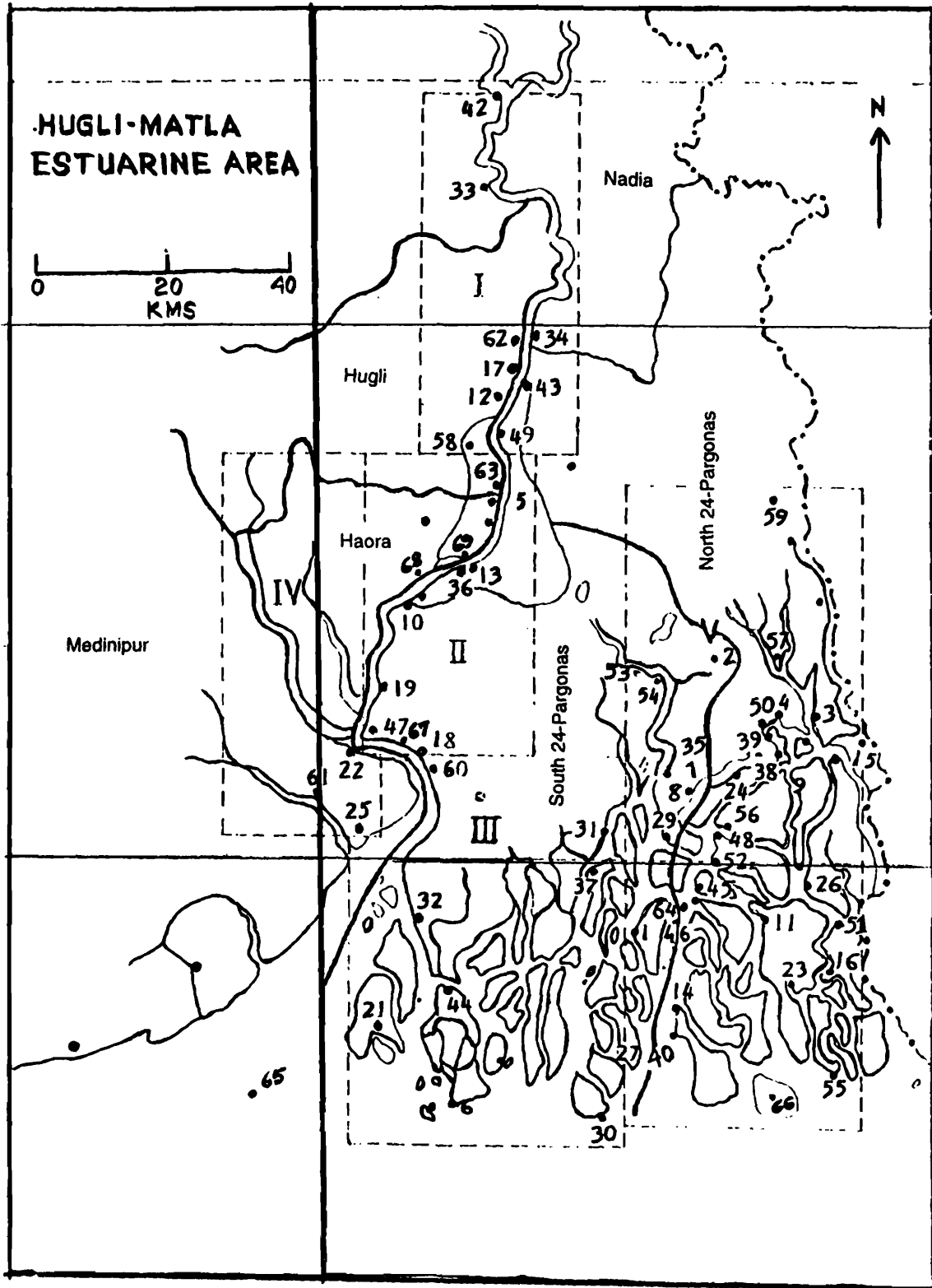
SYSTEMATIC ACCOUNT

Class : CRUSTACEA

Order : DECAPODA

Family : GRAPSIDAE

Diagnosis : Carapace squarish; lateral sides either straight or very slightly arched; front broad; eye-stalks short and thick; chelae often provided with a tuft of hairs on the palm or in the cleft of the fingers.



Distribution of Grapsid Crabs in the Hugli Matla estuary area :

<i>Metaplax distincta</i>	—	22(Geokhali), 25 (Haldia), 32 (Kakdwip), 34 (Majherchar), 58 (Sibganj), 59 (Basirhat).
<i>Varuna litterata</i>	—	5 (Ballykhal), 12 (Chandannagar), 17 (Bandel Church), 22 (Geokhali), 58 (Sibganj).
<i>Metopograpsus messor</i>	—	20 (Gadiwara), 21 (Gangasagar), 22 (Geokhali), 59 (Basirhat), 67(Roychak).
<i>Sesarma edwardsi</i>	—	5 (Ballykhal), 19 (Falta), 34 (Majherchar), 59 (Basirhat), 68 (Phuleswar).
<i>Metaplax intermedia</i>	—	15 (Chhotamollakhali), 21 (Gangasagar), 29 (Jharkhali), 47 (Nurpur).
<i>Metaplax dentipes</i>	—	22 (Geokhali), 25 (Haldia), 32 (Kakdwip).
<i>Ptychognathus dentatus</i>	—	19 (Falta), 22 (Geokhali), 68 (Phuleswar).
<i>Sesarma bidens</i>	—	6 (Bakkhali), 32 (Kakdwip).
<i>Pyxidognathus fluviatilis</i>	—	34 (Majherchar), 49 (Barackpur).
<i>Sesarma taeniotatum</i>	—	3 (Jhingakhali), 11 (Chamta-South West).
<i>Ptychognathus Onyx</i>	—	19 (Falta), 49 (Barackpur).
<i>Sesarma quadrata</i>	—	49 (Barrackpur).
<i>Sesarma tetragona</i>	—	24 (Gosaba).
<i>Metopograpsus maculatus</i>		66 (Bhangaduni).
<i>Metaplax crenulaa</i>	—	53 (Port Canning).
<i>Pyxidognathus deianira</i>	—	69 (Shibpur).
<i>Sesarma intermedia</i>	—	68 (Phuleswar).
<i>Sesarma kraussi</i>	—	47 (Nurpur)
<i>Sesarma longipes</i>	—	8 (Bhangonkhali).
<i>Clistocoeloma marguiense</i>		21 (Gangasagar).
<i>Pachygrapsus propinquus</i>	—	32 (Kakdwip).
<i>Metasesarma rousseauxii</i>	—	65 (Sandheads).
<i>Metaplax indica</i>	—	10 (Achipur).

A list of the species

Genus 1. *Clistocoeloma* A. M. Edwards.

(1) *Clistocoeloma merguiense* de Man

Genus 2. *Metaplax* H. M. Edwards

(2) *Metaplax crenulata* (Gerstaecker)

(3) *Metaplax dentipes* (Heller)

(4) *Metaplax distincta* H. M. Edwards

(5) *Metaplax indica* H. M. Edwards

(6) *Metaplax intermedia* de Man

Genus 3. *Metasesarma* H. M. Edwards

(7) *Metasesarma rousseauxii* H. M. Edwards

Genus 4. *Metopograpsus*, H. M. Edwards

(8) *Metopograpsus maculatus* H. M. Edwards

(9) *Metopograpsus messor* (Forsk.)

Genus 5. *Pachygrapsus* Randall

(10) *Pachygrapsus propinquus* de Man

Genus 6. *Ptychognathus* Stimpson

(11) *Ptychognathus dentatus* (de Man)

(12) *Ptychognathus onyx* Alcock

Genus 7. *Pyxidognathus* A.M. Edwards

* (13) *Pyxidognathus deianira* de Man

* (14) *Pyxidognathus fluviatilis* Alcock

Genus 8. *Sesarma* Say

(15) *Sesarma bidens* (De Haan)

- (16) *Sesarma edwardsi* de Man
 * (17) *Sesarma intermedia* (De Haan)
 * (18) *Sesarma kraussi* de Man
 (19) *Sesarma longipes* Krauss
 (20) *Sesarma quadrata* (Fabricius)
 (21) *Sesarma smithi* H. M. Edwards
 (22) *Sesarma taeniolatum* White
 (23) *Sesarma tetragona* (Fabricius)

Genus 9. *Varuna* A. M. Edwards

- (24) *Varuna litterata* (Fabricius)

(*) Asterisk denotes new records from the area under study

Key to the Genera of Grapsidae

1. External maxillipeds with oblique hairy ridge 2
 External maxilliped without oblique hairy ridge 5
2. Carapace quadrilateral 3
 Carapace nearly square 4
3. Carapace dorsally covered with small clusters of hairs.....*Clistocoeloma*
 Carapace without clusters of hairs *Metaplax*
4. Carapace hairy, post frontal lobes distinct *Sesarma*
 Carapace smooth, post frontal lobes indistinct *Metasesarma*
5. Lateral sides of carapace without teeth and front more than half the greatest breadth of carapace 6
 Lateral sides of carapace with teeth and front less than half the greatest breadth of carapace 7
6. Antennae completely excluded from the orbit *Metopograpsus*

- Antennae not excluded from the orbit *Pachygrapsus*
7. Carapace flat and depressed 8
- Carapace deep, strongly convex in both directions *Pyxidognathus*
8. Male palm with a patch of hairs at the finger cleft *Ptychognathus*
- Male palm without patch of hairs at the finger cleft *Varuna*

Genus 1. *Clistocoeloma* A.M. Edwards

1873. *Clistocoeloma* A. M. Edwards, *Nouv Archiv. du Mus IX* : 310.

1936. *Clistocoeloma* : Tweedie, *Bull Raff. Mus.* **12** : 68.

Diagnosis : Antennae completely excluded from the orbit; merus of external maxillipeds short; lateral borders of carapace dentate

1. *Clistocoeloma merguiense* de Man

1888. *Clistocoeloma merguiense* : de Man, *J. Linn. Soc. London* **22** : 195

1976 *Clistocoeloma merguiense* : Sakai *Crabs of Japan & the adjacent seas*, Tokyo : 674.

Material examined : 5 exs., Sagar Is., 31.vii. 1974 & 4. i. 1983, A. Misra.

Diagnosis : Carapace a little more than three-fourths as long as broad; dorsal surface convex and well demarcated; anterior half of lateral border cristate, tomentose, indistinctly divided into three lobes and posterior half of lateral border depressed, not crested or tomentose.

Remarks : Of the three Indo-pacific species only one, viz.. *Clistocoeloma merguiense* is represented here. Availability moderate in this estuarine belt.

Distribution : *India* : West Bengal : South 24 Parganas; Nicobar Island. *Outside India* : Malaysia; Singapore; Korea; Japan.

Genus 2. *Metaplax* H.M. Edwards

1852. *Metaplax* H. M. Edwards, *Ann Sci.: Nat Zool.*, (3) xviii : 161

1957. *Metaplax* Chhapgar, *J. Bombay Nat. Hist. Soc.*, **54** (3) : 522

Diagnosis : Carapace little depressed and slightly arched anteriorly; cervical and branchial grooves distinct; lateral borders provided with 4 or 5 teeth; antennae not excluded from the orbit; chelipeds differ in the sexes, longer in male and shorter in female.

Key to species of *Metaplax*

1. Anterior border of carpus and propodus of legs smooth 2
Anterior border of carpus and propodus of legs spiny *M. crenulata*
2. All the male abdominal segments separated 3
Third to fifth abdominal segments fused together *M. Indica*
3. Male dactylus without prominent lobe on its dentary edge and chelipeds equal 4
Male dactylus with prominent lobe on its dentary edge and chelipeds unequal 5
4. Anterior border of merus of legs free from Spines *M. dentipes*
Anterior border of merus of first and last pair of legs with a single and middle two pairs with several spines *M. distincta*
5. Anterior border of merus of legs with a single spine *M. intermedia*

2. *Metaplax crenulata* (Gerstaecker)

1856. *Rhaconotus crenulatus* : Gerstaecker, *Arch. Naturgesch. Jahrg.*, **XXII** : 142

1986. *Metaplax crenulata* : Chakraborty, Choudhury & Deb, *J. Bengal Nat. Hist. Soc.*, **5** (1) : 63

Material examined : 1 ex., Canning, 4. iii. 1986 B. P. Haldar.

Diagnosis : Carapace three-fourths as long as broad, convex and its surface pitted; lateral border provided with five teeth; chelipeds, in male, three times and in female $1\frac{1}{2}$ times the length of carapace.

Remarks : Larger than other species of the genus. Easily available from Sundarban area as reported by the Collector.

Distribution : *India* : West Bengal : South 24 Parganas. *Outside India* : Burma; Malaysia.

3. *Metaplax dentipes* (Heller)

1865. *Helice dentipes* Heller, *Crustaceen der Novara Reise* : 62

1937. *Metaplex dentipes* : Chopra & Das. *Rec. Ind. Mus.*; **39** : 433

Material examined : 5 exs., Haldia 5.iv.1977, 2 exs., Tamruk, 8.iii.1984, A.Misra; 1 ex., Kakdwip, 8 iii.1985, 2 exs., Geokhali, 22.iii.1985, B. P. Halder.

Diagnosis : Carapace more than three-fourths as long as broad; lateral border provided with four teeth; orbital portion of male cut into 4 or 5 teeth; though anterior border of merus of legs quite free from spines; sometimes there are inconspicuous spinules.

Remarks : This species is closely related to *M. crenulata*, but differing from it by lateral border of carapace, length of chelipeds and anterior border of carpus and propodus of legs. This species is found in abundance in the mid estuarine belt.

Distribution : *India* : West Bengal : South 24 Parganas and Midnapur; Eastern coast of India.

Outside India : Burma; Thailand; Srilanka.

4. *Metaplex distincta* H.M.Edwards

1852. *Metaplex distinctus* H.M. Edwards, *Ann. Sci. Nat. Zool.* (3) xviii : 162

1961. *Metaplex distincta* : Sankarankutty, *J. Mar. Biol. Assoc. India*, **3** : 110

Material examined : 4 exs., Haldia, ? . iii. 1984, 8 exs., Shivgunge, ? , 2 exs., Majherchar, ? viii. 1988, A. Misra; 1 ex., Basirhat, 6. ix. 1984, 1 ex., Kakdwip, 8. iii, 1985, 2 exs., Geokhali, 22. iii. 1985, 1 ex., Shivgunge, 2. iv. 1989, B. P. Halder.

Diagnosis : Orbital portion of male provided with 9 or 10 little, bilobulate teeth; anterior border of merus of legs with spines.

Remarks : Distinguished from *M.dentipes* by spines on anterior border of merus of legs. This species is available in plenty in middle and upper estuarine belt.

Distribution : *India* : West Bengal : North & South 24 Parganas, Howrah, Nadia, Midnapur; Andhra Pradesh; Tamil Nadu ; Andaman & Nicobar Is. ; Maharashtra.

Outside India : Burma.

5. *Metaplex Indica* H.M.Edwards

1852. *Metaplex indicus* H.M. Edwards, *Ann. Sci. Nat. Zool.* (3) xiii : 161

1986. *Metaplex indica* : Chakraborty, Choudhury & Deb, *J. Bengal Nat. Hist. Soc.* **5** (1) : 63

Material examined : 7 exs., Achipur, 4. iii. 1933.

Diagnosis : Front nearly one-third the extreme breadth of carapace; anterior border of merus as well as carpus and prododus of legs unarmed.

Remarks : Species may easily be identified by fused abdominal segments and appears to be rare in studies area.

Distribution : India : West Bengal : South 24 Parganas, Orissa; Andhra Pradesh; Maharashtra. *Outside India* : Pakistan.

6. *Metaplex intermedia* de Man

1888. *Metaplex intermedius* de Man, *J. Linn. Soc. Zool.*, xxii : 166

1986. *Metaplex intermedia* : Chakraborty, Choudhury & Deb, *J. Bengal Nat. Hist. Soc.* 5 (1) : 63

Material examined : 4 exs., Nurpur, 7. xii. 1983, A Misra; 5 exs., Chota Mollakhali, 12.ix.1984, 4 exs., Jharkhali, 20.v.1985, 1 ex., Sagar Is., 23.xii. 1987, B.P. Halder.

Diagnosis : Inner end of orbit provided with a series of 5 or 6 little even teeth; dactylus of male larger chelipeds having a lobe on its cutting edge and fixed finger is broad.

Remarks : This species can be readily differentiated from other congeneric species by unequal chelipeds and a prominent lobe on its dentary edge. This species appears to be abundant upto mid-Matla and lower part of Hugli estuary.

Distribution : India : West Bengal : South 24 Paraganas , Orissa; Andhra Pradesh.

Outside India : Burma.

Genus 3. *Metasesarma* H.M. Edwards

1853. *Meta sesarma* H. M. Edwards, *Ann Sci. Nat Zool.*, (3) xx : 188

1939. *Metasesarma* Sakai, *Studies on the crabs of Japan, Tokyo* : 699.

Diagnosis : Antennae much smaller and completely excluded from the orbit; lateral border of carapace entire.

7. *Metasesarma rousseauxii* H. M. Edwards

1888. *Sesarma aubryi* de Man (nec A. M. Edwards), *J. Linn. Soc. Zool.*, xxii : 168

1947. *Metasesarma rousseauii* : Tweedie, *Bull. Raff. Mus.*, (18) : 34

Material examined ; 1 ex., Sandheads, mouth of the river Hugli.

Diagnosis : Carapace deep, eye naked, lateral side without any tooth; front more than half the greatest breadth of carapace; gastric and cardiac region separated by a semilunar groove; legs unarmed, third pair longest.

Remarks : *Metasesarma*, land and freshwater crab, is represented by three species in the Indo-pacific region. Of which, only one species, viz., *M. rousseauxii*, is known to occur in this region. The specimen is identified from old unnamed collection and this species is unrepresented in the present survey material. Hence it appears to be rare.

Distribution : *India* : West Bengal : South 24 Parganas; Andhra Pradesh; Tamil Nadu; Andaman & Nicobar Is. ; Minicoy. *Outside India* : Madagascar; Srilanka; Burma; Philippines; Australia.

Genus 4. *Metopograpsus* H.M. Edwards

1853. *Metopograpsus* H. M. Edwards, *Ann. Sci. Nat. zool.*, (3) xx : 164

1957. *Metopograpsus* : Chhapgar, *J. Bombay. Nat. Hist. Soc.* 54 (3) : 516 :

Diagnosis : A single transverse ridge present in between orbits and lateral parts of cervical groove; chelipeds subequal or unequal with spooned tip; wrinkles present on the upper surface of arm and wrist.

Key to species of *Metopograpsus*

Carapace more elongated, length being seven-eighths of its breadth*M. maculatus*

Carapace not much elongated, length being four-fifths of its breadth*M. messor*

8. *Metopograpsus maculatus* H. M. Edwards

1853. *Metopograpsus maculatus* H. M. Edwards, *Ann. Sci. Nat. Zool.*, (3) xx : 165

1886. *Metopograpsus maculatus* : Chakraborty, Choudhury & Deb. *J. Bengal Nat. Hist. Soc.* 5 (1) : 61

Material examined : 1 ex., Bhangaduni Is. (Kedo block), 18.ix.1984, A. Misra.

Diagnosis : Free edge of front nearly straight, no transverse markings on post-frontal region; inner angle of lower border of orbits not denticulate; tips of chelae spooned but not very blunt; terminal segment of male abdomen somewhat three lobed appearance.

Remarks : Found among brickbats in this estuarine zone at high tidal mark and appears to be restricted at the mouth of the estuary.

Distribution : *India* : West Bengal South 24 Parganas; Orissa; Andhra Pradesh; Maharashtra; Andaman Is. *Outside India* : Srilanka; Burma; Malaysia; East Indies

9. *Metopograpsus messor* (Forsk.)

1818. *Cancer messor* Forskal, *Descrip. Anim. in. itin. orient* : 88

1986. *Metopograpsus messor* : Chakrabrty, Choudhury & Deb, *J. Bengal Nat. Hist. Soc.* 5 (1) : 61

Material examined : 3 exs., Sagar Is., 31.vii.1974, 2 exs., Roychak, 7. xii. 1983, A. Misra; 1 ex., Basirhat, 5 ix. 1984, 1 ex., Geonkhali, 22.iii.1985, 2 exs., Sagar Is., 23. xii. 1987, 4 exs., Gadiara, 4.i,1989, 2 exs., Jhumjhumi, 5.i. 1989, B.P.Haldar.

Diagnosis : Free edge of front beaded, some fine transverse markings on the post-frontal region; inner angle of lower border of orbits denticulate; terminal segment of male abdomen simply triangular.

Remarks : Very active and found in abundance among brickbats in the lower and middle-estuarine zone.

Distribution : *India* : West Bengal : North & South 24 Parganas; Midnapur, Howrah; Orissa; Andhra Pradesh; Tamil Nadu; Kerala; Karnataka; Andaman & Nicobar Is; Maharashtra.

Outside India : Saudi Arab; Pakistan; Srilanka; Bangladesh; Burma; Australia.

Genus 5. *Pachygrapsus* Randall

1839. *Pachygrapsus* Randall, *Proc. Ac. Nat. Sci. Philad* : 126

1939. *Pachygrapsus* : Sakai *Studies on the crabs of Japan, Tokyo* : 655

Diagnosis : *Pachygrapsus* resembling *Metopograpsus*, differs only in lateral sides of carapace which may be toothed or not.

10. *Pachygrapsus propinquus* de Man

1908. *Pachygrapsus propinquus* de Man, *Rec. Ind. Mus. Calcutta*, 2 (3) : 216

1918. *Pachygrapsus propinquus* Tesch, *Siboga Exped.* 39c : 76

Material examined : 1 ex., Kakdwip, 9.iii.1985, B.P.Haldar.

Diagnosis : Distance between outer orbital angles being one-third greater than length; cervical groove distinct; lateral margins of carapace convergent posteriorly, slightly concave in the middle.

Remarks : A small species found West Indies eastwards, through the Medaterranean and the American Pacific coast. It seems to be rare form.

Distribution : *India* : West Bengal : South 24 Parganas; Orissa. *Outside India* : U.S.A

Genus 6. *Ptychognathus* Stimpson

1858. *Ptychognathus* Stimpson, *Proc. Ac. Nat. Sci. Philad* : 104

1939. *Ptychognathus* : Sakai. *Studies on the crabs of Japan, Tokyo* : 658

Diagnosis : Regions of carapace not so well-defined dactyli of legs, though compressed, not so broad; antennae standing in orbital hiatus.

Key to species of *Ptychognathus*

Inter angle of wrist dentiform; a patch of hairs on the inner surface of male finger cleft *P. dentatus*

Inner angle of wrist produced to form a long spine; a patch of hairs on the outer surface of male finger cleft *P. onxy*

11. *Ptychognathus dentatus* (de Man)

1892. *Ptychognathus dentatus* de Man, *Weber's Zool Ergebn. Niederl. Ost. Ind. II* : 318

1961. *Ptychognathus dentatus* : Sankarankutty, *J. Mar. Biol. Assoc. India*, 3 : 111

Material examined : 2 exs. Geonkhali 23.iii.1985, 3 exs., Falta, 27.iii.1985, 1 ex., Phuleswar, 4.iv.1989, B.P. Halder.

Diagnosis : Front prominent, straight, length two-fifths the extreme breadth of carapace; antero-lateral borders provided with three sharp teeth marking of carapace quite distinct ;

Remarks : Islands of Indo-Pacific species, entering fresh water above any tidal influence. This species is found moderate in distribution in the mid-estuarine belt.

Distribution : *India* : West Bengal : Howrah; Midnapur, South 24 Parganas; Andaman & Nicobar Is. *Outside India* Bangladesh; Burma.

12. *Ptychognathus onyx* Alcock

1900. *Ptychognathus onyx* Alcock, *J. Asiat. Soc. Bengal, India*, 69 (2) : 404

1918. *Ptychognathus onyx* : Tesch, *Siboga Exped.* 39c : 86

Material examined : 2 exs., Palta, 16.ix.1936; 1 ex., Falta, 27 iii 1985, B.P. Halder.

Diagnosis : This species is similar to *P. dentatus*, but differs in carapace and inner angle of wrist which are much thinner and produced to forms a long spine.

Remarks : The inner angle of wrist forms a long spine and the hairs on outside of finger cleft are chief distinction from *P. dentatus*. This species is found to be moderate in distribution in upper and middle estuarine belt.

Distribution : India : West Bengal : North & South 24 Parganas; Orissa; Andhra Pradesh.

Outside India : Burma.

Genus 7. *Pyxidognathus*, A.M.Edwards

1878. *Pyxidognathus* A.M. Edwards, *Bull. Soc. Philom* (7) iii : 109

1918. *Pyxidognathus* : Tesch, *Zool. Meded. Leiden*, iv : 167

Diagnosis : Antero-lateral borders hardly arched and provided with three teeth; lower border of orbit complete and antennae in the orbital hiatus; carpus and propodus of legs not so broad.

Remarks : *Pyxidognathus*, the fresh and brackish water crab of Indo-pacific region, is represented here by two species although four species are known to occur in the former area.

Key to species of *Pyxidognathus*

More than one spine on posterior border of merus of legs*P.deianira*

A single spine on posterior border of merus of legs *P.fluviatilis*

* 13. *Pyxidognathus deianira* de Man

1888. *Pyxidognathus deianira* de Man *J. Linn. Soc. Zool.* xxii :148

1918. *Pyxidognathus deianira* : Tesch *Zool. Meded. Leiden*, iv : 173

Material examined : 8 exs., Shibpur, 27.i.1917.

Diagnosis : Carapace three-fourths as long as broad, smooth, H-shaped mark in its middle; lower border of orbit, inner border of arm and wrist being denticulate; second pair of legs longest while the fourth pair shortest.

Remarks : This constitutes the first record of this species from the Indian mainland. In the present survey, no material of this species is available, hence appears to be rare.

Distribution : *India* : West Bengal : Howrah; Andaman Is. *Outside India* : Burma.

* 14. *Pyxidognathus fluviatilis* Alcock

1900. *Pyxidognathus fluviatilis* Alcock, *J. Asia. Soc. Bengal, India*, **69** (2) : 408

1918. *Pyxidognathus fluviatilis* : Tesch *Zool. Meded. Leiden*, **iv** ; 176

Material examined : 7 exs. Sundarban, 22.vii.1918, ? ; 11 exs., Pulta, Nov. -Dec. 1937, ? ; 1 ex., Majherchar, 14.viii. 1988, A. Misra.

Diagnosis : This species is closely related to *P. deianira* but differs in the followings : three terminal joints of legs more compressed and posterior border of merus of legs with a single spine.

Remarks : The species is recorded for first time from east coast of India and appears to be rare in this region.

Distribution : *India* : West Bengal : North & South 24 Parganas; Nadia. *Outside India* : Bangladesh.

Genus 8. *Sesarma* Say

1817. *Sesarma* Say *J. Acad. Nat. Sci. Philad* **1** : 76

1957. *Sesarma* : Chhapgar, *J. Bombay Nat Hist. Soc.* **54** (3) : 520

Diagnosis : Carapace usually deep; antennae in the orbital hiatus; eye-stalks much shorter than width of front ; chelipeds usually subequal; third pair of legs longest while first and fourth pairs shortest.

Key to species of *Sesarma*

1. Lateral borders of carapace nearly parallel 2
 - Lateral borders of carapace not parallel 7
2. Upper surface of male palm with two oblique comb-like ridges3
 - Upper surface of male palm without oblique comblike ridges4
3. Lateral borders of carapace with one tooth *S. bidens*
 - Lateral borders of carapace without tooth*S. quadrata*

4. Upper border of male dactylus without tubercles 5
 Upper border of male dactylus with tubercles 6
5. A sharp spine present at inner angle of wrist*S.edwardsi*
 Sharp spine absent at inner angle of wrist*S.intermemia*
6. Male dactylus with 40-60 fine uniform tubercles*S.taeniolum*
 Male dactylus with 9-10 coarse tubercles*S. tetragona*
7. Upper border of male dactylus without spines 8
 Upper border of male dactylus with two blunt black spines*S. smithi*
8. Postfrontal lobes prominent.....*S.longipes*
 Postfrontal lobes not so prominent*S.kraussi*

15. *Sesarma bidens* (De Haan)

1835. *Grapsus (Pachysoma) bidens* De Haan, *Faun. Japan Crust.* : 60

1986. *Sesarma bidens* : Chakraborty, Choudhury & Deb, *J. Bengal Nat.Hist. Soc.*, 5 (1) : 62

Material examined : 2 exs., Bakkhali, ? iii. 1985, 1 ex., Kakdwip, 26. xii. 1987, B.P. Halder.

Diagnosis : Carapace comparatively broader than long; lateral sides, a little convergent posteriorly; chelipeds differ in sexes, upper surface of male dactylus are coarser, shorter and more tubercle-like.

Remarks : The species can be readily identified by its comblike ridges on upper surface of male-palm. It appears to be abundant in studied area.

Distribution : *India* : West Bengal : South 24 Parganas; Orissa; Andhra Pradesh; Andaman & Nicobar Is. *Outside India* : Srilanka; Thailand; Hongkong; Japan.

16. *Sesarma edwardsi* de Man

1887. *Sesarma edwardsi* de Man, *Zool. Jahrb. Syst.* II : 649

1936. *Sesarma edwardsi* : Tweedie, *Bull. Raff. Mus.* (12) : 51

Material examined : 1 ex., Basirhat, 5. ix. 1984, B.P. Halder; 8 exs., Falta, 27.iii.1985, B.P. Halder; 4 exs., Phuleswar, 6.iv.1989, B.P. Halder; 4 exs., Majherchar, 8. iv. 1989, 10 exs., Babugungeghat, 13.viii.1988, A Misra; 5 exs., Ballykhal, 17.viii.1988, A. Misra.

Diagnosis : Carapace square, lateral border with a sharp tooth; spine absent on upper border of arm, only a short spine in inner border of arm; upper surface of wrist and dactylus, outer surface of palm, lower surface of fixed finger closely covered with tubercles; abdomen, in male, very broad.

Remarks : Spine at inner angle of wrist and broader abdomen in male are the characteristic feature of this species. In mid-estuarine zone it appears to be abundant.

Distribution : *India* : West Bengal : North & South 24 Parganas; Howrah; Hugli; Nadia; Kerala; Andaman Is.; Maharastra. *Outside India* : Bangladesh; Burma; Srilanka.

***17. *Sesarma intermedia* (De Haan)**

1835. *Grapsus (Pachygrapsus) intermedius* De Haan, *Faun. Japan Crust.* : 61

1939. *Sesarma intermedia* : Sakai, *Studies on the crabs of Japan, Tokyo* : 684

Material examined : 1 ex., Phuleswar, 4. iv.1989, B.P. Halder.

Diagnosis : Carapace quadrangular, lateral borders slightly divergent backwards and cut into two teeth, front more than half the greatest breadth; upper surface of palm with some oblique granular lines and the inner surface with a transverse granular crest; proximal half of upper surface of male dactylus granular.

Remarks : Middle sized species, distance between external orbital angles is 18mm. The species is recorded for first time from east coast of India. It appears to be rare because in the present survey only one specimen of this species is collected.

Distribution : *India* : West Bengal : Howrah; Andaman & Nicobar Is. *Outside India* : Burma; Korea; Hongkong and Japan.

***18. *Sesarma Kraussi* de Man**

1887. *Sesarma kraussi* de Man, *Zool. Jahrb. Syst.* 2 : 652

1936. *Sesarma kraussi* : Tweedie, *Bull. Raff. Mus.*, (12) : 51

Material examined : 1 ex., Nurpur, 7.xii.1983, A. Misra.

Diagnosis : Lateral borders of carapace divergent posteriorly and cut into two teeth. Outer surface of wrist, both surfaces of palm nearly smooth; a row of sharp granules along the outer

surface of fixed finger; upper border of arm ends not acute; legs even, 3rd. pair being more than $3\frac{1}{2}$ times the length of carapace.

Remarks : This is an endemic form restricted its distribution in the Indian ocean only. This species is recorded for first time from east coast of India and is represented by a single specimen.

Distribution : *India* : West Bengal : South 24 Parganas ; Nicobar Is. *Outside India* : Burma; Singapore.

19. *Sesarma longipes* Krauss

1843. *Sesarma longipes* Krauss, *Sudafr. Crust.* : 44

1986. *Sesarma longipes* : Chakraborty, Choudhury & Deb , *J. Bengal Nat. Hist. Soc.*, 5 (1) : 63

Material examined : 1 ex., Matla river (Bhangonkhalighat) 11.iii.1985, S.K. Ghosh.

Diagnosis : Lateral border of carapace divergent posteriorly and cut into one tooth. Outer surface of wrist, both surfaces of palm, lower border of fixed finger with granules; upper border of arm ends acutely, legs uneven, 3rd. pair being more than $2\frac{1}{2}$ times the length of carapace.

Remarks : This is an endemic form restricted its distribution in the Indian ocean only and appears to be rare in the studied area.

Distribution : *India* : West Bengal : South 24 Parganas; Andaman & Nicobar Is. *Outside India* : Natal.

20. *Sesarma quadrata* (Fabricius)

1798. *Cancer quadratus* Fabricius, *Ent. Syst. Suppl.* : 341

1957. *Sesarma quadrata* : Chhapgar, *J. Bombay Nat. Hist. Soc.* 54 (3) : 520

Material examined : 3 exs., Barackpur, 2.viii.1909. ? ; 2 exs., Matla river, December 1916, S.W. Kemp; 4 exs., Utterbhag, 18.iii.1934, S.L.Hora.

Diagnosis : Carapace deep, little convergent posteriorly; front more than half the greatest breadth of carapace; outer surface of arm, wrist and palm granular; inner border of arm bears a large tooth.

Remarks : The species can be recognised by its palm and lateral border of carapace. Though not represented in current survey material the species is found to extend its distribution from lower to upper estuarine belt.

Distribution : *India* : West Bengal : North & South 24 Parganas; Orissa; Andhra Pradesh; Kerala; Maharastra; Andaman & Nicobar Is. *Outside India* : Pakistan; Srilanka; Burma.

21. *Sesarma smithi* H. M. Edwards

1853. *Sesarma smithi* H. M. Edwards, *Arch. Mus. Paris* 7 : 149

1939. *Sesarma smithi* : Sakai, *Studies on the crabs of Japan, Tokyo* : 686

Material examined : 1 ex., Baghmara Khal, 17.ix.1983, S.Chatterji.

Diagnosis : Lateral border of carapace convex in their anterior half and concave in their posterior half with two teeth.

Remarks : The species is recorded for the first time from India. The species easily be distinguished from others by peculiar shape of carapace and colouration. The species is rare in this belt.

Distribution : *India* : West Bengal : South 24 Parganas. *Outside India* : Thailand; Singapore; Indonesia; Philippines; Australia; South Africa; Brazil.

22. *Sesarma taeniolatum* White

1847. *Sesarma taeniolatum* White, *List. Crust. Brit. Mus.* : 38

1986. *Sesarma taeniolatum* : Chakraborty, Choudhury & Deb, *J. Bengal Nat. Hist. Soc.*, 5 (1) : 62

Material examined : 10 exs., Jhingakhali, 4 exs., Chamta Block, 8 exs., Bhangaduni Is., September 1983, A Misra.

Diagnosis : Carapace deep, square, dorsally flat; lateral sides with one tooth; chelipeds similar in both sexes; outer surface of arm, wrist and palm granular; a granular ridge present on inner surface of palm; finger meet at tip.

Remarks : Large sized species, differ from others by fine teeth on the dactylus. This species is found to occur in moderate distribution from lower to upper estuarine belt.

Distribution : *India* : West Bengal : South 24 Parganas; Andhra Pradesh; Maharashtra.

Outside India : Pakistan; Thailand; Singapore; Philippines; China.

23. *Sesarma tetragona* (Fabricius)

1798. *Cancer tetragonus* Fabricius, *Suppl. Entom. Syst.* : 341

1917. *Sesarma tetragona* : Tesch, *Zool. Meded Leiden*, III : 206

Material examined : 2 exs., Sundarban, May 1985, B. P. Halder

Diagnosis : Resembling *S. taeniolatum* in all respect except the carapace slightly broader than long and number of teeth more less on dactylus.

Remarks : Distinguished from *S. taeniolatum* by the size and number of teeth on dactylus. The species appears to be abundant in this estuarine belt.

Distribution : *India* : West Bengal : South 24 Parganas; Orissa; Tamil Nadu; Andaman.

Outside India : Srilanka.

Genus 9. *Varuna* A. M. Edwards

1830. *Varuna* A. M. Edwards *Dict.Hist. Nat.*, XVI : 511

1957. *Varuna* : Chhapgar, *J. Bombay Nat. Hist. Soc.* 54 (3) : 518

Diagnosis : Carapace a little broader than long with thin sharp edges. Front straight, prominent, anterolateral borders cut into three teeth; antennae in the orbital hiatus; chelipeds equal, fingers sharp, pointed. Middle two pairs of legs longest and the last one shortest; last three pairs of legs used for swimming.

24. *Varuna litterata* (Fabricius)

1798. *Cancer litteratus* Fabricius, *Ent. Syst. Suppl.* : 342

1986. *Varuna litterata* : Chakraborty, Choudhury & Deb, *J. Bengal Nat. Hist. Soc.* 5 : 61

Material examined : 1 ex., Roychak, ? xii. 1983, A. Misra; 2 exs., Geokhali, 22. iii. 1985, B.P. Halder; 1 ex., Ballykhal, 1988, A. Misra; 1 ex., Jhumjhumi, 5.i.1989, B.P. Halder; 1 ex., Bandel Church, 8.i.1989, B.P. Halder; 1 ex., Chandannagar, 9 exs., Shibgunge, 31.iii.1989, B.P. Halder; 2 exs., Phuleswer, 4. iv.1989, 9 exs., Majherchar, 8. iv. 1989 B. P. Halder.

Diagnosis : In middle of carapace makes a letter-H. Inner border of arm denticulated, inner angle of wrist with large sharp spine, inner surface of palm granular.

Remarks : Indo-pacific form, found in abundance in brackish water near river mouth, open sea even in the freshwater. This species consumed as food by the poor people.

Distribution : *India* : West Bengal : South 24 Parganas; Howrah, Hugli, Midnapur, Nadia; Orissa; Andhra Pradesh; Kerala; TamilNadu; Maharastra; Bihar.

Outside India : East Africa; Bangladesh; Burma; Singapore; Hongkong; Japan; Australia; New zealand.

SUMMARY

The family Grapsidae comprises four subfamilies, of which three are represented in the Hugli-Matla estuarine belt. Of the three, Grapsinae is represented by three species under the genera *Metopograpsus* and *Pachygrapsus*; Varuninae is represented by five species under the genera *Varuna*, *Ptychognathus* and *Pyxidognathus*; Sesarminae is represented by sixteen species belonging to the genera *Sesarma*, *Metasesarma*, *Metaplex* and *Clistocoeloma*. Out of twenty four species, four are recorded for the first time from the area under study. Status of all the species are also dealt in short.

ACKNOWLEDGEMENTS

I am grateful to Dr. A. K. Ghosh, Director, Zoological Survey of India, Calcutta, for providing the laboratory facilities to work out the collection. I am grateful to Dr. M. Deb, Scientist 'SD' of Crustacea Division for encouragement. Thanks are also due to Drs. B.P. Halder, Zoologist and A. Misra, Asstt. Zoologist, and their party members, for taking the pains in collecting these forms.

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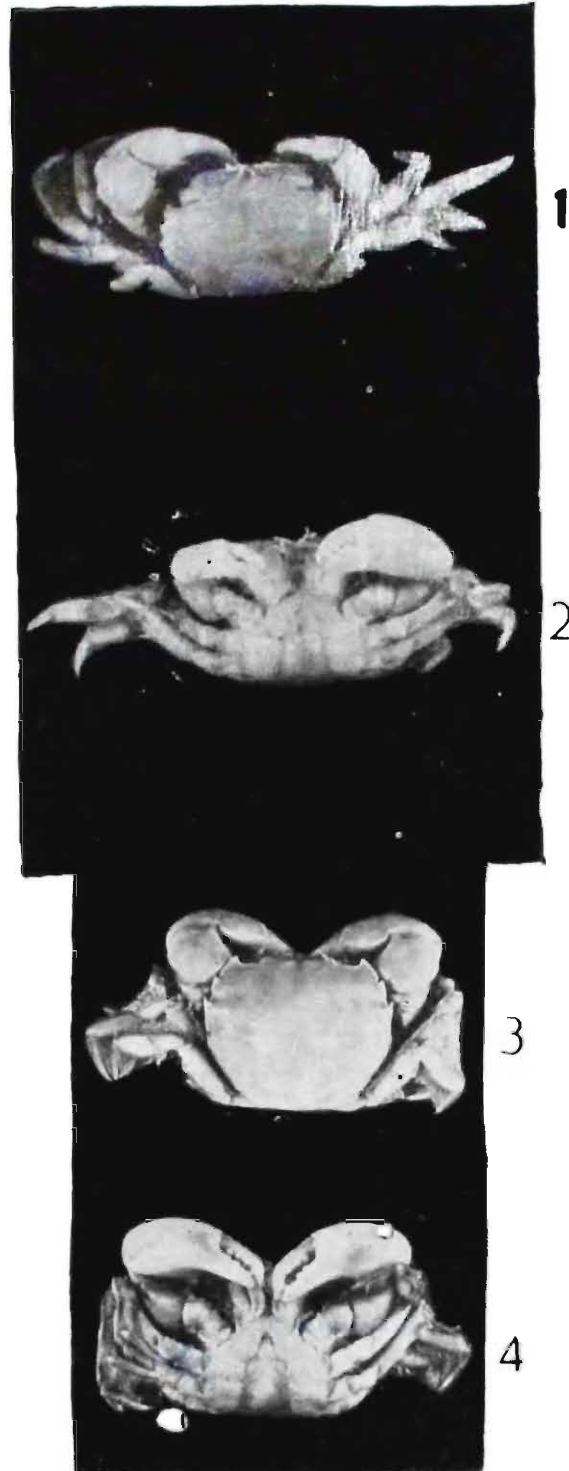


PLATE I :

Fig. 1 : *Pyxidognathus deianira* de Man (Dorsal view) ; 2 : *Pyxidognathus deianira* de Man (Ventral view) ; 3 : *Pyxidognathus fluviatilis* Alcock (Dorsal view) ; 4 : *Pyxidognathus fluviatilis* Alcock (Ventral view).

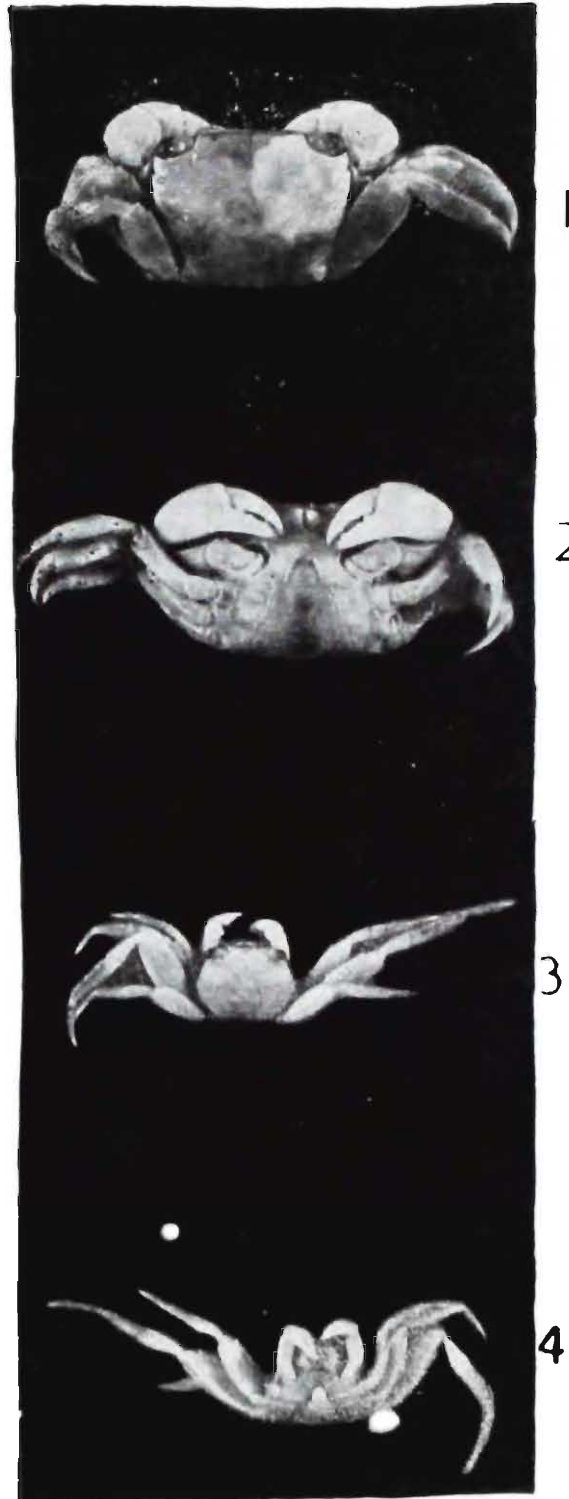


PLATE II :

Fig. 1: *Sesarma intermedia* (De Haan) (Dorsal view); 2: *Sesarma intermedia* (De Haan) (Ventral view); 3: *Sesarma kraussi* de Man (Dorsal view); 4: *Sesarma kraussi* de Man (Ventral view).

PORTUNIDAE : DECAPODA : CRUSTACEA

SIPRA BHADRA

Zoological Survey of India, Calcutta – 700.016.

INTRODUCTION

The Portunid crabs are more or less well represented in the Indian waters. Some of them are important economically in containing sizeable species which are used for human food. Several reports on Indian Brachyura reveal the occurrence of 69 species and these are known from the contributions of Chopra (1935) on the crabs of Bay of Bengal, Chapghar (1957) on the crabs of Bombay, Sankarankutty (1961) on the crabs of Andaman & Nicobar Islands, and Chakraborty, Chowdhury & Deb (1986) on the crabs of Sunderbans. Last named authors reported only three species of Portunids from the Sunderbans. Besides this Alcock made extensive collections of Brachyurans from Indian waters and his observations are recorded in his monumental publications (1895 –1900).

The present study is based on a small collection of portunid crabs brought in by the members of the Hugli–Matla estuarine Survey (1984–88) parties and on a few specimens lying in the unnamed collection of the Zoological Survey of India. On examination the material was found belonging to 15 species under 4 genera. This paper deals with the material and methods, key to the genera and species together with the diagnostic characters of the genera and species and their geographical distribution.

MATERIALS AND METHODS

Crabs were collected by means of stout wooden forceps. Crabs living in burrows were collected by placing a bait near the mouth of the burrow. Crabs which live in caves were collected by using baits or by small hand net.

After collection crabs were killed in formalin. Then the specimens were washed in water and transferred to 70–90% alcohol. Care was taken so that they were not allowed to shed their limbs which they usually do when they were thrown directly in alcohol. In case, specimen shed off its limbs, the later should be preserved along with the specimen.

SYSTEMATIC ACCOUNT

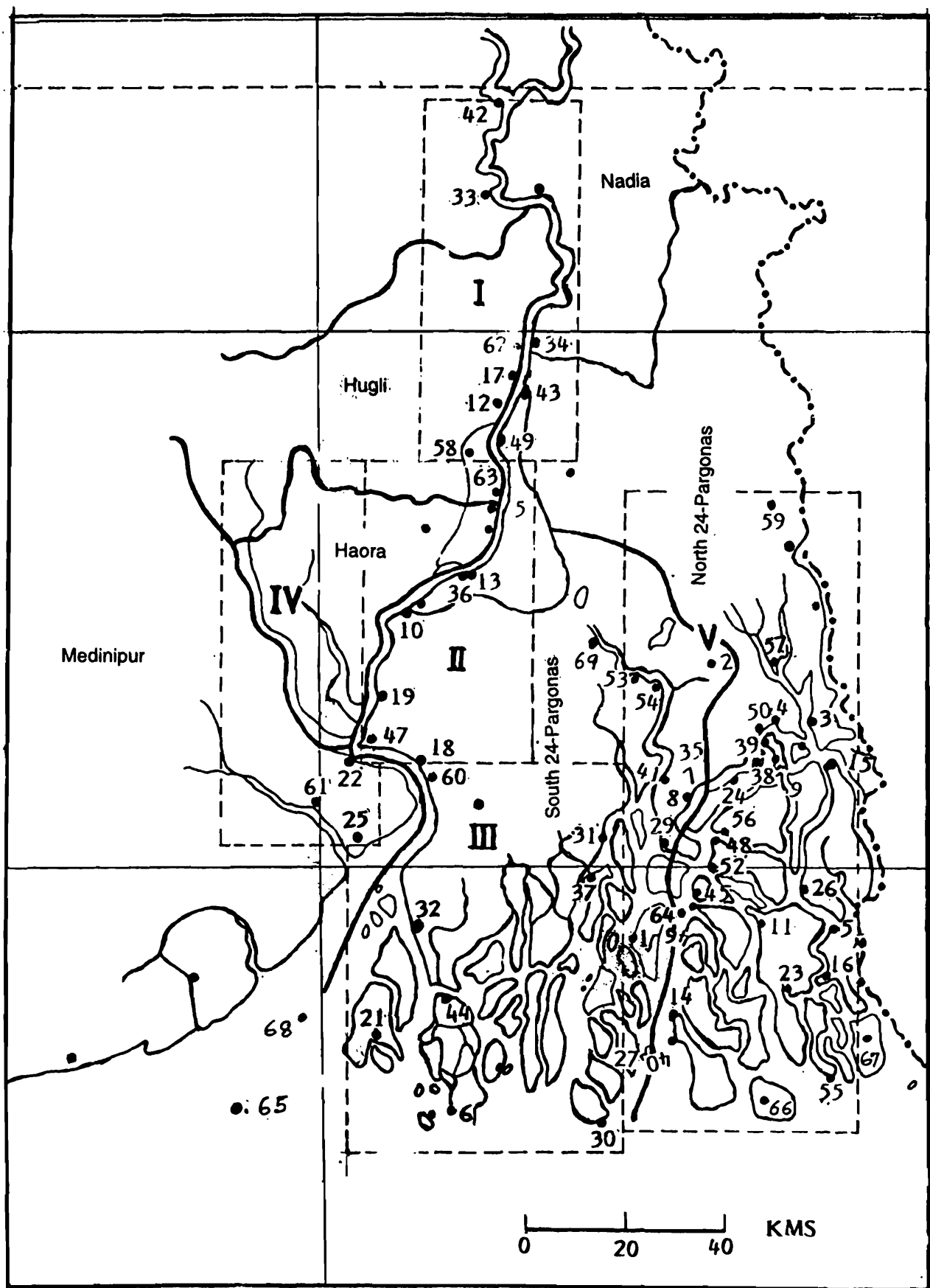
Class : CRUSTACEA

Order : DECAPODA

Suborder : REPTANTIA

Section : BRACHYURA

Family : PORTUNIDAE



Distribution of Portunidae in the Hugli-Matla estuarine area.

Map showing the distribution of portunid crabs in Hugli-Matla estuarine area.

Species commonly occurring in the study area

- | | | |
|--|---|---|
| 1. <i>Scylla serrata</i> | — | 56 (Sajnakhali), 18 (Diamond Harbour), 24 (Gosaba),
55 (Port Canning,) 6 (Bakkhali), 21 (Gangasagar),
64 (Vidya-Matla Junction), 3 (Jhingakhali), 67 (Baghmara),
66 (Bhangaduni) |
| 2. <i>Charybdis (Charybdis) cruciata</i> | | 65 (Sandheads), 6 (Bakkhali), 29 (Jharkhali),
68 (Mouth of river Hugli). |
| 3. <i>Charybdis merquiensis</i> | — | 65 (Sandheads), 24 (Gosaba). |
| 4. <i>Charybdis (Goniosoma) rostrata</i> | | 6 (Bakkhali), 21 (Gangasagar), 24(Gosaba),
69 (Pyali river), 65 (Sandheads),
64 (Vidya Matla Junction). |

Species reported only once in the study area

- | | | |
|---|---|---------------------------|
| 1. <i>Portunus sanquinolentus</i> | — | 65 (Sandheads) |
| 2. <i>Portunus pelagicus</i> | — | 65 (Sandheads) |
| 3. <i>Portunus hastatoides</i> | — | 65 (Sandheads) |
| 4. <i>Portunus pubescens</i> | — | 21 (Gangasagar) |
| 5. <i>Portunus gladiator</i> | — | 64 (Vidya Matla junction) |
| 6. <i>Charybdis (Charybdis) miles</i> | — | 65 (Sandheads) |
| 7. <i>Charybdis (Charybdis) Variegata</i> | — | 65 (Sandheads) |
| 8. <i>Charybdis (Charybdis) Callianassa</i> | — | 65 (Sandheads) |
| 9. <i>Charybdis (Goniohellenus) Vadorum</i> | — | 65 (Sandheads) |
| 10. <i>Charybdis (Goniosoma) affinis</i> | — | 6 (Bakkhali) |
| 11. <i>Lissocarcinus arkati</i> | — | 65 (Sandheads) |

Family : PORTUNIDAE

Carapace generally broader than long. Frontal teeth 2 to 6 in number. Last pair of legs modified for swimming. Antero-lateral teeth vary from five to nine in number.

LIST OF SPECIES KNOWN FROM THE AREA

- 1 *Scylla serrata* (Forsk.)
2. *Portunus sanguinolentus* (Herbst)
3. *P. pelagicus* (Linnaeus)
4. *P. pubescens* (Dana)
5. *P. hastatoides* (Fabricius)
6. *P. gladiator* Fabricius
7. *Charybdis (Charybdis) cruciata* (Herbst)
8. *C. merguensis* (de Man)
9. *C. (Charybdis) miles* (de Haan)
10. *C. (Charybdis) variegata* (Fabricius)
11. *C. (Charybdis) Callianassa* (Herbst)
12. *C. (Goniohellenus) vadorum* Alcock
13. *C. (Goniosoma) rostrata* (A. Milne Edwards)
14. *C. (Goniosoma) affinis* Dana
15. *Lissocarcinus arkati* Kemp.

Key to the genera of the family Portunidae

- 1 Antennal flagellum small and stands in the orbital hiatus 2
 Antennal flagellum excluded from the orbital hiatus 3
2. Hand inflated; surface of carapace smooth and the regions ill-defined *Scylla* De Haan
 Hand costate and prismatic; surface of carapace divided into regions *Portunus* Weber
3. Antero-lateral borders with six teeth including the outer orbital angles; front with six lobes, exclusive of the supra-orbital angles *Charybdis* De Haan

Antero-lateral borders cut into five teeth including the outer orbital angles; front with two broad lobes besides the inner supra-orbital angles *Lissocarcinus* Adam & White

Genus 1. *Scylla* De Haan

1833. *Scylla* De Haan, *Faun, Japon. Crust.* : 44

1950. *Scylla* : Barnard, *Ann. South. Afric. Mus.*, 38 : 160

Diagnosis : Carapace broad, moderately convex, with an almost unbroken surface; front cut into four teeth; antero-lateral borders cut into nine teeth of nearly equal size; antennules fold nearly transversely; flagellum stands in the orbital hiatus; chelipeds massive, longer than any of the legs; legs stout but in the fourth pair, merus and carpus are shortened and broadened, and propodite and dactylus are foliaceous for swimming; abdomen of male broadly triangular, consisting of five segments; 3rd-5th terga being fused. The genus *Scylla* is represented by only one species.

1. *Scylla serrata* (Forsk.)

1755. *Cancer serratus* Forskal, *Descr. Anim.* : 90

1986. *Scylla serrata* : Chakraborty, Chowdhury & Deb, *J. Ben. Nat. Hist. Soc.*, 5 : 64

Material examined : 1 ex, Sazinakhali, 2.5.61, A.S.R. Ayengar; 1 ex, Matla river, 14.3.68, A Daniel; 4 exs, Diamond Harbour, 26.9.79, Dr. T. Roy; 1 ex, Jhingakhali, Sunderban, 13.9.83, S. Biswas; 2 exs, Chani Block, Sunderban, 15.9.83, S. Bhunga; 1 ex, Baghmara, 17.9.83, S.R. Dey Sarkar; 1 ex, Bhangaduni Is, 18.9.83, A Misra; 4 exs, Gosaba, 8.9.84, B.P. Haldar; 5 exs, Port Canning, 18.5.85, B.P. Haldar; 1 ex, Bakkhali, 3.4.87, H.P. Haldar; 3 exs, Ganga Sagar Island, 23.12.87, B.P. Haldar.

Diagnosis : Front cut into four lobes or bluntish teeth of about equal size; antero-lateral borders cut into nine teeth of about equal size; hand and surface of carapace smooth; hand inflated; abdomen of male triangular; dark greenish grey in colour.

Remarks : *Scylla serrata* is the common edible crab of India. It is known in Bengal as "Nona Kankra" or the salt water crab. It is generally a brackish water species, but can adapt to fresh waters also. It is available at the Sunderban in large quantities through out the year.

Distribution : *In India* : West Bengal; South 24 Parganas, Midnapur; Orissa; Andhra Pradesh; Tamil Nadu; Karnataka; Maharastra; Gujarat. *Elsewhere* : Africa; Pakistan; Mergui; Burma; Formosa; Sagami Bay; Japan; Australia; Tahiti; Auckland.

Genus 2. *Portunus* Weber

1795. *Portunus* Weber, *Nomen. Entom.* : 93

1965. *Portunus* : Sakai, *The Crabs of Sagami Bay* : 116

Diagnosis : Carapace usually broad and depressed or little convex; front cut into from three to six – usually four teeth; antero-lateral borders cut into nine teeth (including the outer orbital angle) of which the 9th may be enlarged or not; antennules fold transversely; flagellum stands in the orbital hiatus; chelipeds longer, usually much longer than any of the legs, and massive; legs compressed; abdomen of the male is five-jointed.

Key to the species of the genus Portunus

1. Postero–lateral angle of carapace angular *Hastatoides* Fabricius
 Postero–lateral angle of carapace rounded 2
2. Antero–external angle of merus of external maxillipeds strongly produced in lateral direction *gladiator* Fabricius
 Antero–external angle of merus of external maxillipeds rounded, not laterally produced 3
3. A spine at the distal end of the posterior border of arm *pelagicus* (Linnaeus)
 —No Spine on the posterior border of the arm
 - (a) Carapace marked with three large blood-red spots *sanguinolentus* (Herbst)
 - (b) No such large spots on the carapace; body covered with short hairs and granules *pubescens* (Dana)

2. *Portunus sanguinolentus* (Herbst)

1783. *Cancer sanguinolentus* Herbst, Krabben, I(ii) : 161

1961. *Portunus sanguinolentus* : Sankarankutty, *J. Mar. Biol. Ass. India* 3 : 103

Material examined : 4 exs, Sandheads, 20.6.24, P.V. Lady Fraser.

Diagnosis : Carapace very broad and marked posteriorly by three large blood-red spots; antero–lateral borders cut into nine teeth (including the outer orbital angle) the last of which is about four times longer than any of the others; no spine on the posterior border of the arm of chelipeds.

Remarks : It is common edible crab and prefers sandy or muddy bottoms, 10 to 30 meters deep. Its meat is used for medicine. This species occurs quite commonly at the Sandheads.

Distribution : *In India* : West Bengal; South 24 Parganas, Midnapur; Orissa; Andhra Pradesh; Tamil Nadu; Kerala; Karnataka; Nicobars. *Elsewhere* : East coast of Africa; Pakistan; Sri

Lanka; Hongkong; Phillipine; Japan; Hawaii.

3. *Portunus pelagicus* (Linnaeus)

1758. *Cancer pelagicus* Linnaeus, *Syst. Nat.* Xth ed. 1 : 626

1961. *Portunus pelagicus* : Sankarankutty, *J. Mar. Biol. Ass. India* 3 : 103

Material examined : 2 exs, sandheads, P.V. Lady Fraser, Date?

Diagnosis : Whitish or pale bluish irregular spots present on the carapace; the granulation on the dorsal surface is very prominent; a spine present at the far end of the posterior border of the arm of chelipeds.

Remarks : It is common edible crab. Its meat and soup is supposed to act as a medicine. It is not commonly found at the Sandheads.

Distribution : *In India* : West Bengal; South 24 Parganas, Midnapur; Orissa; Tamil Nadu; Kerala; Karnataka; Andaman. *Elsewhere* : East coast of Africa; Hongkong; Phillipine; Japan; Nagasaki; Formosa; Australia.

4. *Portunus pubescens* (Dana)

1852. *Lupa pubescens* Dana, *U. S. explo. exped.*, 1838 – 1842 : 274

1961. *Portunus pubescens* : Stephenson, *Aust. J. Mar. Freshwat. Res.*, 12(1) : 111

Material examined : 1 ex, Sagar Island, 6.7.77, S. Palma.

Diagnosis : Body covered with short hairs and granules; front composed of four teeth, the middle two being most prominent; length of carapace distinct, more than half the greatest width.

Remarks : This species differs from other species in having numerous soft hairs on entire body and the carapace relatively narrower. It is a rare species at this locality.

Distribution : *In India* : West Bengal; South 24 Parganas, Tamil Nadu. *Elsewhere* : Japan; Hawaii; Australia.

5. *Portunus hastatoides* Fabricius

1798. *Portunus hastatoides* Fabricius, *Ent. Syst. Suppl* : 368

1959. *Portunus hastatoides* : Stephenson, & Campbell, *Aust. J. Mar. Freshwat. Res.*, 10, no. 1, : 101

Material examined : 2 exs, Sandheads, P.V. Lady Fraser, date?

Diagnosis : Front cut into four teeth, the middle two of which are very much narrower and acuter than the others; antero-lateral borders cut into nine teeth, the last of which is larger than the others; postero-lateral border of carapace angular; posterior border of propodus of last legs finely serrulate; two distinct spines present on posterior border of arm.

Remarks : Inhabits the bottoms of sand or mud, 30 to 100 metres deep. It occurs quite commonly along the eastern coast of India from the sandheads to the Palk straits.

Distribution : *In India* : West Bengal; South 24 Parganas, Tamil Nadu; Lakshadweep; Andamans. *Elsewhere* : Persian Gulf; Sri Lanka; Singapore; Hongkong.

6. *Portunus gladiator* Fabricius

1798. *Portunus gladiator* Fabricius, *Ent. Syst. Suppl.* : 368.

1959. *Portunus gladiator* : Stephenson, & Campbell, *Aust. J. Mar. Freshwat. Res.*, **10**,(1) : 84–124.

Material examined : 3 exs, Matla river, Jan–Feb. 1911, J. H. Row.

Diagnosis : Carapace depressed and its surface broken by subregional elevations, the summits alone of which are granular; two spines present on the posterior border of the arm and one spine on the hand; dactylus of last pair of legs have no spot.

Remarks : Inhabits the bottoms of sand, broken shells, 30 to 100 metres deep. It is not commonly found at the Sunderbans.

Distribution : *In India* : West Bengal; South 24 Parganas; Pondicherry; Tamil Nadu. *Elsewhere* : Sri Lanka; Mergui; Sumatra; Nagasaki; Queensland.

Genus 3. *Charybdis* De Haan

1833. *Charybdis* De Haan, *Faun. Japan. Crust.* : 9, 10

1965. *Charybdis* Sakai, *The Crabs of Sagami Bay* : 120

Diagnosis : Front cut into six lobes or teeth exclusive of the supra-orbital angles; antero-lateral borders cut into six teeth including the outer orbital angles. Chelipeds massive, longer than any of the legs; legs compressed; in the last pair the merus and carpus are shortened and broadened and the propodite and dactylus typically foliaceous for swimming.

Key to the species of the genus Charybdis

1. Transverse ridges distinctly present 4

- Transverse ridges not distinct. 2
2. Four or more large spines on the anterior border of the arm of cheliped
..... *C. miles* (De Haan)
- Not more than three large spines on the anterior border of the arm of cheliped. 3
3. First spine of antero lateral border of carapace anteriorly truncated and notched
..... *C. cruciata* (Herbst)
- First spine of antero-lateral border of carapace acute
- (a) An acute spine on the posterior border of carpus of last pair of legs.
..... *C. merguensis* (de Man)
- (b) Spine absent on the posterior border of carpus of last pair of legs. *C. affinis*
Dana
4. Spine present on the posterior border of arm of cheliped. postero-lateral border of carapace
angular..... *C. vadorum* Alcock
- Spine absent on posterior border of arm. Postero-lateral border of carapace curved,
rounded 5
5. One or two transverse ridges present on the posterior half of branchial regions
..... *C. variegata* (Fabricius)
- No transverse ridge present on the posterior half of the branchial region 6
6. Carapace convex; 2 spines on anterior border of arm of cheliped
- (a) Carapace about two-thirds as long as broad; 3 spines on hand *C. callianassa*
(Herbst)
- (b) Carapace about four-fifths as long as broad; 2 spines on hand
..... *C. rostrata* (A. Milne Edwards)

7. *Charybdis* (*Charybdis*) *Cruciata* (Herbst)

1794. *Cancer cruciatus* Herbst, *Krabben* 5 : 155

1986. *Charybdis* (*Charybdis*) *cruciata* : Chakraborty, Chowdhury and Deb, *J. Bengal. Nat. HistSoc*;
5 : 64

Material examined : 1 ex, Mouth of river Hugli, 1922-23, P.V. Lady Fraser; 1 ex.

Sandheads, 1922-23, P.V. Lady Fraser; 3 exs, Bakkhali, 7.3.85, B.P. Haldar; 1 ex, Jharkhali, 25.6.86, B.P. Haldar.

Diagnosis : First spine of the antero-lateral sides of carapace bifid, the last is almost spine-like while the other four broad anteriorly-acuminate lobes; dorsal surface of carapace with six longitudinal bands of dark brown colour extending over three-quarters of its length; sixth abdominal tergum of male with curved and gradually convergent sides.

Remarks : This species is one of the commonest portunids at the sandheads. It is a very common species in the Indian waters, occurring extensively both in the Bay of Bengal and the Arabian Sea.

Distribution : *In India* : West Bengal; South 24 Parganas, Orissa; Tamil Nadu; Maharastra. *Elsewhere* : Pakistan; Singapore; Hongkong; Formosa; Nagasaki; Australia.

8. *Charybdis merguiensis* (de Man)

1888. *Goniosoma merguiense* de Man, *J. Linn. Soc. Zool.*, **22** : 82

1950. *Charybdis merguiensis* : Barnard, *Ann. S. Afric. Mus.*, **38** : 168

Material examined : 1 ex, Sandheads, 1922-23, P.V. Lady Fraser; 1 ex, Sunderban, Dr. A.K. Hazra; 4 exs, Gosaba 20.6.86, B.P. Haldar.

Diagnosis : Teeth on the frontal lobe of crab acute; an acute spine on the posterior border of the carpus of the last pair of legs present; the sixth abdominal tergum of male as long as broad.

Remarks : It is a common species at this locality.

Distribution : *In India* : West Bengal; South 24 Parganas, Andhra Pradesh; Tamil Nadu; Maharastra; Andaman. *Elsewhere* : Persian; Pakistan; Tavoy; Mergui; Singapore; Hongkong.

9. *Charybdis (Charybdis) miles* (De Haan)

1835. *Portunus (Charybdis) miles* De Haan, *Faun. Japon. Crust.* : 41

1976. *Charybdis (Charybdis) miles* : Sakai, *Crabs of Japan & adjacent Seas* : 358

Material examined : 1 ex, Sandheads, 22.3.23, P.V. Lady Fraser.

Diagnosis : Entire animal covered with soft velvety hairs; first tooth of the antero-lateral sides of carapace notched.

Remarks : This species can easily be recognized by the sharpness of the antero-lateral teeth and frontal lobes, and by the slender chelipeds. It is not commonly found at the Sunderbans.

Distribution : *In India* : West Bengal; South 24 Parganas. *Elsewhere* : Gulf of Martaban; Hongkong; Nagasaki; Tokyo Bay; Sagami Bay.

10. *Charybdis (Charybdis) variegata* (Fabricius)

1798. *Portunus variegatus* Fabricius, *Ent. Syst. Suppl.* : 364

1976. *Charybdis (Charybdis) variegata* : Sakai, *Crabs of Japan & adjacent seas* : 359.

Material examined : 1 ex., Sandheads, 1922-23, P.V. Lady Fraser.

Diagnosis : Front cut into six teeth, of which the middle two the most prominent; antero-lateral borders cut into six teeth which gradually increase in size from before backwards; last antero-lateral spine twice as long as any of the others.

Remarks : It is not commonly found at the Sunderbans.

Distribution : *In India* : West Bengal; South 24 Parganas, Tamil Nadu. *Elsewhere* : Red Sea; Persian Gulf; Malay Archipelago; Hongkong; Nagasaki.

11. *Charybdis (Charybdis) callianassa* (Herbst)

1790. *Cancer callianassa* Herbst, *Krabben*, 3 : 45

1961. *Charybdis (Charybdis) callianassa* : Stephenson, *Aust. J. Mar. Freshwat Res.*; 12(1) : 116.

Material examined : 1 ex., Sandheads, 1922-23, P.V. Lady Fraser.

Diagnosis : Carapace convex; two spines on anterior border of arm; antero-lateral borders cut into six teeth, of which the first one anteriorly notched and the last one spine like; free edges of all the teeth finally serrulate; sides of 6th abdominal tergum of male parallel for half their extent.

Remarks : This species is uncommon at the Sandheads. The range of distribution of the species over the Indo-Pacific area is not very extensive.

Distribution : *In India* : West Bengal; South 24 Parganas, Maharastra. *Elsewhere* : Pakistan; Sumatra.

12. *Charybdis (Gonihellenus) vadorum* Alcock

1899. *Charybdis (Gonihellenus) hoplites* Var. *vadorum* Alcock, *J. Asiat. Soc. Bengal*, 68 : 67

1935. *Charybdis (Gonihellenus) vadorum* : Chopra, *Rec. Indian. Mus.*, 37 : 493

Material examined : 1 ex., Sandheads, 1922-23, P.V. Lady Fraser.

Diagnosis : Carapace depressed and covered with short fine hairs; length of carapace half or slightly more than half of its greatest breadth; last spine of the antero-lateral border longer than the others.

Remarks : This is a rare species at the Sunderban.

Distribution : *In India :* West Bengal; South 24 Parganas, Orissa; Andhra Pradesh.

Elsewhere : Persian Gulf; Gulf of Oman; Arakan Coast.

13. *Charybdis (Goniosoma) rostrata* (A. Milne Edwards)

1861. *Goniosoma rostratum* A. Milne. Edwards, *Archiv. du. Mus.* **10** : 379

1935. *Charybdis (Goniosoma) rostrata* : Chopra, *Rec. Ind. Mus.*; **37** : 491

Material examined : 1 ex, Frasergunj, 13.12.17, B. Prasad; 1 ex, Pyali river, 9.3.34, S.L.Hora; 5 exs, Sandheads, 1927, P.V. Lady Fraser; 54 exs. Bakkhali, 21.12.78, K.N. Reddy; 43 exs, Ganga Sagar, 25.10.1979, K.N. Reddy; 4 exs, Gosaba, 5.3.81, H.C. Ghosh; 14 exs, Matla river, 11.3.85, T. Roy.

Diagnosis : Front cut into six teeth, of which the middle two bluntly pointed and project far beyond the others, next to them on either side broad and slope outwards, and the third on either side small, narrow and nearly straight; first antero-lateral tooth very acute and the last more spine-like than the others; 6th tergum of male abdomen broader than long and with curved and gradually convergent sides.

Remarks : This species occurs quite commonly at the Sandheads. It is a shallow water species occurring all along the coast from the Malacca straits to the coast of Sri Lanka.

Distribution : *In India :* West Bengal; South 24 Parganas, Orissa; Tamil Nadu; Andaman.

Elsewhere : Sri Lanka; Mergui; gulf of Martaban.

14. *Charybdis (Goniosoma) affinis* Dana

1852. *Charybdis affinis* Dana, *Proc. Ac. Nat. Sci. Philad.* : 85

1937. *Charybdis (Goniosoma) affinis* : Shen, *Bull. Raffl. Mus.*, no. 13 : 119

Material examined : 3 exs., Bakkhali, 7.3.85, B.P. Haldar.

Diagnosis : Surface of carapace and cheliped pubescent; a transverse ridge on the cardiac region but none on posterior half of branchial region; 3 spines on anterior border of arm, 5 on upper surface of hand; sides of 6th abdominal tergum of male curved and gradually convergent.

Remarks : This species is not commonly found at the Sunderbans.

Distribution : *In India :* West Bengal; South 24 Parganas, Orissa; Karnataka. **Elsewhere :** Mergui; Akyab.

Genus 4. *Lissocarcinus* Adams & White

1848. *Lissocarcinus*, Adams & White, *Samarang Crust* : 45

1950. *Lissocarcinus* : Barnard, *Ann. South. Afric. Mus.*, 38 : 145

Diagnosis : Carapace either not or very little broader than long, smooth or with a single ridge running obliquely inwards from the last tooth of either antero-lateral border; front cut into two broad lobes besides the inner supraorbital angles; antero-lateral borders cut into five lobes or teeth including the outer orbital angle; Chelipeds short, but a little longer than the legs, arm short, without any distinct spines.

15. *Lissocarcinus arkati* Kemp.

1923. *Lissocarcinus arkati* Kemp, *Rec. Ind. Mus.*, 25 : 405-408

1976. *Lissocarcinus arkati* : Sakai, *Carbs of Japan and adjacent seas* : 329

Material examined : 2 exs, Sandheads, 1922-23, P.V. Lady Fraser.

Diagnosis : Dorsal surface of carapace covered with transverse ridges but the posterior part smooth; Chelipeds covered with ridges and granules; front cut into two broad lobes besides the inner supra-orbital angles.

Remarks : This species appears to be fairly common at the sandheads.

Distribution : *In India* : West Bengal; South 24 Parganas. *Elsewhere* : Madagascar; Hongkong; Tosa Bay; Japan.

SUMMARY

Protunid carbs have been collected from different districts of West Bengal. They belong to subfamilies Portuninae and Caphyrinae. Further, subfamily Portuninae is represented by 14 species belonging to the three genera, namely *Scylla*, *Portunus* and *Charybdis* and Caphyrinae is represented by a single genus i.e., *Lissocarcinus*. Diagnosis of all the fifteen species have been dealt here along with their horizontal distributional pattern.

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OCYPODIDAE : DECAPODA : CRUSTACEA

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INTRODUCTION

Brachyuran crabs from a major component of macrofauna on Hugli-Matla estuarine zone. Crabs occurring in association with the mangal, as reported in the literature, belong to six families, although only one, the Ocypodidae contribute large numbers (Jones, 1984).

Ocypodid crabs occur virtually throughout the intertidal zone with peak abundance from mean high water level to mean low water level of spring tides. There is a distinct zonation of genera and species reflecting adaptation to different degrees of terrestriality (Macintosh, 1984). On the muddy river belt of the Hugli (Nabadwip down to Sagar Island) and Matla (Canning to Holiday Island) in West Bengal representatives of the following genera are encountered : *Macrophthalmus*, *Scopimera*, *Dotilla*, *Dotillopsis*, *Tympanomerus*, *Uca* and *Ocypoda*.

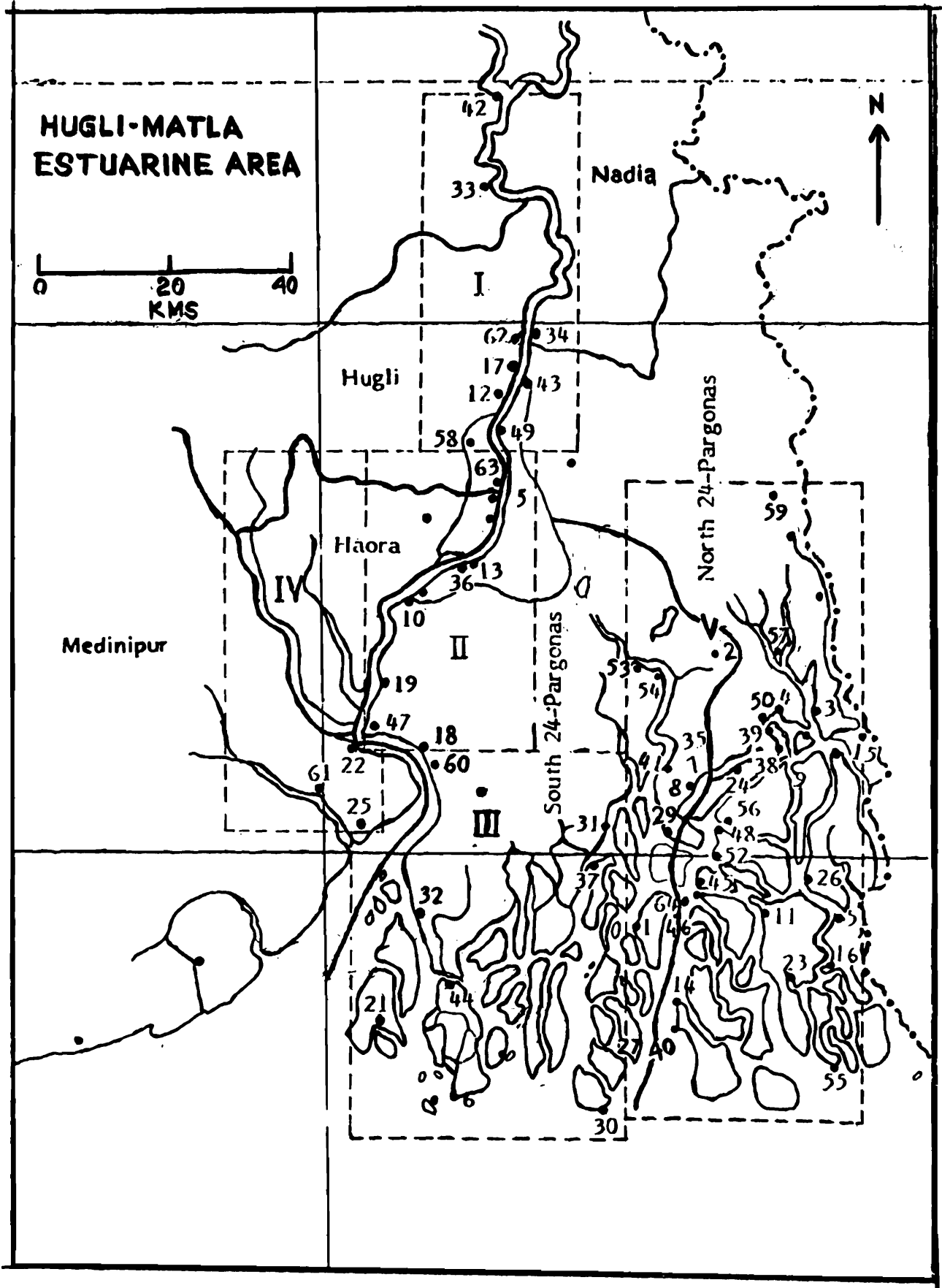
Literature on Ocypodid crabs of the Sundarbans reveals that the group has been worked in India by Alcock (1900), de Man (1908), Kemp (1915, 1919), Annandale (1923), Pearse (1932), Chopra & Das (1930, 1937), Altevogt (1955, 1959), Panikkar & Aiyar (1938), Nair & Pillai (1975), Bhavanarayana (1975), Chhapgar (1955, 1957), Crane (1975), Chakraborty (1981), Anonymous (1987), Bairagi & Misra (1988). As a result, a total of 49 species under 8 genera and one family comprised of 3 subfamilies have been reported from India.

The present work is an attempt to study the taxonomy of this group of the Hugli-Matla estuarine belt. Material for this study was collected during 1985 to 1989 from different localities of vast stretches of the aforesaid estuarine belt covering 24 Parganas (South & North), Medinipur, Haora and Hugli districts. Altogether 21 species belonging to 7 genera and one family comprised of 3 subfamilies have been worked out. Of these, only 8 species are added as new to the area under study.

The present paper deals with the diagnostic characters, distribution and key for identification of 21 species hitherto known from the area under study. It also furnishes a general habitat as well as the method of collection and preservation of the group. Synonymies have been reduced to avoid over repetition but include the original and most recent references.

MATERIAL AND METHODS

Crabs for this study were collected from the intertidal zone of the Hugli-Matla estuarine belt of West Bengal. Many species in this zone are socially active throughout the year, so seasons may be disregarded for the study of seasonal variation. A vital factor in selecting for field work is a particular stretch of estuarine belt in the day at the time of low tide. Burrowing crabs of the



EXPLANATION OF MAP

Distribution of abundant species

<i>Name of species</i>	<i>Collecting station No.</i>
<i>Ocypoda macrocera</i>	6
<i>Uca (Deltuca) rosea</i>	6, 25, 29
<i>Uca (Deltuca) dussumieri spinata</i>	6, 29, 44
<i>Tympanomerus stapletoni</i>	22, 47
<i>Tympanomerus gangeticus</i>	15, 24, 53

Distribution of rare species

<i>Scopimera investigatoris</i>	3
<i>Macrophthalmus transversus</i>	25
<i>Macrophthalmus vassipes</i>	29
<i>Macrophthalmus brevis</i>	21
<i>Macrophthalmus pacificus</i>	24

mudflat are observed in the tidal zone of muddy or sandy substratum. General observations were made on *Uca*, *Dotilla*, *Macrophthalmus*, *Scopimera*, *Dotillopsis*, *Tympanomerus* and *Ocypoda*.

Most of the crabs were collected by digging from their burrows with a shovel. Particular individual crab was caught by closing the passage of the burrow with a long narrow blade or fork. Firstly, observing the crab near the mouth of the burrow the fork or long narrow blade is inserted to close the passage of the hole. Individual crab was then collected from its burrow with a forcep and then dropped in a jar.

Ocypodid crabs were collected by trap. Trap is usually made by fine net with 1.5 cm mesh size, 30 cm length and 15cm breadth. The net is knotted at one end in the middle of a narrow wooden stick about 30 cm long is placed a little distance from the hole and spreaded over it. Then for fixing the net over the substratum some quantity of soil is to be spread over the net. During the undisturbed period the crab will come out of the hole and its spines at the cheliped and walking legs will be hooked in the mesh of the net and it will not be possible for the crab to go down into the burrow. The trapped crab is to be caught by forcep and dropped in a jar.

The specimens are to be left in a jar containing 4% formalin prepared from fresh water. After a while the specimens will be fixed and unused formalin is to be drained out gently and the specimens are washed with fresh water. Again the specimens are to be left in a jar containing 4% formalin covering the specimens twice their depth and a small quantity of borax is to be added with it. After 7 days the crabs are to be changed to 70% alcohol for final preservation.

SYSTEMATIC ACCOUNT

- | | |
|---------------|--|
| Class | CRUSTACEA |
| Order | DECAPODA |
| Section | BRACHYURA |
| Family | OCYPODIDAE |
| Sub Family I. | OCYPODINAE |
| Genus 1. | <i>Ocypoda</i> Fabricus |
| (1) | <i>Ocypoda ceratophthalma</i> (Pallas) |
| (2) | <i>Ocypoda macrocera</i> Milne-Edwards |
| Genus 2. | <i>Uca</i> Leach |
| (3) | <i>Uca (Deltuca) rosea</i> (Tweedie) |

- (4) *Uca (Deltuca) dussumieri spinata* Crane
- (5) *Uca (Celuca) lactea annulipes* (Milne-Edwards)
- (6) *uca (Celuca) triangularis bengali* Crane

Sub Family II. SCOPIMERINAE

Genus 3. *Scopimera* de Haan

- * (7) *Scopimera investigatoris* Alcock
- * (8) *Scopimera globosa* de Haan

Genus 4. *Dotillopsis* Kemp

- (9) *Dotillopsis brevitarsis* (de Haan)

Genus 5. *Dotilla* Stimpson

- (10) *Dotilla blanfordi* Alcock
- * (11) *Dotilla intermedia* de Man

Genus 6. *Tympanomerus* Rathbun

- (12) *Tympanomerus stapletoni* de Man
- (13) *Tympanomerus gangeticus* Kemp

Sub Family III. MACROPHTHALMINAE

Genus 7. *Macrophthalmus* (Latreille)

- * (14) *Macrophthalmus transversus* (Latreille)
- (15) *Macrophthalmus crassipes* Milne-Edwards
- (16) *Macrophthalmus pectinipes* Guirin
- (17) *Macrophthalmus brevis* (Herbst)
- * (18) *Macrophthalmus erato* de Man
- * (19) *Macrophthalmus depressus* Ruppell
- (20) *Macrophthalmus teschi* Kemp
- * (21) *Macrophthalmus pacificus* Dana

Species new to the area are marked by asterik (*)

Family : OCYPODIDAE

Diagnosis : Brachyganthous crabs with narrow frontal grooves and somewhat deflexed ; orbits occupying almost entire anterior border of carapace, outer orbital margins often incomplete; eyestalk slender; maxilliped usually completely covering the large buccal cavity; in male one cheliped often enlarged and abdomen narrower than female.

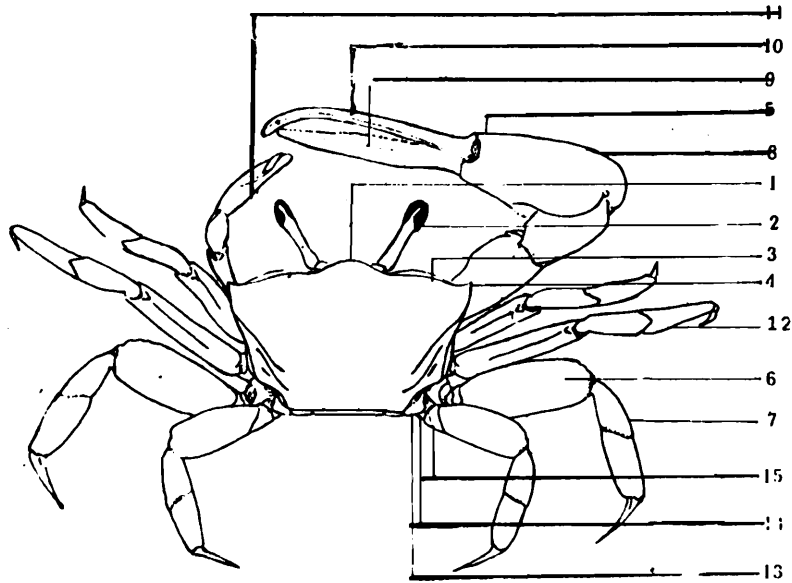


Fig. 1 Diagrammatic dorsal view of a fiddler crab: 1, front ; 2, eyestalk with eye; 3, upper orbital margin; 4, antero-lateral angle; 5, major cheliped; 6, merus; 7, carpus; 8, manus; 9, pollex; 10, dactyl; 11, minor cheliped; 12, walking leg; 13, coxa; 14, basis; 15, ischium.

Key to Sub Families of Ocypodidae

- 1. Hairy-edged pouch present in branchial cavity between bases of 2nd and 3rd pair of legs OCYPODINAE
- Hairy-edged pouch absent in branchial cavity between bases of 2nd and 3rd pair of legs 2
- 2. Tympana present on merus of legs SCOPIMERINAE
- Tympana absent on merus of legs MACROPHTHALMINAE

Subfamily I. OCYPODINAE

Diagnosis : Carapace roughly quadrilateral or pentagonal; frontal grooves narrow; afferent branchial opening thickly fringed with setae; one cheliped enlarged in male, chelipeds in female equal.

Remarks : The Subfamily contains two genera eg. *Ocypoda* (beach crab or racing crab) and *Uca* (Calling or fiddler crab).

Key to Genus of Sub-Family Ocypodinae

Carapace pronouncedly broadened anteriorly; antennular flagellum small, not hidden beneath the front; eye-stalk slender and long, cornea small and terminal; chelipeds of male enormously unequal *Uca* Leach

Carapace not very broadened anteriorly; antennular flagellum rudimentary; eye-stalks thick and cornea swollen, occupying whole ventral part of former; chelipeds unequal in both sexes *Ocypoda* Fabricus

Genus 1. *Ocypoda* Fabricus

1798. *Ocypoda* Fabricus, *Ent. Syst. Suppl.*; : 347.

1956. *Ocypoda* : Monod, *Memorius de l'Institute Francais d'Afrique Noire*, 45 : 390.

Diagnosis : Afferent branchial opening thickly fringed with setae between bases of 2nd and 3rd pair of legs; flagellum of antenna small and folding obliquely, inter-antennular septum broad; front narrow.

Remarks : This genus is represented in West Bengal by two species.

Distribution : *India* : West bengal, Orissa, Tamil Nadu, Kerala, Lakshadweep, Maharashtra, Gujarat, Andamans and Nicobars. *Outside India* : Africa, Pakistan, Ceylon, Burma, Malaysia, Indonesia, China, Japan, Western Australia and South America.

Key to Species of *Ocypoda*

Fingers of small cheliped pointed at tip.....*O. ceratophthalma*

Fingers of small cheliped not pointed but expanded at tip*O. macrocera*

(1) *Ocypoda ceratophthalma* (Pallas)

1772. *Cancer ceratophthalmus* Pallas, *Spicilegia Zool.*, 9 : 83, pl. 5, figs. 7,8.

1987. *Ocypoda ceratophthalma* : Chakraborty, et al., *J. Bengal nat. Hist. Soc.*, 5 (1) : 57.

Material examined : 2 (M) and 1 (F), Sagar Island, South 24 Pargonas, 15, xii. 1983.

Diagnosis : Carapace square and posterior border elegantly beaded; upper orbital margin a little oblique; eyestalk prolonged beyond the eye into a style of variable length; stridulating ridge of large manus with tubercles gradually passing into striae with hairs; two rows thickly hairs on anterior surface of manus of first two pairs of legs; fingers (dactyl) of both chelipeds pointed at tip.

Habitat : Middle to upper littoral zone of sandy substratum.

Remarks : The species live in burrows in sand, amphilious in littoral estuarine zone and commonly gregarious in habit. The colouration of adults is brick red.

Distribution : *India* : West Bengal : South 24 Pargonas; Orissa; Tamil Nadu; Maharashtra ; Lakshadweep ; Nicobars. *Outside India* : Indo-Pacific from east coast of Africa to Sandwich Island.

(2) *Ocypoda macrocera* H. Milne-Edwards

1861. *Ocypoda macrocera* H. Milne-Edwards, *Arch. Mus. Hist. nat.* Paris, **10** : 309.

1987. *Ocypoda macrocera* : Chakraborty, et al., *J. Bengal nat. Hist. Soc.*, **5** (1) : 57.

Material examined : 8 (M) and 2 (F), Bakkhali, South 24 Pargonas, 5.iii.1985.

Diagnosis : Upper orbital margin oblique; marginal row of granules on the external maxillipeds not prominent; dactyl tip of small cheliped not pointed but expanded and blunt; stridulating ridge entirely of striae and less hairy.

Habitat : Middle to upper tidal zone of sandy substratum.

Remarks : The carapace is of a faint reddish-chestnut colour. The chelipeds are red at the base with red spine and the outer surface of the large claw is bright orange. The walking legs are french grey in colour.

This species is found living in the sand at the edge of the mouth of the Bakkhali channel round the year. They appear to be equally abundant in this sandy beach.

Distribution : *India* : West Bengal : South 24 Pargonas ; Orissa. *Outside India* : Gulf of Siam.

Genus 2. *Uca* Leach

1814. *Uca* Leach, *Crustaceology in the "Edinburgh Encyclopaedia"* ; Brewster, **7** : 383-437.

1975. *Uca* : Crane, *Fiddler crabs of the world* : 15.

Diagnosis : Major cheliped and minor cheliped of male enormous size and both in female being minute; small eyes on long eye-stalk; antennae long; ambulatories short.

Remarks : Only two subgenera of *Uca* are found in the Hugli-Matla estuary, namely, *Deltuca* and *Celuca*. Under these two subgenera there are 4 species and 3 subspecies.

Distribution : Cosmopolitan.

Key to Subgenera, Species and Subspecies of UCA

1. Frontal groove narrow 2 (Subgenus *Deltuca* Crane)
- Frontal groove broad 3 (Subgenus *Celuca* Crane)
2. Antero-lateral carapace margin present and submarginal ridges of front with a distinct narrow median groove *U. (D.) dussumieri spinata* Crane
- Antero-lateral carapace margin absent and submarginal ridges of front without a distinct narrow median groove *U. (D.) rosea* (Tweedie)
3. Carapace with straight antero-lateral margins and tip of pollex of large cheliped with small triangular tooth *U. (C.) Lactea annulipes* (Milne-Edwards)
- Carapace without antero-lateral margins and tip of pollex of the large cheliped without triangular tooth.....*U. (C.) triangularis bengali* Crane

(3) *Uca (Deltuca) rosea* (Tweedie)

1937. *Gelasimus roseus* Tweedie, *Bull Raffles Mus.*, 13 : 145, fig. 1f, 2c.

1988. *Uca (Deltuca) rosea* : Bairagi and Misra, *J. Bombay nat.Hist. Soc.*, 85 (2) : 449.

Material examined : 3 (M) and 2 (F), Jharkhali, South 24 Pargonas, 21. ix. 1984; 2 (F) (one ovigerous), Bakkhali, South 24 Pargonas, 5.iii. 1985; 1 (M) and 1 (F), Haldia, Midnapure, 17. iii. 1985, N. Bairagi.

Diagnosis : Carapace without antero-lateral margins; anterolateral angles acute and produced; dorso-lateral margins strongly converging; frontal groove narrow; orbits strongly oblique and with smooth floor; two grooves running almost entire length of major dactyl; chela tip forceps-like in large chela of male; gonopod with broad anterior and posterior flanges, inner process broad, flat and well developed.

Habitat : Upper intertidal zone of the river and creek bank of soft muddy substratum.

Remarks : The report of *Uca acuta acuta* from Sundarbans, West Bengal by Chakraborty et al., (1987) is misleading as the study on the unnamed collection from the aforesaid area indicates that *Uca acuta acuta* referred to *Uca (Deltuca) rosea* (Bairagi and Misra, 1988).

This species is most abundant and widely distributed in the mangrove fringed estuarine belt of the Sundarbans.

Distribution : *India* : West Bengal : South 24 Parganas ; Medinipur ; Andamans ; Nicobars. *Outside India* : Pakistan; Burma; Malaysia; Indonesia.

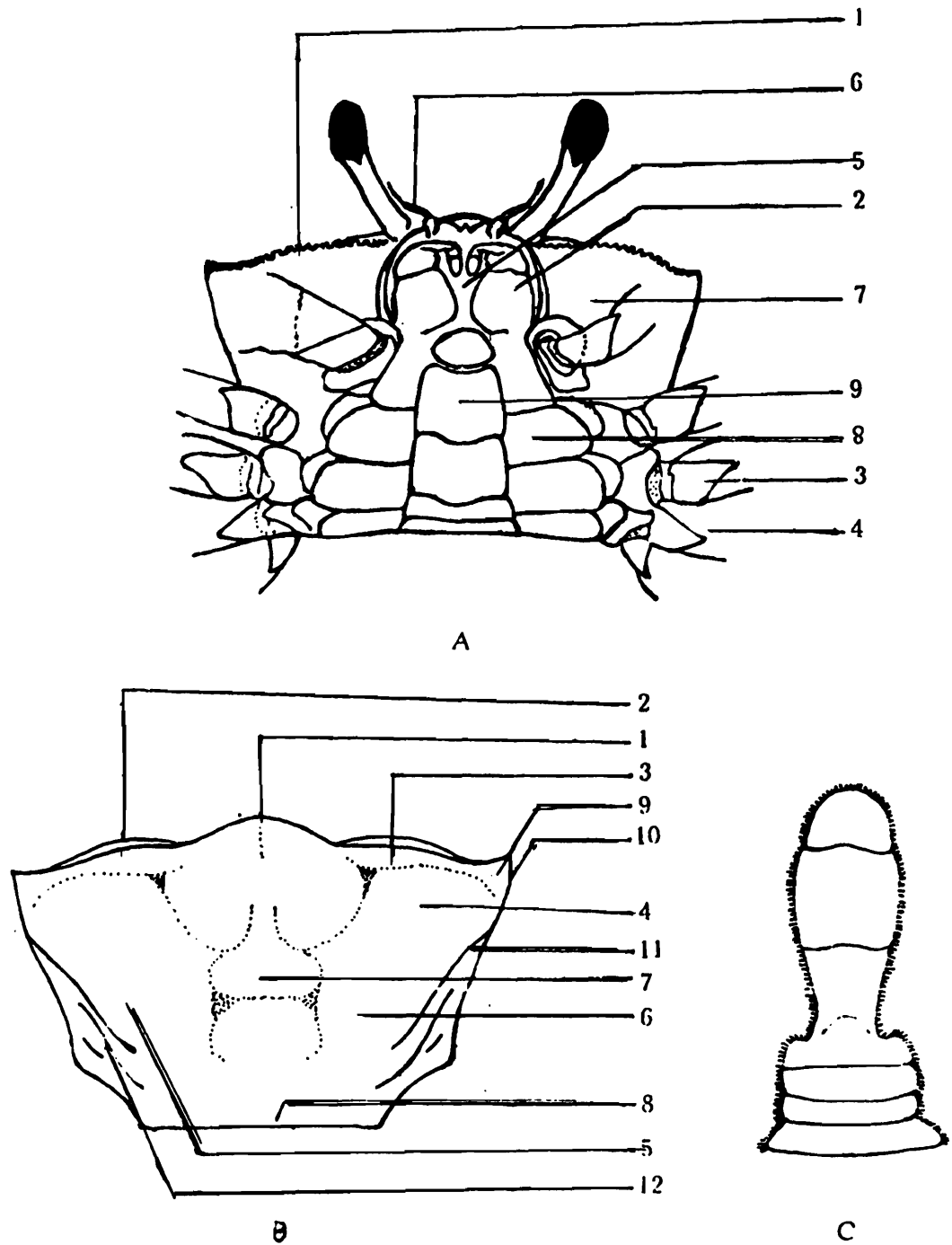


Fig. 2. A Diagrammatic ventral view of *Uca*; 1, suborbital margin; 2, 3rd maxilliped; 3, ichium; 4, merus; 5, buccal cavity; 6, antenna; 7, pterygostomium region; 8, sternum; 9, abdomen.

B. Diagrammatic dorsal view of a carapace of *Uca*; 1, front; 2, eyebrow; 3, orbital margin; 4, hepatic region; 5, branchial region; 6, cardiac region; 7, mesogastric region; 8, intestinal region; 9, anterolateral angle; 10, anterolateral margin; 11, dorsolateral margin, 12, posterolateral striae.

C. Diagrammatic view of a male abdomen of *Scopimera globosa*.

(4) *Uca (Deltuca) Dussumieri Spinata* Crane

1975. *Uca (Deltuca) dussumieri spinata* Crane, *Fiddler crabs of the world* : 36, fig, 27C.

1987. *Uca dussumieri dussumieri* : Chakraborty et al., *J. Bengal nat. Hist. Soc.* 5 (1) : 59.

Material examined : 4 (M) and 2 (F) (one ovigerous), Jharkhali, South 24 Pargonas, 24. ix. 1984; 2 (M) and 1 (F), Bakkhali, South 24 Pargonas, 7.iii. 1985; 1 (M), Iswaripur near Namkhana, South 24 Pargonas, 7.iv.1987, N. Bairagi.

Diagnosis : Carapace with short finely serrated antero-lateral margins, antero-lateral angle acute; dorso-lateral margins converging; tuberculate boss present on female carapace behind dorsolateral margins; front with submarginal ridges well separated; gonopod with large anterior flange and small posterior one; in large male distal structure of gonopod easily visible.

Habitat : Soft muddy or silty substratum of low littoral zone in mangrove fringed canal and river banks.

Remarks : Carapace is bluish-grey in life, large cheliped and walking legs pale yellow, young bright cobalt blue. This species appears to be abundant in the lower estuarine zone.

Distribution : *India* : West Bengal : South 24 Pargonas, Tamil Nadu; Andhra Pradesh.

Outside India : Burma; Malaysia; Singapore; Thailand;Indonesia; Philippines; China.

(5) *Uca (Celuca) lactea annulipes* (Milne-Edwards)

1837. *Gelasimus annulipes* Milne-Edwards, *Hist. nat. Crust.*, 2 : 55, pl.18, figs. 10-13.

1975. *Uca (Celuca) lactea annulipes* : Crane, *Fiddler crabs of the world* : 299, fig. 18 A-C.

1987. *Uca lactea annulipes* : Chakraborty et al., *J. Bengal nat. Hist. Soc.*, 5 (1) : 58.

Material examined : 4 (M) and 1 (F), Golbari Khal near Bakkhali, South 24 Pargonas, 6. iii.1985; 3 (M) and 1 (F), Haldia Medinipur, 17.iii.1985, N Bairagi.

Diagnosis : Carapace with antero-lateral margins almost straight, antero-lateral angles acute, dorso-lateral margins converging posteriorly and frontal groove broad; eye-brow short and narrow and orbit considerably oblique; tip of large dactylus hook-like ; pollex tip with a small predistal tooth; gonopod without torson, anterior flange larger than posterior, gonopore opening through a narrow notch near posterior margin.

Habitat : Sandy or muddy sand substratum in the upper littoral zone.

Remarks : Carapace black in life with 3 to 4 light blue transverse bands crossing the entire width, manus of the major cheliped reddish pink. Meri of walking legs and minor cheliped red or pale red in both sexes.

This species is not found in the Matla river. It is commonly available along the bank of the Hugli river up to Haldia, Medinipur.

Distribution : *India* : West Bengal : South 24 Parganas, Medinipur; Orissa; Tamil Nadu; Pondichery; Kerala; Maharashtra; Andaman and Nicobar Islands. *Outside India* : Africa ; Pakistan; Ceylon; Malaysia; Indonesia; Philippines.

(6) *Uca (Celuca) triangularis bengali* Crane

1975. *Uca (Celuca) triangularis bengali* Crane, *Fiddler crabs of the World* : 290, Fig. 32 N-O.

1987. *Uca triangularis bengali* (Nobili) : Chakraborty *et al.*, *J. Bengal nat. Hist. Soc.*, 5 (1) : 59.

Material examined : 6 (M) Jhingakhali, South 24 Parganas, 18.ix.1983; 1(M) and 1(F), Bakkhali, South 24 Parganas, 7.iii.1985; 2 (M) and 2 (F), Jharkhali, South 24 Parganas, 22.v.1985, N. Bairagi.

Diagnosis : Anterolateral angles of carapace strongly acute and produce, dorso-lateral margins converging, frontal groove moderately broad, orbits strongly oblique, eyebrow narrow; manus of large cheliped tuberculate; dactyl with two broad shallow grooves—one just above gap, and other in the usual proximal and subdorsal position; chela tip simple, hooked and tip of dactyl hanging over tip of pollex; gonopod with short thumb.

Habitat : Muddy substratum in upper littoral zone and often in shady place under mangrove.

Remarks : Carapace pale orange, major cheliped with yellowish manus, ambulatories are orange to yellow in both sexes. This species occurs on the bank of tidal streams of brackish water. Large population have been observed along the roots of mangroves and on the mud of mangrove floor.

Distribution : *India* : West Bengal : South 24 Parganas; Tamil Nadu; Pondichery.

Outside India : Burma; Malaysia

Subfamily II. SCOPIMERINAE

Diagnosis : Carapace very deep, subglobose or quadrilateral; frontal groove narrow and deflexed; antennular flagellum rudimentary; chelipeds equal or subequal in both sexes; orbits shallow; tympana present.

Key to Genera of Scopimerinae

1. Penultimate segment of 2nd maxilliped greatly expanded 2
 —. Penultimate segment of 2nd maxilliped not expanded 3
2. Lateral walls of carapace with deep convolute sculpture *Dotilla* Stimpson
 —. Lateral walls of carapace without conspicuous sculpture
 *Scopimera de* Haan
3. Tympana present *Dotillopsis* Kemp
 —. Tympana absent..... *Tympanomerus* Rathbun

Genus 3. *Scopimera* de Haan

1833. *Scopimera* de Haan, Siebold's *Fauna Japon Crust.* : 24.

1978. *Scopimera* : Quinn and Fielder, *Crustaceana*, 34 (3) : 310.

Diagnosis : Carapace narrow and globose; tympana present at merus of legs and cheliped; merus of external maxilliped shorter than ischium; lateral wall of carapace usually without conspicuous sculpture; manus and dactyl of chelipeds slender and gradually tapering.

Key to Species of *Scopimera*

1. 4th and 5th abdominal segments of male combined together
 *S. globosa* de Haan
 —. 4th and 5th abdominal segments of male not combined together
 *S. investigatoris* Alcock

* (7) *Scopimera investigatoris* Alcock

1900. *Scopimera investigatoris* Alcock, *J. Asiat. Soc. Bengal*, 69 : 369.

1919. *Scopimera investigatoris* : Kemp, *Rec. Indian Mus.*, 16 : 316, fig. 5 a, b.

Material examined : 2 (M) and 1 (F), Tiger reserve area, Sundarbans, South 24 Pargonas, 13.ix. 1983, A. K. Mondal.

Diagnosis : Ischium of 3rd maxillipeds longer than merus; tympana on meral segments of walking legs divided longitudinally by a narrow ridge; antero-lateral portions of carapace much inflated and separated by an abrupt declivity from outer orbital angles; 4th segment of male abdomen anteriorly emarginate, 5th longitudinally channelled; abdomen of female with convex lateral margins.

Habitat : Soft muddy with sand silted substratum in the low and middle littoral zones.

Remarks : Carapace is pale grey in colour. Most of the species of this genus live on the sea-shore. This species makes its way into brackish water or estuarine water or back water with variable salinity, but the environment in such situation is unfavourable and the crabs usually fail to reach their normal size. The species appears to be rare.

Distribution : *India* : West Bengal : South 24 Pargonas; Orissa. *Outside India* : Barma.

* (8) *Scopimera globosa* de Haan

1835. *Ocypode (Scopimera) globosa* de Haan, Siebold's *Fauna Japonica Crust.*, : 53, pl. 11, fig. 3.

1981. *Scopimera globosa* : wada *Seto mar. biol. Lab.*, **26** (1-3) : 243.

Material examined : 1 (M) and 1 (F) (ovigerous), Tiger Reserve area, Sundarbans, South 24 Pargonas, 13.ix. 1983, A.k. Mondal.

Diagnosis : Carapace posteriorly divergent and with tubercles; front bluntly pointed and narrow; lateral margin of carapace finely crenulated; 3rd maxillipeds bulge strongly; ischium longer than merus; tympana present on outer side of merus; 4th and 5th abdominal segments of male combined together; orbits with strong dorsal inclination, upper orbital margins end with a blunt extra-orbital tooth.

Habitat : Low littoral Zone with sandy mud substratum.

Remarks : This species is for the first time reported from the Indian waters. Earlier record of Muller (1887) from Trincomale, Sri Lanka was erroneously recorded by Kemp (1919).

Distribution : *India* : West Bengal : South 24 Pargonas. *Outside India* : Ceylon; Malaysia; Hong Kong; China; Japan; Korea.

Genus 4. *Dotilopsis* Kemp

1919. *Dotilopsis* Kemp, *Rec. Indian Mus.*, **16** : 334.

1987. *Dotilopsis* : Chakraborty *et al.*, *J. Bengal nat. Hist. Soc.*, **5** (1) : 60.

Diagnosis : Carapace cuboidal and dorsal surface deeply grooved ; penultimate segment of 2nd maxilliped a little expanded and ultimate segment terminal in position; tympana of merus ill-defined ; 5th, 6th and 7th abdominal segments of male narrow and 4th segment greatly expanded on either side; abdomen in female broadly oval.

(9) *Dotillopsis brevitarsis* (de Man)

1888. *Dotilla brevitarsis* de Man, *J. Linn. Soc.*, **22** : 130.

1987. *Dotillopsis brevitarsis* : Chakraborty *et al.*, *J. Bengal nat. Hist. Soc.*, **5** (1) : 60.

Material examined : 2 (M) and 1 (F) (ovigerous), South of Pargumti, South 24 Pargonas, 9. ix. 1984; 6 (M) and 4 (F), Gosaba, South 24 Pargonas; 17. ix. 1984; 4 (M) and 1 (F), Canning, South 24 Pargonas, 17.v.1985, N. Bairagi.

Diagnosis : Sculpture of carapace prominent with deeply grooved, frontal groove continued to posterior margin, orbits shallow but distinct; manus with conspicuous longitudinal carinae at lower and inner portion, dactyl with a row of hair at upper margin; merus of external maxillipeds larger than ischium; tympana of merus ill-defined; 1st and 2nd walking legs at the lower portion of manus and carpus with tuft of hairs.

Habitat : Soft mud or semiliquid consistency of the lower littoral zone on the bank of Matla river. Through essentially an estuarine form it has been found in a small backwater near the open sea as well as a considerable up the Gangetic delta (Kemp, 1919).

Remarks : Carapace and walking legs at the base are grey. Cheliped is orange red except for the upper surface of the carpus which is grey. This species is common in the lower and middle Matla estuarine belt.

Distribution : *India* : West Bengal : South 24 Pargonas. *Outside India* : Burma ; Malaysia.

Genus 5. *Dotilla* Stimpson

1858. *Dotilla* Stimpson, *Proc. Acad. Sci. Philad.*, : 98.

1987. *Dotilla* : Chakraborty, *et al.*, *J. Bengal nat. Hist. Soc.*, **5** (1) : 60.

Diagnosis : Lateral walls of carapace with deep convolute sculpture, front with narrow deflexed lobe; penultimate segment of 2nd maxilliped expanded; 4th segment of abdomen overlapping 5th and with a thick bush of hair at its distal end in both sexes; abdomen of male not constricted; chelipeds equal and dactyl slender and a little deflexed.

Key to Species of *Dotilla*

1. Lower surface of manus of cheliped strongly carinate*D.intermedia* de Man
- : Lower surface of manus of cheliped not carinate*D. blanfordi* Alcock

(10) *Dotilla blanfordi* Alcock

1900. *Dotilla blanfordi* Alcock, *J. Asiat. Soc. Bengal*, **69** (2) : 366.

1987. *Dotilla blanfordi* : Chakraborty *et al.*, *J. Bengal nat. Hist. Soc.*, **5** (1) : 60.

Material examined : 2 (M), Kakdwip, 24 Pargonas, 25.viii. 1983, S.K. Tandon.

Diagnosis : Carapace with two lateral oblique grooves running from antero-lateral angle to postero-lateral angle; six-rayed of equal shallow grooves running from the mesogastric towards front, hepatic, branchial and cardiac; gastric region with 4 symmetrical tubercles; dactyl in cheliped a little longer than manus; merus of legs with tympana.

Habitat : Sandy or sand with muddy substratum in lower and mid-littoral zones. Except once the species has not been reported from the area under study.

Remarks : Carapace and walking legs are grey in colour with pale yellow cheliped.

Distribution : *India* : West Bengal : South 24 Pargonas, Maharashtra. *Outside India* : Pakistan.

*(11) *Datilla intermedia* de Man

1888. *Dotilla intermedia* de Man, *J. Linn. Soc. Zool.*, **22** : 135, pl. 4, figs. 4-6.

1919. *Dotilla Intermedia* : Kemp, *Rec. Indian Mus.*, **16** : 331, text-fig. 10 a-f.

Material examined : 7 (M) and 5 (F) Sagar Island South 24-Pargonas, A. Misra.

Diagnosis : Carapace sculptured with distinct grooves; two oblique grooves running from the hepatic and branchial regions towards postero-lateral angles; dactylus of male cheliped with two parallel rows of tubercles at dorsal and subdorsal position, inner margin of dactyl with a low rounded lobe near base of its prehensile edge; dorsal surface of manus granulated and at the lower margin with a row of tubercles forming a ridge; first abdominal sternum with a pair of large outstanding triangular teeth anteriorly.

Habitat : Sandy substratum in low littoral zone.

Remarks : Carapace and walking legs are grey in colour. Cheliped is yellow but the upper surface of the manus pale yellow. The species is for the first time recorded from West Bengal.

Distribution : *India* : West Bengal : South 24 Pargonas ; Orissa; Tamil Nadu.

Outside India : Burma.

Genus 6. *Tympanomerus* Rathbun

1897. *Tympanomerus* Rathbun, *Proc. Biol. Soc. Washington*, **11** : 164.

1919. *Tympanomerus* : Kemp, *Rec. Indian Mus.*, **16** : 336.

Diagnosis : Carapace quadrilateral and broader than long; front narrow with deflexed; orbital groove large; external maxillipeds completely close buccal cavern; merus much longer than ischium; chelipeds in both sexes equal; tympana absent or ill-defined.

Key to Species of *Tympanomerus*

- Carpus of cheliped with a tooth *T. gangeticus* Kemp
 Carpus of cheliped without any tooth *T. stapletoni* de Man

(12) *Tympanomerus stapletoni* de Man

1908. *Tympanomerus stapletoni* de Man, *Rec. Indian Mus.*, 2 : 212, pl. 18, figs. 1, 1 a-e.

1919. *Tympanomerus stapletoni* : kemp, *Rec. Indian Mus.*, : 16 : 344.

Material examined : 1 (M) and 2 (F), Nurpur, South 24 Parganas, 7. xii. 1983, A. Misra; 2 (M) and 3 (F), Geonkhali, Medinipur, 24. iii. 1985, N. Bairagi.

Diagnosis : Carapace quadrilateral, frontal groove broad, antero-lateral margin with crest and discontinuous posteriorly; orbits transverse with terminal eyes, extra-orbital tooth prominent; suborbital margins finely serrated; merus longer than ischium; manus of cheliped smooth at upper dorsal and lower border finely granular; 5th abdominal segment of male deeply constricted, 7th segment as long as broad.

Habitat : Found in small burrows in soft muddy substratum in mid-littoral zone.

Remarks : Carapace is green, chelipeds and legs marble white with partly reticulate green pigment. It is evidently abundant in estuary and seems to occur only in places near or a little beyond the limit of tidal influence.

Distribution : *India* : West Bengal : South 24 Parganas ; Medinipur. *Outside India* : Bangladesh.

(13) *Tympanomerus gangeticus* Kemp

1919. *Tympanomerus gangeticus kemp*, *Rec. Indian Mus.*, 16 : 347, pl. 13, fig. 3.

1987. *Illyoplax gangeticus* : Chakraborty, *et al.*, *J. Bengal nat. Hist. Soc.*, 5 (1) : 60.

Material examined : 1 (F), Chhotomollakhali, South 24 Parganas, 12. ix. 1984; 7 (M) and 5 (F), Gosaba, South 24 Parganas, 17. ix. 1984; 4 (M), Canning, South 24 Parganas, 17. v. 1985 N. Bairagi.

Diagnosis : Carapace broader than long and upper surface with scattered setae, frontal groove broad with rounded lateral angles; antero-lateral angle with crest; carpus of cheliped elongated with a tooth; lower surface of manus with fine granules ; dactyl with a short rows of small teeth at base; first two walking legs with short wooly hair on carpus and manus; 5th abdominal segment of male with a little shallow and distal margin less convergent anteriorly.

Habitat : Soft mud in lower littoral zone.

Remarks : Carapace is grey in life while dactyl of cheliped white and with dark spots on the walking legs. This is found in abundance in the lower and middle Matla estuarine area.

Distribution : *India* : West Bengal : South 24 Pargonas ; Maharashtra.

Outside India : Absent.

Subfamily III. MACROPHTHALMINAE

Diagnosis : Carapace quadrilateral, broader than long; frontal groove a little broad or narrow; antenna folded transversally; eyestalk usually elongated; chelipeds usually subequal.

Genus 7. *Macrophthalmus* Latreille

1829. *Macrophthalmus* Latreille, *Cuvier Rigne An.* (ed. 2), 4 : 44.

1987. *Macrophthalmus* : Chakraborty et al., *J. Bengal nat. Hist. Soc.*, 5 (1) : 60.

Diagnosis : Carapace depressed and quadrilateral, broader than long; antero-lateral border with two prominent teeth; frontal groove narrow; orbit narrow occupying whole anterior border of carapace; eyestalk very long and slender; chelipeds equal or subequal in both sexes.

Key to Species of *Macrophthalmus*

1. Lateral borders of carapace convergent posteriorly 2
- Lateral borders of carapace somewhat parallel..... 5
2. Eyestalk project beyond antero-lateral angle *M. transversus* (Latreille)
- Eyestalk not project beyond antero-lateral angle 3
3. Branchial region of carapace with large granulated tubercles
..... *M. crassipes* H. Milne-Edwards
- Branchial region of carapace without any granulated tubercles 4
4. Branchial region of carapace with large spiniform granules *M. pectinipes* Guerin
- Branchial region of carapace without any spiniform granules.....*M. brevis* (Herbst)
5. Sub-orbital margin with two oblique tubercles *M. erato* de Man
- Sub-orbital margin without oblique tubercles 6
6. Upper border of manus of cheliped with a row of large granules and lower surface quite smooth *M. depressus* Ruppell

- . Upper border of manus of cheliped without large granules and lower surface conspicuously granular anteriorly 7
7. Inner surface of chela including dactyl densely covered with hair *M. teschi* Kemp
- . Inner surface of chela not densely covered with hair *M. pacificus* Dana

(14) *Macrophthalmus transversus* (Latreille)

1817. *Gonoplax transversus* Latreille, *Nouv. Diet. d'hist. nat.*, 2 ed., t. 13 : 237.

1919. *Macrophthalmus transversus* : Kemp, *Rec. Indian Mus.*, 16 : 386, pl. 24, fig. 1.

Material examined : 1 (M) Haldia, Medinipur, 7.xi.1986, A. Misra.

Diagnosis : Carapace much broader than long and lateral border posteriorly convergent; eyestalk long and projecting beyond external orbital angle; frontal groove narrow; upper orbital margin faintly convex and serrated along its half, suborbital margin projecting much forward and with minute denticles; lower surface of manus with a row of serrated crests of cheliped and dactyl with a large molar tooth near the base; branchial region with 4 denticulated tubercles.

Habitat : Sandy silted mud in the lower littoral zone.

Remarks : Carapace is bluish grey in life. Cheliped and ambulatories are grey while upper portion of the manus white. This was so far unknown to this area and seems to be rare form.

Distribution : *India* : West Bengal : Medinipur ; Orissa ; Pondicherry.

Outside India : Africa; Indonesia.

(15) *Macrophthalmus crassipes* H. Milne-Edwards

1852. *Macrophthalmus crassipes* H. Milne-Edwards, *Annl. Sci. nat.zool.*, 18 (3) : 157.

1967. *Macrophthalmus crassipes* : Dall, *Comp. Biochem. Physiol.*, 21 : 653.

Material examined : 1 (M) and 1 (F), Jharkhali, South 24 Pargonas, 23.ii.1986, N. Bairagi.

Diagnosis : Lateral border of carapace convergent posteriorly and upper surface of carapace with fine granules except middle portion; eyestalk not projected beyond antero-lateral angle; anterolateral tooth triangular, incision narrow between external orbital angle and antero-lateral tooth; upper orbital margins crenulated and oblique; sub-orbital margins serrated; branchial region with three large granulated tubercles; above the posterior margin a prominent single row of compact granules parallel to the former extending both the postero-lateral margins; a spine at the

middle of inner surface of manus of cheliped near the carpal joint, inner surface of manus and dactyl with much hairy.

Habitat : Muddy substratum in the lower littoral zone.

Remarks : Carapace is pale orange in life. Cheliped and ambulatories are grey. Upper surface of manus of the cheliped is white. This is for the first time reported from India and appear to be a rare form.

Distribution : *India* : West Bengal : South 24 Pargonas. *Outside India* : China; Thailand; Malaysia; Caroline Island; Australia.

(16) *Macrophthalmus pectinipes* Guerin

1839. *Macrophthalmus pectinipes* Guerin, Voy. "Favorite" 5 (2) : 169, pl. 49.

1987. *Macrophthalmus pectinipes* : Chakraborty *et al.*, *J. Bengal nat. Hist. Soc.*, 5 (1) : 60.

Material examined : 2 (M), Haldia, 26. vi. 1983, A Misra; 3 (M), Pargumti, south 24 Pargonas. 12.ix.1983, A. Misra.

Diagnosis : Lateral border of carapace convergent posteriorly and carapace with large spinous tubercles; frontal groove narrow; orbits oblique, upper orbital margin elegantly denticulated and lower orbital margin unevenly crenulated; eyestalk slender and curved but not projected beyond antero-lateral angle; antero-lateral border with 3 acute teeth while postero-lateral border convergent; dactyl base of male cheliped with a tooth and thickly hairy at upper margin; merus of walking legs with a spine.

Habitat : Muddy substratum in the lower littoral zone.

Remarks : Carapace is uniformly grey and the tubercles pearly white in life. This species is quite common in this area.

Distribution : *India* : West Bengal : South 24 Pargonas ; Medinipur; Orissa; Maharashtra.

Outside India : Pakistan; Malaysia.

(17) *Macrophthalmus brevis* (Herbst)

1804. *Cancer brevis* Herbst, *Naturgesch. Krabben U. Krebse*, 3 (4) : 9, pl. 60, fig. 4.

1987. *Macrophthalmus brevis* : Anonymous, *Mangrove Ecosystem of Sundarbans*, Department of Marine Science (C.U.) : 74.

Material examined : 1 (M), Harinbari, Sagar Island, South 24 Pargonas, 11.iv.1982, S. Nandi.

Diagnosis : Lateral border of carapace convergent posteriorly and 3 small granulated tubercles at the branchial region, frontal groove narrow; eyestalk not projected beyond antero-lateral

angle; upper orbital margin crenulated and oblique, suborbital margin finely serrated; external orbital angle obliquely projected forward; manus of male cheliped elongated with a distinct spine near inside carpal end, inner surface of manus and dactyl with hair.

Habitat : Mud with sandy silted substratum in the lower intertidal zone.

Remarks : In life carapace is grey in colour. This species is very rare in the estuarine belt of West Bengal.

Distribution : *India* : West Bengal : South 24 Pargonas ; Pondicherry.

Outside India : Mauritius; Burma; Malaysia; East Indies.

(18) *Macrophthalmus erato* de Man

1888. *Macrophthalmus erato* de Man, *J. Linn. Soc. Zool.*, **22** : 125, pl. 8 ; figs. 12-14.

1960. *Macrophthalmus erato* : Guinot and Dumortier, *Crustaceana*, **1** (2) : 117.

Material examined : 3 (F), (1 ovigerous), Sagar Island, South 24 Pargonas. 28.v.1975, A.K.Das; 3 (M) and 4 (F), Bakkhali, South 24 Pargonas, 6.iii.1985, N. Bairagi.

Diagnosis : Carapace smooth at the middle but with a few granules in the branchial region, lateral border of carapace somewhat parallel; frontal groove moderately narrow and eyestalk not projected beyond antero-lateral angle; upper orbital margin slightly oblique and finely crenulated, suborbital margin with two triangular lobe or oblique tubercles at distal end; 3 margins of merus of cheliped serrated, manus longer than the merus and inner surface hairy and with a spine; 3rd walking leg with a tuft of hair at manus and carpus.

Habitat : Sandy substratum in the lower littoral zone.

Remarks : Carapace is pale grey in life. This species is for the first time reported from West Bengal.

Distribution : *India* : West Bengal : South 24 Pargonas ; Orissa. *Outside India* : Burma; Hongkong; Malaysia; Indonesia.

(19) *Macrophthalmus depressus* Ruppell

1830. *Macrophthalmus depressus* Ruppell, *24 Kurzschr 'a' nz. Krabben d' Rothen Meeres* : 19, pl. 4, fig.6.

1975. *Macrophthalmus depressus* : Rice, *Bull. Br. Mus. nat. Hist. (Zool.)*, **28** (5) : 237.

Material examined : 2 (M) and 1 (F), Haldia, Medinipur, 16.iii.1985; 1(F) (ovigerous), Gosab, South 24 Pargonas, 27.v.1985; 1(M) and 1 (F), Sonakhali, South 24 Pargonas, 29.v.1985, N. Bairagi.

Diagnosis : Lateral border of carapace somewhat parallel and carapace surface granular except its middle part; frontal groove narrow; upper orbital margin nearly straight, suborbital margin distinctly and regularly crenulated and without oblique tubercles; eyestalk slender, reaching nearly to external orbital angle; outer orbital angle rectangular; manus in male cheliped short, upper border with a row of large granules and lower surface quite smooth; dactyl with a large rectangular tooth near base; 2nd and 3rd walking legs densely covered with hair at carpus and propodites.

Habitat : Muddy substratum in the lower intertidal zone.

Remarks : In life carapace is grey in colour. This is a common form in the estuarine belt of West Bengal.

Distribution : *India* : West Bengal : South 24 Pargonas; Medinipur; Tamil Nadu; Pondicherry; Maharashtra. *Outside India* : East Africa; Suez; Yemen; Bahrain; Ceylon; Burma.

(20) *Macrophthalmus teschi* Kemp

1919. *Macrophthalmus teschi* Kemp, *Rec. Indian Mus.*, **16** : 393, pl. 24, figs. 8-9.

1986. *Macrophthalmus teschi* : Chakraborty *et al.*, *J. Bengal nat. Hist. Soc.*, **5** (1) : 60.

Material examined : 1 (M) Pargumti South 24 Pargonas, 9.ix.1984; 3 (M) and 2 (F), Jharkhali, South 24 Pargonas, 21.v.1985; 1 (M) and 1 (F), Gosaba, 25.v.1985, N. Bairagi.

Diagnosis : Carapace surface granular and lateral border somewhat parallel; frontal groove moderately narrow and eyestalk not projected beyond antero-lateral angle; upper orbital margin finely crenulated, suborbital margin serrated and without oblique tubercles; antero-lateral margins finely crenulated and angle with two teeth; postero-lateral striae with two simple rows of granules; upper border of manus of cheliped smooth, the whole inner surface of cheliped including finger densely covered with hair, pollex base with a large tooth.

Habitat : Soft muddy substratum in the lower intertidal zone.

Remarks : Carapace is grey in life. This species is common in the Matla estuarine belt.

Distribution : *India* : West Bengal : South 24 Pargonas. *Outside India* : Burma.

(21) *Macrophthalmus pacificus* Dana

1851. *Macrophthalmus pacificus* Dana, *Proc. Acad. nat. Sci. Philad.*, **5** : 248.

1974. *Macrophthalmus pacificus* : Nye, *New Zeland JI. mar. freshwat. Res.*, **8** (2) : 243.

Material examined : 1 (M), Birajmanir Char, Gosaba, South 24 Pargonas, 27.v.1985, N. Bairagi.

DISTRIBUTION OF OCYPODID CRABS IN INDIA

Name of States Name of Species	West Bengal	Orissa	Andhra Pradesh	Tamil- Nadu	Pondi chery	Kerala	Goa	Maha- rashtra	Gujarat	Laksha- dweep	Andaman & Nicobar	Remarks
1. <i>Ocypoda ceratophthalma</i>	+	+		+				+		+	+	
2. <i>Ocydoda macrocera</i>	+	+										
3. <i>Uca (Deltuca) rosea</i>	+										+	
4. <i>Uca (Deltuca) dussumieri spinata</i>	+		+	+								
5. <i>Uca (Celuca) lactea annulipes</i>	+	+		+	+	+		+			+	
6. <i>Uca (Celuca) triangularis bengali</i>	+			+	+							
7. <i>Scopimera investigatoris</i>	+	+										
8. <i>Scopimera globosa</i>	+											
9. <i>Dotillopsis brevitarsis</i>	+											
10. <i>Dotilla blanfordi</i>	+							+				
11. <i>Dotilla Intermedia</i>	+	+										
12. <i>Tympanomerus stapletoni</i>	+											
13. <i>Tympanomerus gangeticus</i>	+							+				
14. <i>Macrophthalmus transversus</i>	+	+			+							
15. <i>Macrophthalmus crassipes</i>	+											
16. <i>Macrophthalmus pectinipes</i>	+	+						+				
17. <i>Macrophthalmus brevis</i>	+				+							
18. <i>Macrophthalmus erato</i>	+	+										
19. <i>Macrophthalmus depressus</i>	+			+	+			+				
20. <i>Macrophthalmus teschi</i>	+											
21. <i>Macrophthalmus pacificus</i>	+						+		+		+	

Diagnosis : Lateral border of carapace somewhat parallel and carapace surface smooth and glossy to naked eye, two longitudinal slightly pubescent lines on each side of branchial region and a third row lying before them and running in a transverse direction; frontal grooves narrow and eyestalk not projected beyond the antero-lateral angle; external orbital angle somewhat blunt and rectangular; suborbital margin without oblique tubercles; upper border of manus smooth in male cheliped, dactyl with a large quadrangular tooth somewhat before the middle; last walking leg with a small spine at distal end on the anterior margin.

Habitat : Sandy substratum in the lower intertidal zone.

Remarks : Carapace is uniformly grey in life. It is for the first time recorded from the area under study and appears to be a rare form.

Distribution : India : West Bengal : South 24 Parganas ; Goa; Gujarat; Nicobar.

Outside India : Malaysia; Samoa; Upolu; Loo Choo Island; Australia; Japan.

SUMMARY

The present paper deals with 21 species of Ocypodid crabs from the Hugly-Matla estuarine area of West Bengal. Of these, 8 species, namely *Scopimera investigatoris* Alcock, *Scopimera globosa* de Haan, *Dotilla intermedia* de Man, *Macrophthalmus transversus* (Latreille), *Macrophthalmus crassipes* H. Milne-Edwards, *Macrophthalmus erato* de Man, *Macrophthalmus depressus* Ruppell and *Macrophthalmus pacificus* Dana are recorded for the first time from the area under study. The diagnostic characters and keys to genera and species have been provided. A classified list of species, methods of collection and preservation have also been included.

ACKNOWLEDGEMENTS

The author is grateful to Dr. A. K. Ghosh, Director, Zoological Survey of India, Calcutta, for providing laboratory facilities and Dr. B.P. Haldar, Zoologist, for their initiative and interest during the entire period of studies and proper guidance.

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PRAWNS AND SHRIMPS (CRUSTACEA : DECAPODA)

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INTRODUCTION

Prawn and shrimp material collected from Hugli—Matla estuarine complex by the Sundarban Field Research Station, Canning, was studied. The material comprising about 2000 specimens revealed the presence of 21 species belonging to 5 genera under the families Penaeidae, Sergestidae, Palaemonidae and Hippolytidae. To indicate the size of the specimens observed, total length was measured from the tip of the rostrum to the tip of the telson.

Geographically, the collection localities encompass the Indian part of Sundarbans and fall in two districts viz., South 24-Parganas and North 24-Parganas. In the reclaimed and inhabited areas, the localities are more or less easily discernible, as they are followed by the mention of the name of the administrative block. In the Reserve Forests, the localities are not so easily discernible and hence the nomenclature followed by the authorities of "Project Tiger" and "24-Parganas Divisional Forest" are adopted for locating them. Here also, each locality name is followed by the name of the forest block as well as the name of the Wildlife Sanctuary or National Park or other Reserve Forest in which it falls and the name of the supervising Forest Authority.

Abbreviations followed in this regard are as follows:—

SWS— Sajnekhali Wildlife Sanctuary

BR— Basirhat Range

NPER— National Park East Range

NPWR— National Park West Range

STR— Sundarban Tiger Reserve

24—PDF—24 Parganas Divisional Forest

LIST OF THE SPECIES IDENTIFIED

Class : CRUSTACEA

Order : DECAPODA

Sub Order : DENDROBRANCHIATA

Family : PENAEDIDAE

1. *Metapenaeus affinis* (H. Milne Edwards)
2. *M. brevicornis* (H. Milne Edwards)
3. *M. dobsoni* (Miers)
4. *M. lysianassa* (de Man)
5. *Parapenaeopsis sculptilis* (Heller)
6. *P. stylifera* (H. Milne Edwards)
7. *Penaeus indicus* H. Milne Edwards
8. *P. japonicus* Bate
9. *P. merguensis* de Man
10. *P. monodom* Fabricius
11. *P. penicillatus* Alcock

Family : SERGESTIDAE

12. *Acetes erythraeus* Nobili
13. *A. indicus* H. Milne Edwards

Sub Order : PLEOCYEMATA

Infra Order : CARIDEA

Family : PALAEMONIDAE

14. *Exopalaemon styliferus* (H. Milne Edwards)
15. *Macrobrachium equidens* (Dana)
16. *M. javanicum* (Heller)
17. *M. lamarrei* (H. Milne Edwards)

18. *M. mirabile* (Kemp)

19. *M. rosenbergii* (de Man)

20. *M. rude* (Heller)

Family : HIPPOLYTIDAE

21. *Hippolysmata (Exhippolysmata) ensirostris* Kemp.

SYSTEMATIC ACCOUNT

Class : CRUSTACEA

Order : DECAPODA

Key to sub-order

- 1. Gills dendrobranchiate.....Dendrobranchiata
- Gills phyllobranchiate or trichobranhiate.....Pleocyemata

Sub order : DENDROBRANCHIATA

Key to the families for the species identified.

- 1. Last two pairs of walking legs well developed; gills many.....PENAEIDAE
- Last one or two pairs of walking legs reduced or absent; gills few or wanting.....SERGESTIDAE.

Family : PENAEIDAE

Key to the genera known from Hugli Matla estuarine complex

- 1. Rostrum with ventral teeth.....*Penaeus*
- Rostrum without ventral teeth.....2

2. A distal fixed pair of spines and 1-3 pairs of mobile spines on the telson.....3
 — No distal fixed pair of spines, but lateral mobile spines may be present on the telson.....4
3. Petasma symmetrical, 3rd maxilliped without basial spine.....*Parapenaeus*.
 — Petasma asymmetrical, 3rd maxilliped with basial spine.....*Metapenaepsis*.
4. Expod on 5th pereopod absent; pleurobranch on 7th thoracic somite present.....*Metapenaeus*.
 — Expod on 5th pereopod present; pleurobranch on 7th thoracic somite absent.....5
5. Carapace without longitudinal sutures; ischial spine on 2nd pereopod present.....*Atypopenaenus*.
 — Carapace with longitudinal sutures; ischial spine on 2nd pereopod absent.....*Parapenaepsis*.

Genus : *Metapenaeus* Wood-Mason & Alcock, 1891

Key to the species known from Hugli-Matla estuarine complex.

- 1 Abdomen with a number of pubescent depressed areas.....2
 — Abdomen without depressed areas and uniformly glabrous; median plates of the lycum larger than posterior plates*M. brevicornis*.
2. Ischial spine on 1st pereopod present.....*M. monoceros*.
 — Ischial spine on 1st pereopod absent.....3
3. Rostrum exceeding distal end of basal segment of antennular peduncle.....4
 — Rostrum short, not reaching distal end of basal segment of antennular peduncle.....*M. lysianassa*.
4. Basial spine of 3rd pereopods in adult male long, barbed; 2 tubercles on merus of 5th pereopod in males.....*M. dobsoni*.
 — Basial spine of 3rd pereopods in adult male simple; 1 tubercle on merus of 5th pereopod in males.....*M. affinis*.

1. *Metapenaeus affinis* (H. Milne Edwards)

1837. *Penaeus affinis* H. Milne-Edwards, *Hist. nat. Crust. Paris*, 2 : 416.
 1906. *Metapeneus affinis* : Alcoc *Cat. Indian Decapod Crust.*, pt. 3 (1) : 20
 1915. *Penaeopsis affinis* : Kemp, *Mem. Indian Mus.*, 5 : 321.
 1969. *Metapenaeus affinis* : George, *Bull. cent. mar. Fish Res. Inst.*, 14 : 31.

Material : 1M (75mm), Reg. No. KN-437, Ukilbazar, Kakdwip, 12.xi.1979, A.K. Mondal; 4 exs. (42-70 mm), Reg. No. KN-439, Harwood Point, Kakdwip, 28.iii.1982, J. K. De; 2 exs. (60 mm), Reg. No. KN-440, Harwood Point, Kakdwip, 28.ii.1982, J.K. De; 3 exs. (20-60 mm), Reg. No. KN-441, Ghat No. 8, Kakdwip, 4.iv.1982, J.K. De; 3 exs. (20-50 mm), Reg. No. KN-442, Nikarighat, Canning, 5.v.1982, J.K. De; 2 exs. (20-30 mm), Reg. No. KN-443, Kakdwip, 29.xi.1982, N.C. Nandi; 1 ex. (32 mm), Reg. No. KN-445, Kakdwip, 16.iii.1983, J.K. De; 6 exs. (30-50 mm), Reg. No. KN-447, West of Gosaba 3.1.1985, J.K. De; 1F, Reg No. KN-449, Ukiler Hat, Kakdwip, 10.v.1986, N.C. Nandi ; 2 exs. (35-55 mm), Reg. No. KN-450, Sandeshkhali, 18.vi.1986, N.C. Nandi ; 1M, 1F, Reg. No. KN-452, Kalinagar, Hingalganj, 20.vi.1986, N.C.Nandi ; 6 exs. (30-45 mm), Reg. No. KN-454, Belekhali, Canning, 17.iii.1987, N.C. Nandi; 1F (85 mm), Reg. No. KN—456, Hinachakhali, Canning, 22.ix.1987, S.C. Saren; 56 exs., Reg. No. KN-457, Raidighi, Mathurapur, 3.vii.1987, N.C. Nandi; 3 exs., Reg. No. KN-459, Nikarighat, Canning, 21.vii.1988, M.K. Dev Roy; 1 ex., Reg. No. KN-461, Dabu, Canning, 11.x.1988, K.N. Reddy; 4 exs. (60-110 mm), Reg. No. KN-463, Sandeshkhali, 8.xi.1988, R.A. Khan; 1F, Reg No. KN-464, Chulkati, Chaulkhali, Thakuran River, 24-PDF 9.xi.1988, R.A. Khan ; 1 ex (70 mm), Reg. No. Kn-465, Tooshkhali, Sandeshkhali, 12.xi.1988, R.A. Khan; 4MM, 4FF (50-65 mm), Reg No. KN-466, Gosaba, 4.iii.1989, R.A. Khan ; 1 ex (100mm), Reg No. KN-467, Dhanchi, Patharpratima; 10.iii.1989, R.A. Khan ; 2 exs (60 mm), Reg. No. KN-468, Sajnekhali, SWS-STR, 14.iii.1989, R.A. Khan.

Diagnostic Characters : Body tomentose; rostrum with not less than 9 dorsal teeth, exceeding the distal end of basal segment of antennular peduncle; antennal spine strong, produced as salient ridge to small hepatic spine, the ridge bounding well marked post antennular groove which meets cervical groove.

A strong spine present on the basis of all 3 pairs of chelipeds.

In petasma, the two halves form a compressed tube, ending in a pair of two-lipped spouts, like short horns.

Thelycum concave, lateral lobes fairly flat and transversely cut into unequal segments; median plate grooved longitudinally and projects between 2 lobes of the sternum between 4th pair of legs.

Distribution : Indian Seas through Malaysia and parts of Indonesia to Hong Kong and Japan.

2. *Metapenaeus brevicornis* (H. Milne Edwards)

1837. *Penaeus brevicornis*. H. Milne Edwards, *Hist. nat. Crust, Paris*, 2 : 417.
 1906. *Metapeneus brevicornis* : Alcock, *Cat. Indian Decapod Crust.*, pt. 3 (1) : 22.
 1918. *Panaeopsis brevicornis* : Kemp, *Mem. Asiat Soc. Bengal*, 6 (5) : 294.
 1969. *Metapenaeus brevicornis* George, *Bull. cent. mar. Fish. Res. Inst.*, 14 : 28.

Material : 1 ex (70mm), Reg. No. KN-469, Muriganga, Kakdwip, 11.xi.1979, A.K. Mondal; 1 ex (80 mm), Reg. No. KN-470, Hugli River, Kakdwip 14.xi.1979, A.K. Mondal; 1 ex (90mm), Reg. No. Kn-471, Paharichak, Prathamgheri, 1.iv.1983, J.K. De. 1M (85mm), Reg. No. KN-473, Frasergunj, Namkhana, 19.xii.1983, N.C. Nandi; 4 exs (70-85 mm), Reg. No. Kn-474, Frasergunj, Namkhana 21.xii.1983, N.C. Nandi; 1 ex (65mm), Reg. No. Kn-475, Rakhaskhali, Patharpratima, 16.viii.1984, J.K. De; 1 ex (60 mm). Reg. No. KN-476, Nazat, Hingalganj, 19.vi.1986, N.C. Nandi; 1M (70mm) Reg. No. KN-477, Frasergunj, Namkhana 19.xii.1986, N.C. Nandi; 2FF (65 & 75 mm), Reg. No. KN—478, Jambu Id., off the mouth of Muriganga River, 20.xii.1986, N.C. Nandi; 3 exs (72-105mm), Reg. No. Kn-480, Kishorimohanpur, Kultali, 8.xi.1988, R.A. Khan; 2 FF (100-120mm), Reg. No. KN-482, Chulkati, Chaulkhali, Thakuran River, 24 PDF, 9.xi.1988, R.A. Khan; 1M, 1F, Reg. No. KN-483, Bheries at Golabari, Herobhanga, Canning, 21.ii.1989, K.N. Reddy; 2FF (75-95mm) Reg. No. KN-484, Gosaba, 4.iii.1989, R.A. Khan; 2FF (65-80mm), Reg. No. KN-485, Kalas, mouth of Thakuran River, 24-P.D.F. 10.iii.1989, R.A. Khan.

Diognostic Characters : Body-not, or very little tomentose; rostrum with a decided crest bearing 7 teeth, reaches the distal end of basal segment of antennular peduncle; antennal spine is weak and not continued as a well marked post-antennular ridge, so that the post-antennular groove is shallow.

A strong spine present on the basis of all 3 pairs of chelipeds. Ischial spine present on 1st pereopods.

In petasma, the two halves form a compressed tube ending in a pair of simple spouts, each of which carries near its middle a filament.

Thelycum concave, its mediam lobe is shaped like a figure of eight, the posterior portion being encircled by the flat crescent-shaped lateral lobes, the anterior portion being embraced between the processes of the 4th thoracic sternum.

Distribution : Pakistan through India, Malayasia, Thailand, Indonesia to about East Borneo

3. *Metapenaeus dobsoni* (Miers)

1878. *Panaeus dobsoni* Miers, *Proc. Zool. Soc. London*, P. 302.
 1906. *Metapeneus dobsoni* : Alcock, *Cat. Indian Decapod Crust.*, pt. 3(1) ; 21

1915. *Penaeopsis dobsoni* : Kemp, *Mem. Indian Mus.*, 5 : 322.

1969. *Metapenaeus dobsoni* : George, *Bull. cent. mar. Fish. Res. Inst.*, 14 : 29.

Material : 5 exs., KN-486, Dabu, Canning, 11.x.1988, K.N.Reddy.

Diagnostic Characters : Rostrum with 8-9 proximal teeth forming a crest, a well marked uptilted distal portion devoid of teeth; surpassing the tip of the antennular peduncle. Antennal spine not very strong and not continued backward as a strong ridge; post antennal sulcus not deep.

A strong spine on the basis of all 3 pairs of chelipeds, the one on the 3rd pair in adult males long and barbed.

In petasma, the two halves form a compressed tube ending in a pair of simple distomedian spouts; and at the origin of these spouts there are 4 papillae, 2 anterior and 2 posterior.

Thelycum consists of a broad concave median tongue, ensheathed posteriorly in horse-shoe shaped process formed by the union of the lateral lobes of its own. In impregnated females, the thelycum is obscured by a pair of white conjoined triangular pads.

Distribution : India through Malaysia and Indonesia to Philippine Islands.

4. *Metapenaeus lysianassa* (de Man)

1888. *Penaeus lysianassa* de Man, *J. Linn. Soc. Lond. (Zool.)* 22 (140) : 290.

1906. *Metapeneus lysianassa* : Alcock, *Cat. Indian Decapod Crust.*, pt. 3 (1) : 23.

1969. *Metapenaeus lysianassa* : George, *Bull cent. mar. Fish. Res. Inst.* 14 : 28.

Material : 1 ex. (38mm), Reg. No. KN-489, Harwood Point, Kakdwip, 28.ii.1982, J.K. De; 12 exs. (30-40mm), Reg. No. KN-490, Harwood Point, Kakdwip, 28.ii.1982, J.K. De; 1 ex (56 mm), Reg. No. KN-491, Harwood Point, Kakdwip, 28.iii.1982, J. K. De ; 112 exs. (20-30 mm), Reg. No. KN-492, Ghat No. 8, Kakdwip, 4.iv.1982, J.K. De; 79 exs. (20-40 mm), Reg. No. KN-493, Nikarighat, Canning, 5.v.1982, J.K. De; 12 exs. (20-55 mm), Reg. No. KN-494, Kakdwip, 29.xi.1982, N.C. Nandi; 4 exs. (20-30 mm), Reg. No. KN-496, Kakdwip, 16.iii.1983, J.K. De; 1M, 1F (50-65 mm) Reg. No. KN-497, Mandirtola, Sagar Id., 14.iv.1983, J.K. De; 1 ex, Reg. No. KN-498, Budhakhali, Kakdwip, 7.xii.1983, N.C. Nandi; 2 exs. (50-60 mm), Reg. No. KN-499, Frasergunj, Namkhana, 19.xii.1983, N.C. Nandi; 2 exs (30 & 40 mm), Reg. No. KN-500, Hatania Duania, Namkhana, 31.xii.1983, J.K. De; 5 exs (32-43 mm), Reg. No. KN-501, Chemaguri, Sagar Id., 10.ix.1984, J.K. De; 1 ex (40 mm), Reg. No. KN-502, Gosaba, 1.i.1985, J.K. De; 2 exs. (50-85 mm), Reg. No. KN-503, Sonakhali, Basanti, 2.iv.1985, R.A. Khan; 1 ex (40-50 mm), Reg. No. KN-505, Purandar, Basanti, 5.iv.1985, R.A.Khan; 7 exs (50-60 mm), Reg. No. KN-507, Netidhopani, N.P.W.R-STR, 20.iv.1985, R.A. Khan; 6 exs (30-60 mm), Reg. No. KN-508, Gosaba, 23.iv.1985, R.A. Khan; 1 ex. (50 mm), Reg. No. KN-509, Gosaba, 24.iv.1985, R.A. Khan; 2 exs (45 mm), Reg. No. Kn-510, Matla River at Dighir Par, Canning, 3.iv.1986, R.A. Khan; 1 ex (45 mm), Reg. No. Kn-511, Natrabari, Golabari Herobhanga,

Canning, 12.vi.1986, N.C. Nandi; 1 ex (58 mm), Reg. No. KN-512, Sandeshkhali, 18.vi.1986, N.C. Nandi; 1 ex (40 mm), Reg. No. KN-513, Nazat, Hingaljanj, 19.vi.1986, N.C. Nandi; 4 exs. (40-60 mm), Reg. No. KN-515, Belekhal, Canning, 17.iii.1987, N.C. Nandi; 8 exs. (20-45 mm), Reg. No. Kn-516, Purandar, Basanti, 5.iv.1987, R.A. Khan; 1 ex (50 mm), Reg. No. KN-517, Raidighi, Mathurapur, 3.vii.1987, N.C. Nandi; 7 exs (40-45 mm), Reg. No. Kn-518, Saimari, Mayadwip, NPWR-STR, 23.viii.1987, N.C. Nandi; 1 ex (65 mm), Reg. No. KN-519, Haldibari, Goashaba, NPWR-STR, 7.i.1988, R.A. Khan; 3 exs. (35-40 mm), Reg. No. KN-520, Golabari, Herobhanga, Canning, 11.x.1988, K.N. Reddy; 1 ex. Reg. No. KN-521, Pirkhali, SWS-STR, 2.xi.1988, R.A. Khan; 1M, 1F, Reg. No. KN-523, Confluence of Matla and Bidya Rivers, Netidhopani, STR, 4. xi.1988, R.A. Khan; 2 exs (35-40 mm), Reg. No. Kn-524, Arbesi, BR-STR, 12.xi.1988, R.A. Khan; 7 exs. (45-48 mm), Reg. No. KN-525, Marich Jhanpi, Jhilla-I, BR-STR, 13.xi.1988, R.A. Khan; 8MM, 8FF, Reg. No. KN-526, Bheries at Golabari Herobhanga, Canning, 21.ii.1989, K.N. Reddy; 3FF (55-62 mm), Reg. No. KN-527, Gosaba, 4.iii.1989, R.A. Khan; 1F (50mm), Reg. No. KN-528, Panchamukhani, SWS-STR 5.iii.1989, R.A. Khan; 1F, Reg. No. KN-530, Haldibari, Goashaba, NPWR-STR, 13.iii.1989, R.A. Khan; 2 exs., Reg. No. KN-531, Sajnekhali, STR, 14.iii.1989, R.A. Khan; 2 exs. (52 mm), Reg. No. KN-532, Arbesi, BR-STR 15.iii.1989, R.A. Khan.

Diagnostic Characters : Rostrum wide and short not reaching to distal end of basal antennular segment.

In petasma, the distomedian projection with vestigial apical filament represented by a pair of rounded bosses.

In thelycum, the anterior and lateral plates are of ovoid in shape and subequal in size; conjoined pads usually set askew.

Distribution : India, Sri Lanka to North Borneo. In India, mostly on east coast of Hugli River, Orissa and Gulf of Mannar.

Genus : *Parapenaopsis* Alcock, 1901

Key to the species from Hugli-Matla estuarine complex.

1. Second pereopod with basial spine.....2
- Second pereopod without basial spine.....*P. uncta*.
2. Teleson with a pair of fixed subapical spines; distal half of rostrum unarmed.....*P. stylifera*.
- Teleson without fixed subapical spines, with or without lateral movable spines; distal 1/3 or less of rostrum unarmed.....*P. sculptilis*.

5. *Parapenaeopsis sculptilis* (Heller)

1862. *Penaeus sculptilis* Haller, *Verh. Zool. Bot. Ges. Wien* 12 : 528.

1957. *Parapenaeopsis sculptilis* : Dall, *Aust. J. mar. Freshw. Res.*, 8 (2): 217.

1969. *Parapenaeopsis sculptilis* : George, *Bull. cent. mar. Fish. Res. Inst.*, 14 : 35.

Material : 6FF (60-72 mm), Reg. No. KN-533, Chhayer Gheri, 15.x.1979. A.K. Mondal; 4 exs. (105-125 mm), Reg. No. Kn-534, Vakil Bazar, Kakdwip, 12.xi.1979. A.K. Mondal; 5 FF (90-130mm), Reg. No. KN-535, Vakil Bazar, Kakdwip 12.xi.1979, A.K. Mondal; 4 exs. (40-60 mm), Reg. No. KN-536, Hugli River, near Kakdwip, 14.xi.1979, A.K. Mondal; 8 exs (65-85 mm), Reg. No. KN-537, Namkhana, 15.xi.1979, A.K. Mondal; 1 ex (45 mm), Reg. No. KN-538, Harwood Point, Kakdwip, 6.iii.1980, A.K. Mondal; 3 exs. (60-100mm), Reg. No. KN-539, Harwood Point, Kakdwip, 26.iv.1980. A.K. Mondal; 4 exs. (60-85 mm), Reg. No. KN-540, Bakkhali, Namkhana, 19.v.1980, A.K. Mondal; 2 exs (69 & 80mm), Reg. No. Kn-541, Kurali Khal, Canning 22.v.1980, A.K. Mondal; 1 ex. (60 mm), Reg. No. KN-542, Namkhana, 27.vi.1980, A.K. Mondal; 1M (70 mm), Reg. No. KN-543, Harwood Point, Kakdwip, 28.vi.1980, A.K. Mondal; 1 ex (80 mm), Reg. No. KN-544, Bhuban Nagar, Kakdwip, 10.x.1982, J.K. De; 1F (150 mm), Reg. No. KN-545, Jambu Id., off the mouth of Muriganga River, 31.xii.1982, N.C. Nandi; 4 exs (40-70mm), Reg. No. KN-546, Pathar Jettyghat, Patharpratima, 2.ii.1983, J.K. De; 1 ex. (50mm), Reg. No. KN-547, Belekhal, Canning, 17.iii.1987, N.C. Nandi; 4FF, (45-65 mm), Reg. No. KN-548, Mandirtola, Sagar Id., 14.iv.1983, J.K. De; 10 exs. (35-90 mm) Reg. No. KN-549, Mandirtola, Sagar Id., 15.iv.1983, J.K. De; 3 exs (50-110 mm), Reg. No. KN-550, Bhagavatpur, Patharpratima, 27.v.1983, N.C. Nandi; 2FF, 3 MM (50-80 mm), Reg. No. KN-551, Balasurai, 10.xi.1983, J.K. De; 1F (120mm), Reg. No. KN-552, Frasersgunj, Namkhana, 19.xii,1983, N.C. Nandi; 1M, 1F (105-115mm), Reg. No. KN-553, Frasersgunj, Namkhana, 20.xii.1983, N.C. Nandi; 3 exs (80-85mm), Reg. No. KN-554, Frasersgunj, 21.xii, 1983, N.C. Nandi; 1 ex (30 mm), Reg. No. KN-555, Phuldubi, Sagar Id., 11.iv.1984, J.K. De; 28 exs. (40-90 mm), Reg. No. KN-556, Gosaba I.i. 1985, J.K. De; 34 exs (30-90mm), Reg. No. KN-557, West of Gosaba, 3.i.1985, J.K. De; 21 exs. (30-95 mm), Reg. No. KN—558, Gosaba, 4.i.1985, J.K. De; 1M, 1F, (80-85 mm), Reg. KN-559, Jharkhali, 10.iv.1985, R.A. Khan; 1 ex (30 mm), Reg No. KN-560, Gosaba, 25.iv.1985, R.A. Khan; 1F, Reg. No. KN-561, Ukiler Hat, Kakdwip, 10.v.1986, N.C. Nandi; 5 exs (50-70 mm), Reg. KN-562, Nazat, Hingaljanj, 19.iv.1986, N.C. Nandi; 1M, 1F (120-140 mm), Reg. No. KN-563, Jambu Id., Off the mouth of Muriganga River, 20.xii.1986, N.C. Nandi; 1F (145 mm), Reg No. KN-564, Frasersgunj, 21.xii.1986, N.C. Nandi; 2FF (115-145mm), Reg. No. KN-565, Taltola, 15.ii.1987, N.C. Nandi, 2FF, 1M (100-130mm), Reg. No. KN-566, Purandar, Basanti, 17.ii.1987, N.C. Nandi; 2 exs. (102 mm), Reg. No. KN-567, Saimari, Mayadwip, NPWR-STR, 23.viii.1987, N.C. Nandi; 1 ex. (94 mm), Reg. No. KN-568, Netidhopani, NPWR-STR, 31.viii.1987, R.A. Khan; 1F (122 mm), Reg. No. KN-569, Haldibari, Goashaba, NPWR-STR 7.i.1988, R.A. Khan; 1M, 1F (105-145 mm), Reg. No. KN-570, Matla River at Dabu, Canning, 22.vii.1988, M.K. Dev. Roy; 7 exs (60-

120 mm), Reg. No. KN-571, Sandeshkhali, 8.xi.1988, R.A. Khan; 1M, 1F (100 mm), Reg. No. KN-572, Kishorimohanpur, Kultali, 9.xi.1988, R.A. Khan; 2FF (120-125 mm), Reg. No. KN-573, Tooshkhali, Sandeshkhali, 12.xi.1988, R.A. Khan; 3FF (42-55mm), Reg. No. KN-574, Gosaba, 4.iii.1989, R.A. Khan; 1F (85m), Reg. No. KN-575, Kalas, mouth of Thakuran River, 24-PDF, 10.iii.1989, R.A. Khan; 3 exs (100-110 mm), Reg. No. KN-576, Dhanchi, Patharpratima, 10.iii.1989, R.A. Khan; 1F(170 mm), Reg. No. KN-577, Kendokhal, Bhangaduni Id, NPWR-STR, 12.iii.1989, R.A. Khan.

Diagnostic Characters : Rostrum with 6-8 teeth, epigastric tooth either feeble or absent; in males reaching upto 2nd segment of antennular peduncle with teeth spreading upto the tip while in females with its edentate tip reaching beyond the antennular peduncle.

Antennal spine large, the carina reaching half distance between spine and hepatic spine; hepatic carina distinct only for lower $\frac{1}{2}$ sulcus, starting below hepatic spine and running towards sharp pterygostomial angle.

Epipodites present on 1st and 2nd pereopods, ischial spines absent.

In petasma, the two halves form a compressed tube with paired apical spout-like projections directed anterolaterally and opening ventrally, distance between their apices almost equal that of distolateral projections, which is $\frac{2}{5}$ total length of petasma. Petasma constricted at 0.7 its length; a pair of very large prominent lateral proximal projections, slightly curved dorsally, ending posteriorly in knob-like processes.

In thelycum, anterior plate slightly concave, two low tubercles on posterior edge separated by shallow median depression and articulating with corresponding pair of tubercles on rectangular posterior sternal plate later with tubercle bearing tuft of setae.

Distribution : India through Malaysia, Indonesia to Hong Kong and Australia and New Guinea. In India, northern areas of East and West coasts.

6. *Parapeneopsis stylifera* (H. Milne Edwards)

1837. *Panaeus styliferus* H. Milne Edwards, *Hist. nat. Crust Paris*, 2 : 418.

1906. *Parapeneopsis stylifera* : Alcock, *Cat. Indian Decapod Crust.*, pt. 3 (1) : 36.

1969. *Parapeneopsis stylifera* : George, *Bull. cent. mar. Fish. Res. Inst.* 14 : 34.

Material : 10 exs. (20-50 mm), Reg. No. Kn-578, Gosaba, 24.iv.1985, R.A. Khan; 6 exs. (30-50 mm), Reg. No. Kn-693, Haldibari, Goashaba, NPWR-STR, 22.viii.1987, R.A. Khan; 2 exs. (30-50 mm) Reg. No. Kn-694, Gosaba, 23.iv.1985, R.A. Khan; 1 ex. (40 mm), Reg. No. KN-695, Netidhopani, NPWR-STR, 20.4.1985 R.A. Khan; 1 ex (75 mm), Reg. No. KN-696, Pahari Chak Pratham Gheri, 1.iv.1983, J.K. De.

Diagnostic Characters : Rostrum sigmoid with a proximal crest bearing 5-7 teeth + epigastric, the distal portion styliform and edentate, strongly upcurved, projecting much beyond the tip of antennular peduncle. Post rostral carina distinct almost extending to posterior border of carapace. A fine longitudinal suture running from orbit to the gastric and a short transverse suture extending across the branchiostegite at the level of the 3rd pair of legs.

Orbital spine small, post-ocular sulcus moderately deep at an angle of 45° to rostrum. Cervical sulcus shallow and short, not quite reaching longitudinal suture. Antennal spine prominent, antennal carina ending below hepatic spine. Hepatic sulcus is very clear and is horizontal in its anterior $\frac{1}{4}$; hepatic carina distinct for lower $\frac{1}{2}$. Sulcus from below hepatic spine to the sharp pterygostomian angle.

Mastigobranchiae and basal spines on first two pereopods. Telson with 2 or more pairs of conspicuous subapical fixed spines.

Petasma simple and tubular; the distolateral projections slender, horn like and straight, directed anterolaterally with ventral openings; distomedian projections small and curved ventrally. Proximal lateral enlargements of petasma of moderate size and evenly rounded.

Thelycum consists of a large concave and square anterior median plate, posterior extension as a slender stem like process. Lateral plates smaller, fused posteriorly, each with an anteromedian indentation corresponding to a knob-like posterior process of the anterior lobe.

Distribution : India and Sri Lanka through Malaysia to Indonesia and Borneo.

Genus : *Penaeus* Fabricius, 1798

Key to the species known from Hugli-Matla estuarine complex.

1. Adrostral carina reaching almost to posterior border of carapace; gastrofrontal carina present.....2.
- Adrostral carina not reaching behind middle of carapace; gastrofrontal carina absent.....4
2. Telson armed usually with 3 pairs of spinules.....3.
- Telson unarmed; rostrum with 1 ventral tooth.....*P. canaliculatus*.
3. Adrostral sulcus narrower than post rostral carina; anterior plate of thelycum rounded at the apex.....*P. japonicus*.
- Adrostral sulcus as wide as post rostral carina; anterior plate of thelycum bifid at the apex.....*P. latisulcatus*.

4. Hepatic carina present5.
- Hepatic carina absent6.
5. Hepatic carina horizontally straight ; 5th pereopod without exopodite.....*P. monodon*.
- Hepatic carina inclined at an angle of 15° anteroventrally ; 5th pereopod with small exopodite.....*P. semisulcatus*.
6. Gastro orbital carina occupying the posterior 2/3 distance between hepatic spine and orbital angle.....*P. indicus*.
- Gastro orbital carina absent or not reaching hepatic spine and occupying the middle 1/3 distance between hepatic spine and orbital angle7.
7. Dactylus of 3rd maxilliped in adult males, half of propodus ; adrostral carina not reaching as far as epigastric tooth*p. merguensis*.
- Dactylus of 3rd maxilliped in adult males much longer than propodus ; adrostral carina reaching just beyond epigastric tooth*P. penicillatus*.

7. *Penaeus indicus* H. Milne Edwards

1837. *Penaeus indicus* H. Milne Edwards, *Hist. nat. Crust., Paris*, 2 : 415.

1906. *Peneus indicus* : Alcock, *Cat. Indian Decapod Crust.*, pt. 3 (1) : 12.

1969. *Penaeus indicus* : George, *Bull. cent. mar. Fish. Res., Inst.*, 14 : 23.

Material : 1 ex. (50 mm), Reg. No. KN-395, Nikarighat, Canning, 5.v.1982, J.K. De; 1 ex. (70 mm), Reg. No. KN-396, Pahari Chak, Pratham Gheri, 1.iv.1983, J.K. De; 4 exs. (50-80 mm), Reg. No. KN-397, Hatania Duania, Namkhana, 31.xii. 1983, J.K. De; 2 exs. (45-65 mm), Reg. No. KN-398, Rakhaskhali, Patharpratima, 16.viii.1984, J.K. De; 1 ex (60 mm), Reg. No. KN-399, Sonakhali, Basanti, 3.iv.1985, R.A. Khan; 1 ex (50 mm), Reg. No. KN-400, Belekhali, Canning 17.iii.1987, N.C. Nandi; 3FF, 1M (65 – 160 mm), Reg. No. KN-401, Haldibari, Goashaba, NPWR-STR, 22.viii.1987, N.C. Nandi; 1M (75 mm), Reg. No. KN-402, Netidhopani, NPWR-STR, 31.viii.1987, R.A. Khan; 3 exs. (80–120 mm), Reg. No. KN-403, Sandeshkhali, 8.xi.1988, R.A. Khan; 2FF, 1M (80–90 mm), Reg. No. KN-404, Arbesi, BR-STR, 12.xi.1988, R.A. Khan; 2MM, 1F (98-120 mm), Reg. No. KN-405, Marich Jhanpi, Jhila-1, BR-STR, 13.xi.1988, R.A. Khan; 3 exs. (90-120 mm), Reg. No. KN-406, Panchmukhani, SWS-STR, 5.iii.1989, R.A. Khan; 7 exs. (115-170 mm), Reg. No. KN-407, Gona Id., NPER-STR, 6.iii.1989, R.A. Khan; 1F (95 mm), Reg. No. KN-408, Haldibari, Goashaba, NPWR-STR, 13.iii.1989, R.A. Khan; 1M (110 mm), Reg. No. KN-409, Sajnekhali, STR, 14.iii.1989, R.A. Khan; 4 exs. (105-120 mm) Reg. No. KN-410, Arbesi, BR-STR, 15.iii.1989, R.A. Khan.

Diagnostic Characters : Rostrum slender with 7-9/4-5 teeth, the proximal 5 dorsal teeth close together, penultimate and distal teeth widely separated; with distinct double curve, $1\frac{1}{2}$ to 2

times the length of carapace in juvenile stages, but becoming shorter with increasing size, extending beyond tip of antennular scale in large prawns, blade high but not forming a triangular crest.

Adrostral groove shallow, decreasing in depth backwards upto epigastric tooth. Carapace thin, glabrous, carina and sulci feebly defined. Gastro-orbital carina occupying the posterior two-third distance between hepatic spine and orbital angle. Orbito-antennal sulcus wide and ill-defined. Post antennular spine continued as an oblique ridge to the hepatic spine. Hepatic carina absent.

Spine on the merus and carpus of the first pair of pereopods and on the merus of the second pair of pereopods.

In petasma, the median lobe rounded at the tip, projecting forward up to the apex of the lateral lobe ; terminal portion of the distal margin serrated with 12 well-calcified teeth.

In thelycum, the anterior median process roughly semicircular and relatively small situated on sternite between fourth pereopods and provided with minute apical spines on the anterior margin. The two large lateral plates housing seminal receptacles occupy most part of the last thoracic sternite and they meet each other in the median line where the edges of the plates up-curved to form an appearance of a valve.

Distribution : India and Sri Lanka to the West through Gulf of Aden and Madagascar and east coast of Africa and to the east through Malaysia and Indonesia to Philippines, New Guinea and northern Australia. In India, in all coastal waters of east and west.

8. *Penaeus japonicus* Bate

1888. *Penaeus canaliculatus* var. *japonicus* Bate, *Rep. Sci. Res. 'Challenger'* 24 : 245.

1906. *Penaeus canaliculatus* : Alcock, *Cat. Indian Decapod Crust.*, pt. 3(1) : 14 (part)

1969. *Penaeus japonicus* George, *Bull. Cent. mar. Fish. Res. Inst.* 14 : 21.

Material : 2MM (104 mm) Reg. No. KN-413, Kacharighat, Chhoto Mollakhali, Gosaba, 7.iv.1985, R.A. Khan; 1M (120 mm), Reg. No. KN-414, Kalas, mouth of Thakuran River, 24-PDF, 10.iii.1989, R.A. Khan.

Diagnostic Characters : Rostrum with not more than 1 ventral tooth and without any accessory pair of carinae on its blade. Adrostral carina reaching almost to posterior border of carapace, adrostral sulcus narrower than posterior carina, post rostral carina sulcate, sulcus on post rostral carina more than $\frac{1}{2}$ length of carapace ; gastro-frontal carina present, gastro-frontal sulcus with bifurcate posterior end.

No ischial spine on 1st pereopod ; telson armed usually with 3 pairs of spinules.

Thelycum with apex of anterior plate rounded ; seminal receptacle cylindrical, not closed by 2 flaps.

Distribution : Widely distributed throughout the greater part of the Indo-West Pacific, from S. Africa to Philipines.

9. *Penaeus merguensis* de Man

1888. *Penaeus merguensis* de Man, *J. Linn. Soc. Lond (Zool)*, **22** (140) : 287.

1906. *Peneus indicus* var. *merguensis* : Alcock, *Cat. Indian Decapod Crust.*, pt. 3(1) : 13.

1969. *Penaeus merguensis* : George, *Bull. cent. mar Fish. Res. Inst.*, **14** : 24.

Material : 1 ex. (60 mm), Reg. No. KN-415, Gosaba, 3.i.1985, J.K. De; 2FF (92 & 102 mm), Reg. No. KN-417, Frasergunj, Namkhana, 19.xii.1986, N.C. Nandi; 1F (75 mm), Reg. No. KN-418, Netidhopani, NPWR-STR, 31.viii. 1987, R.A. Khan; 2MM (130-135 mm), Reg. No. KN-419, Haldibari, Goashaba, NPWR-STR, 7.i.1988, R.A. Khan; 8FF, Reg. No. KN-421, Confluence of Matla and Bidya Rivers, Netidhopani, STR, 4.xi.1988, R.A. Khan; 13 exs. (50-135 mm), Reg. No. KN-422, Tooshkhali, Sandeshkhali, 12.xi.1988, R.A. Khan; 7 exs (70-90 mm), Reg. No. KN-423, Arbesi, BR-STR, 12.xi.1988, R.A. Khan; 1F (80 mm), Reg. No. KN-424, Marich Jhanpi, Jhila-I, BR-STR, 13.xi.1988, R.A. Khan; 2MM, 1F (120-130 mm), Reg. No. KN-426, Dhanchi, Patharpratima, 10.iii.1989, R.A. Khan; 2FF, 3MM (115-140 mm), Reg. No. KN-427, Kendokhal, Bhangadhuni Id., STR, 12.iii.1989, R.A. Khan.

Diagnostic Characters : Rostrum with 5-8/2-5 teeth, in the dorsals the proximal five close together, penultimate and distal teeth widely separated. In juvenile stages the rostrum long, slender and upcurving, $1\frac{1}{2}$ to 2 times the length of carapace but becoming shorter as it does not keep up with increasing body size. In specimens of 80 mm, it equals the length of carapace, almost straight with higher blade but in further larger specimens it becomes shorter than carapace, not exceeding 2nd segment of antennular peduncle with higher blade and broadly triangular in form. Adrostral carina usually ending between 1st and 2nd teeth.

Carapace glabrous, thin, with sulci and carinae feebly defined. Gastro-orbital carina absent and if present it is feeble and occupying $\frac{1}{3}$ distance between hepatic spine and post-orbital margin; orbito-antennal sulcus wide and ill defined; antennal carina ending in front of hepatic spine, hepatic carina absent.

Ischial spine present on 1st pereopod.

In petasma, the median distal projections not over hanging lateral lobes, distal tip of lateral lobe minutely serrate, outer surface of lobe with large number of minute conical teeth.

Inthelycum, anterior plate slightly concave, one-fourth the length of seminal receptacle, with posterior convex projection inserted between flaps of seminal receptacle. Seminal receptacle round with two flaps forming turgid lips on midline.

Distribution : Pakistan eastward to New Caledonia, penetrating southwards to Australia. In India, mostly in the middle of East and West coasts.

Remarks : This species is similar to *P. indicus* and it is difficult to distinguish them at the juvenile stage. Both the species show the relative shortening of the rostrum during growth. It is comparatively easy to distinguish them at the adult size as they show distinct rostral character. The table given below will help further in separating the two species.

Character	<i>P. indicus</i>	<i>P. merguensis</i>
1. Adrostral carina	reaches 1st rostral tooth	usually ending between 1st and 2nd rostral teeth.
2. Gastro-orbital carina	well defined, occupying poster 2/3 distance between hepatic spine and margin of carapace.	absent or feeble occupying middle 1/3 distance between hepatic spine and margin of carapace.
3. Outer antennular flagellum	longer than carapace	shorter than carapace.
4. Dactyl of 3rd maxilliped in adult male	as long as propodus	half the length of propodus.

10. *Penaeus monodon* (Fabricius)

1798. *Penaeus monodon* Fabricius, *Suppl. Ent. Syst. Hafniae*, Copenhagen, p. 408.

1852. *Penaeus carinatus* : Dana, *U.S. Expl. Exped.*, Philadelphia, **13** (1) : 602.

1906. *Penaeus semisulcatus* : Alcock, *Cat. Indian Decapod Crust.*, pt. 3(1) : 10

1969. *Penaeus monodon* George, *Bull. cent. mar. Fish. Res. Inst.*, **14** : 22.

Material : 1 ex. (145 mm), Reg. no. KN-428, Haldibari, Goashaba, NPWR-STR, 22.viii.1987, N.C. Nandi; 1M, (85 mm) Reg. No. KN-429, Nikarighat, Canning, 21.vii.1988, M.K. Dev Roy; 2FF, (95-170 mm) Reg. No. KN-430, Confluence of Matla and Bidya Rivers, Netidhopani, STR, 4.xi.1988, R.A. Khan; 1F (195 mm), Reg. No. KN-431, Tooshkhali, Sandeshkhali, 12.xi.1988, R.A. Khan; 2MM, 4FF Reg. No. KN-432, Bheries at Golabari, Herobhanga, Canning, 21.ii.1989, K.N. Reddy; 1M (150 mm), Reg. No. KN-433, Dhanchi, Patharpratima, 10.iii.1989, R.A. Khan;

Diagnostic Characters : Rostrum with 7-8/2-3 teeth, usually $\frac{7}{3}$, sigmoid in shape in juveniles and adults, surpassing antennular peduncle in length. Adrostral carina reaching almost to epigastric tooth. Post rostral carina often more or less flat with feeble indications of a sulcus, carina reaching almost to the posterior edge of carapace.

Gastro-orbital carina occupying posterior one-third to half distance between post-orbital margin of carapace and hepatic spine. Hepatic carina prominent, anterior half horizontal, the

posterior often diverging very slightly below horizontal axis ; distinctly separated from the base of antennal carina, which ends above middle of hepatic carina. Hepatic sulcus not well defined.

Ischial spine on 1st pereopod ; no exopod on 5th pereopod.

In petasma, the median anterior lobe small, separated from the laterals by a shallow notch, not projecting as far as lateral lobes. Lateral lobes without distal setae, but with distolateral irregular group of ossicles greatly variable in number.

In thelycum, the length of anterior plate twice its breadth, anterior rounded portion concave, posterior bluntly pointed portion inserted between flaps of seminal receptacle for 2/5 of their length. Seminal receptacle circular ; flaps forming turgid, reflected lips on mid line ; with smooth inner edges in impregnated females.

Distribution : South Africa to Southern Japan. In India, more common on East coast, especially Bengal and Orissa, and all along West coast.

11. *Penaeus penicillatus* Alcock

1905. *penaeus indicus* var. *penicillatus* Alcock, *Ann. Mag. nat. Hist.*, (7) 16 : 525.

1949. *Penaeus penicillatus* Kubo, *J. Tokyo Coll. Fish.*, 36 (1) : 306.

1969. *penaeus penicillatus* George, *Bull. cent. mar. Fish. Res. Inst.*, 14 : 24.

Material : 2FF, Reg. No. KN-434, Kalinagar, Hingaljanj, 20.vi.1986, N.C. Nandi; 1F (150 mm), Reg. No. KN-435, Chulkati, Chaulkhali, Thakuran River, 24-P.D.F., 9.xi.1988, R.A. Khan; 1F (135 mm), Reg. No. KN-436, Kendokhal, Bhangadhuni Id, STR, 12.iii.1989, R.A. Khan;

Diagnostic Characters : Adrostral carina reaching just beyond epigastric tooth, but not reaching behind middle of carapace ; gastro-frontal carina absent ; hepatic carina absent ; gastro-orbital carina absent and if present not reaching hepatic spine and occupying the middle 1/3 distance between hepatic spine and orbital angle.

Maxillary palp 2—segmented, dactyl of 3rd maxilliped of adult male much longer than propodus. Third pereopods exceeding scaphocerite by atleast dactylus.

Distribution : From Karachi coast in Pakistan through Malaysian waters to Taiwan.

Family : SERGESTIDAE

Genus : *Acetes* H. Milne Edwards, 1830

Key to the species from Hugli—Matla estuarine complex

1. Tooth present on inner free margin of the trochanter (basis) of 3rd pereopod ; petasma

without membranous coupling folds *A. indicus*.

- Tooth absent on inner free margin of the trochanter (basis) of 3rd pereopod ; petasma with a pair of folded coupling membranes armed with hooks *A. erythraeus*.

12. *Acetes erythraeus* (Nobili)

1905. *Acetes erythraeus* Nobili, *Bull. Mus, Hist. Nat, Paris*, 10 (3) : 394.

1917. *Acetes erythraeus* : Kemp, *Rec. Indian Mus.*, 13 : 51.

1969. *Acetes erythraeus* : George, *Bull. Cent. mar. Fish. Res. Inst.*, 14 : 47.

Material : 3FF, Reg.No. Kn-600, Halliday Id., 1.ix.1987, R.A. Khan; 1 ex. Reg. No. KN-601, Bidya River, Near Sajnekhali, 3, xi.1988, R.A. Khan.

Diagnostic Characters : Procurved spine present between 1st pair of pleopods. Trochanter (basis) of 3rd pereopods without tooth on inner free margin ; petasma with a pair of folded coupling membranes armed with hooks. In size, it is smaller than *A. indicus*, large females attaining a maximum length of 30 mm and males 20 mm.

Distribution : From Red Sea through Bay of Bengal and Gulf of Siam to Malay Archipelago. On Indian coasts it is found in good quantities in Bengal, Orissa, Madras region on the east coast and off Trivandrum on the South-West coast.

13. *Acetes indicus* (H. Milne Edwards.)

1830. *Acetes indicus* H. Milne Edwards, *Ann. Sci. Natur. Ser. Zool*; 19 : 351

1917. *Acetes indicus* : Kemp, *Rec. Indian mus.*, 13 : 47.

1969. *Acetes indicus* : George, *Bull. cent. mar. Fish Res. Inst.*, 14 : 46.

Material : 10 exs. Reg. No. KN-579, Frasergunj, Nankhana, 19.xii.1983, N.C. Nandi; 43 exs. (20-35 mm), Reg. No. KN-580, Frasergunj; 20.xii.1983, N.C. Nandi; 10 exs. (20-35 mm), Reg. No. KN-581, Frasergunj, 21.xii.1983, N.C. Nandi; 175 exs. (20-35 mm), Reg. No. KN-582, Rakaskhali, Patharpratima, 15.viii.1984, J.K. De; 75 exs. (20-30 mm), Reg. No. KN-583, East of Basanti, 31.iii.1985, R.A. Khan; 5 exs. (20-30 mm), Reg. No. KN-584, Sonakhali, Basanti, 2.iv.1985, R.A. Khan; 20 exs. (20-30 mm), Reg. No. KN-585, Sonakhali, Basanti, 3.iv.1985, R.A. Khan; 100 exs. (20-30 mm), Reg. No. KN-586, Purandar, Basanti, 4.iv.1985, R.A. Khan; 46 exs. (20-30 mm), Reg. No. KN-587, Purandar, Basanti, 4.iv.1985, R.A. Khan; 1 ex. (30 mm), Reg. No. KN-588, Sudhanyakhali, SWS-STR, 17.iv.1985, R.A. Khan; 1 ex. (20 mm), Reg. No. KN-589, Gosaba, 25.iv.1985, R.A. Khan; 10, exs. (20-30 mm), Reg. No. KN-590, Kultali, 22.vi.1986, R.A. Khan; 50 exs. (20-30 mm), Reg. No. KN-591, Edukhali, near Canning, 28.i.1987, S.C. Saren; 53 exs. Reg. No. KN-592, Sonakhali, Basanti, 18.ii.1987, N.C. Nandi; 11 exs. (20-30 mm), Reg. No. KN-593, Nikarighat, Canning, 3.iii.1987, S.C. Saren; 7 exs. (20-30 mm), Reg. No. KN-594, Matla River at Dabu, Canning, 20.v.1987, S.C. Saren; 12 exs. (20-30 mm), Reg. No. KN-595, Matla River at Dabu, Canning 20.v.1987, S.C. Saren; 16

exs. (20-30 mm), Reg. No. KN-596, Haldibari, Goashaba, NPWR-STR, 22.viii.1987, R.A. Khan; 75 exs. (20-30 mm), Reg. No. KN-597, Narayantala, Goashaba, NPWR-STR, 31.viii.1987, R.A. Khan; 14 exs (20-30 mm), Reg. No. KN-598, Edukhali, Canning, 28.x.1987, R.A. Khan; 11 exs. (20-30 mm), Reg. No. KN-599, Mitakhali, Canning, 25.xi.1987, S.C. Saren.

Diagnostic Characters : The genus *Acetes* is characterised by the absence of the last two pairs of pereopods and the presence of two pairs of red spots, one pair on each side, on the tail. In distinguishing the species adult males provide clearcut features in the form of the petasma, and in the secondary sexual characters like the modifications of the external flagellum of the antennule and the elongated antennal peduncle. The degree of curvature of the tip of the clasping spine on the outer antennular flagellum is of specific importance.

Eye, a little more than one-third length of carapace and with slender stalks. Basal segment of antennular peduncle in females about the same length as that of the two distal segments put together ; in males the 2nd segment more slender than in females ; third segment elongated, much longer than the first.

Outer antennular flagellum of male bears a single large clasping spine, with finely serrate inner margin ; on the segment opposite the tip of the spine there is a group of 5-7 close-set spinules.

Third maxilliped reaches a little beyond the tip of 3rd pereopod, and in female, much beyond end of antennular peduncle. Last segment not divided into sub-segments. Basal segments of 3rd maxilliped and the 3 pereopods proportionately stouter. Basis of the 3rd pereopod with a large tooth on the inner margin close to the insertion of ischium.

In females, the sternal plate of 3rd thoracic segment deeply channelled longitudinally, the channel being continued backwards on to the anterior portion of the sternal plate of the 4th thoracic segment. The anterior margin of the 3rd sternite is deeply sunk and almost transverse. A conspicuous tubercle present behind the inner angles of coxae of the 3rd pereopods.

There is a large procurved tooth between the bases of the 1st pleopods in both sexes.

In petasma, each half with a more or less crescent shaped outer lobe with its antero-external border strongly thickened ; proximal end of the internal lobe truncated, much expanded externally and bearing a small process at its inner angle. The surface of the distal portion has a sort of honey-combed appearance, due to the presence of numerous small pits, each of which contains a modified hooklet.

Telson with sharply pointed apex, reaching well beyond the middle of inner uropod. Outer uropods with a prominent tooth on the external border separating the ciliated and non-ciliated portion.

Distribution : India through Mergui Archipelago and Gulf of Siam to Malaya and East Indies. In India, common in northern area in west, and in the east throughout the coastal and estuarine regions.

Sub Order : PLEOCYEMATA

Infra Order : CARIDEA

Family : PALAEMONIDAE

Key to the genera from Hugli—Matla estuarine complex

1. Branchiostegal spine present on the carapace 3
- Branchiostegal spine absent on the carapace 2
2. Hepatic spine present on the carapace *Macrobrachium*
- Hepatic spine absent on the carapace *Leptocarpus*
3. Carapace with branchiostegal suture extending posteriorly from anterior margin at point dorsal to branchiostegal spine *Exopalaemon*
- Carapace without branchiostegal suture *Nematopalaemon.*

Genus : *Exopalaemon* Holthuis, 1950

14. *Exopalaemon styliferus* (H. Milne Edwards.)

1837. *Palaemon longirostris* H. Milne Edwards, *Hist. nat. Crust., Paris*, 2 : 394.

1840. *Palaemon styliferus* : H. Milne Edwards, *Ibid.*, 3 : 638.

1893. *Leander longirostris* : Henderson, *Trans. Linn. Soc. Lond. Zool.*, (2) 5 : 439.

1939. *Leander styliferus* : Chopra, *J. Bombay nat. Hist. Soc.*, 41 : 223, pl. 2, fig. 1.

1950. *Palaemon (Exopalaemon) styliferus* Holthuis, *Siboga Exped.*, 39 (a-9) : 46.

1993. *Exopalaemon styliferus* Chace and Bruce, *Smithsonian Contr. Zool.*, 543 : 5.

Material : 2FF, 1M (60-80 mm), Reg. No. KN-633, Chhayer Gheri, 15.x.1979, A.K. Mondal; 19 exs. (50-95 mm), Reg. No. KN-634, Harwood Point, Kakdwip, 17.x.1979, A.K. Mondal; 39 exs. (30-60 mm), Reg. No. KN-635, Muriganga, Near Kakdwip, 11.xi.1979, A.K. Mondal; 31 exs. (30-90 mm), Reg. No. KN-636, Chemaguri, Sagar Id., 15.x.1979, A.K. Mondal; 35 exs. (30-50 mm), Reg. No. KN-637, River, Near Kakdwip, 14.xi.1979, A.K. Mondal; 19 exs. (45-90 mm), Reg. No. KN-638, Diamond Harbour, 15.i.1980, A.K. Mondal; 1 ex. (40 mm), Reg. No. KN-639, Harwood Point, Kakdwip, 6.iii.1980, A.K. Mondal ; 7 exs. (30-70 mm), Reg. No. KN-640, Harwood Point, Kakdwip, 26.iv.1980, A.K. Mondal; 4 exs. (30-40 mm), Reg. No. KN-645, Harwood Point, Kakdwip, 28.ii.1982, J.K. De; 1 ex. (38 mm), Reg. No. KN-646, Harwood

Point, Kakdwip, 28.iii.1982, J.K. De; 2 exs. (55 mm), Reg. No. KN-647, Nikarighat, Canning, 5.v.1982, J.K. De; 8 exs. (40-60 mm), Reg. No. KN-648, Bhuban Nagar, Kakdwip 10.x.1982, J. K. De; 4 exs. (20-30 mm), Reg. No. KN-649, Kakdwip, 11.xi.1982, N.C. Nandi; 12 exs. (20-45 mm), Reg. No. KN-650, Kakdwip, 29.xi.1982, N.C. Nandi; 8 exs. (55-85 mm), Reg. No. KN-652, Namkhana, 20.iii.1983, J.K. De; 2 exs. (75-85 mm), Reg. No. KN-655, Hujjat ghat, 14.xi.1983, J.K. De; 5 exs. (42-65 mm), Reg. No. KN-656, Frasergunj, Namkhana, 19.xii.1983, N.C. Nandi; 5 exs. (25-45 mm), Reg. No. KN-657, Frasergunj, 21.xii.1983, N.C. Nandi; 3 exs. (50-60 mm), Reg. No. KN-658, Hatania Duania, Namkhana, 31.xii.1983, J.K. De; 14 exs. (20-30 mm), Reg. No. KN-659, Phuldubi, Sagar Id., 11.ix.1984, J.K. De; 20 exs. (32-45 mm), Reg. No. KN-660, Chemaguri, Sagar Id., 10.ix.1984, J.K. De; 14 exs. (35-45 mm), Reg. No. KN-661, South of Surjyapur, Gosaba 2.i.1985, J.K. De; 3 exs. (40-50 mm), Reg. No. KN-662, West of Gosaba, 3.i.1985, J.K. De; 31 exs. (30-40 mm), Reg. No. KN-663, Nikarighat, Canning, 25.ii.1985, S.C. Saren; 11 exs. (40-60 mm), Reg. No. Kn-664, Purandar, Basanti, 5.iv.1985, R.A. Khan; 9 exs. (30-80 mm), Reg. No. KN-665, Sudhanyakhali, SWS-STR 17.iv.1985, R.A. Khan; 8 exs. (35-55 mm), Reg. No. KN-668, Matla River at Dighir Par, Canning, 3.iv.1986, R.A. Khan; 4 exs. (40-55 mm), Reg. No. KN-669, Natrabari, Golabari Herobhanga, Canning, 12.vi.1986, N.C. Nandi; 1 ex. (40 mm), Reg. No. KN-671, Nazat, Hingalganj, 19.vi.1986, N.C. Nandi; 3FF (65-85 mm), Reg. No. KN-672, Jambu Id., off the month of Muriganga River, 20.xii.1986, N.C. Nandi; 3 exs. (40-50 mm), Reg. No. KN-673, Jambu Id., off the mouth of Muriganga River, 20.xii.1986, N.C. Nandi; 4 exs. (30-55 mm), Reg. No. KN-674, Deulbari, Kultali, 14.ii.1987, N.C. Nandi; 1 ex. (45 mm), Reg. No. KN-675, Belekhal, Canning 17.iii.1987, N.C. Nandi; 8 exs. (23 mm), Reg. No. KN-676, Purandar, Basanti, 5.iv.1987, R.A. Khan; 1 ex. (45 mm), Reg. No. KN-678, Netidhopani, NPWR-STR, 31.viii.1987, R.A. Khan; 23 exs. (30-40 mm), Reg. No. KN-679, Kachukhali, Chhoto Mollakhali, Gosaba, 2.xii.1987, R.A. Khan; 2 exs. Reg. No. KN-680, Matla River at Golabari, Herobhanga, Canning, 11.x.1988, K.N. Reddy; 1M, Reg. No. KN-682, Confluence of Matla and Bidya Rivers, Netidhopani, STR, 4.xi.1988, R.A. Khan; 2 exs. (40 mm), Reg. No. KN-683, Sandeshkhali, 8.xi.1988, R.A. Khan; 3 exs. (95-102 mm), Reg. No. KN-684, Kishorimohanpur, Kultali, 8.xi.1988, R.A. Khan; 1 ex. (30 mm), Reg. No. KN-685, Arbesi, BR-STR, 12.xi.1988, R.A. Khan; 1 ex. (40 mm), Reg. No. KN-686, Tooshkhali, Sandeshkhali, 12.xi.1988, R.A. Khan; 8 exs. (48-55 mm), Reg. No. KN-687, Marich Jhanpi, Jhila-I, B.R.-STR, 13.xi.1988, R.A. Khan; 1 ex. Reg. No. KN-688, Bheries at Golabari, Herobhanga, Canning, 21.ii.1989, K.N. Reddy; 3 exs. (30-60 mm), Reg. No. KN-690, Dhanchi, Patharpratima, 10.iii.1989, R.A. Khan; 3 exs. (35-40 mm), Reg. No. KN-691, Arbesi, BR-STR, 15.iii.1989, R.A. Khan.

Diagnostic Characters : Rostrum armed with 5-7 teeth on basal crest, 1-3 dorsal subterminal teeth, and 6-10 ventral teeth; antennular peduncle with distolateral spine on basal segment barely over-reaching adjacent distal margin of segment, free part of shorter branch of dorsolateral flagellum several times as long as fused part ; and pereopod with carpus considerably shorter than chela ; 3rd pereopod with dactylus no more than half as long as propodus. Four posterior abdominal somites not sharply carinate in dorsal mid-line.

Distribution : Pakistan and India to Malayan Archipelago, in shallow coastal waters, brackish and sometimes fresh water areas. In India, northern regions of both coasts.

Genus : *Macrobrachium* Bate, 1868

Key to the species from Hugli—Matla estuarine complex

1. Merus of second cheliped shorter than carpus 2
- Merus of second cheliped as long as or longer than carpus 7
2. Rostrum with a distinct elevated basal crest 3
- Rostrum without a distinct elevated basal crest 6
3. Tip of telson surpassing the tips of the longer posterior spines present on it 4
- Tip of telson surpassed by the longer posterior spines present on it 5
4. Carpus of the 2nd pereopods in adult male distinctly shorter than chela, fingers of that leg as long as palm *M. rosenbergii*.
- Carpus of the 2nd pereopod in adult male almost as long as chela, fingers of that leg less than half as long as palm *M. villosimanus*.
5. Basal crest not much elevated, palm of the 2nd leg not swollen in young specimens, fingers shorter than palm *M. lamarrei*.
- Basal crest distinctly elevated, palm of the 2nd leg swollen in young specimens, fingers longer than palm *M. malcolmsonii*.
6. In adult male large chela of 2nd cheliped with tubercles at both sides of the cutting edges, all joints in 2nd legs pubescent *M. rude*.
- In adult male, large chela of 2nd cheliped without tubercles at each side of the cutting edges *M. equidens*.
7. Fifth legs conspicuously longer than the fourth *M. mirabile*.
- Fifth legs of about the same length as the fourth 9
8. Fingers of 2nd legs of adult male with 1 or 2 fairly large teeth *M. javanicum*.
- Fingers of 2nd legs of adult male with more than 4 teeth placed at regular intervals, sometimes restricted to the proximal part. Fingers with a velvety pubescence in their basal portion *M. scabriculum*

15. *Macrobrachium equidens* (Dana)

1852. *Palaemon equidens* Dana, *Proc. Acad. nat. Sci. Philad.*, **6** : 26.
 1910. *Palaemon sulcatus* Henderson & Matthai, *Rec. Indian Mus.*, **5** : 289.
 1918. *Palaemon sundaicus* Kemp, *Mem. Asiat. Soc. Bengal*, **6** : 261.
 1950. *Macrobrachium equidens* Holthuis, *Siboga Exped.*, **39** (a-9) : 162.

Material : 3 exs. (30-60 mm), Reg. No. KN-602, Kakdwip, 11.xi. 1982, N.C. Nandi; 3 exs. (25-60 mm), Reg. No. KN-603, Frasergunj, Namkhana, 20.xii.1983, N.C. Nandi; 2FF (40-45 mm), Reg. No. KN-604, Rakhaskhali, Patharpratima, 15.iv.1984, J.K. De; 3 exs. (42-60 mm), Reg. No. KN-605, Chemaguri, Sagar Id., 10.ix.1984, J.K. De; 1M (70 mm), Reg. No. KN-609, Sudhanyakhali, SWS-STR, 17.iv.1985, R.A. Khan; 2 exs. (40-50 mm), Reg. No. KN-610, Netidhopani, NPWR-STR, 20.iv.1985, R.A. Khan; 5 exs. (20-50 mm), Reg. No. KN-611, Gosaba, 23.iv.1985, R.A. Khan; 5 exs. (40-55 mm), Reg. No. KN-612, Matla River at Dighir Par, Canning, 3.iv.1986, R.A. Khan; 3FF (45-55 mm), Reg. no. KN-614, Sandeshkhali, 18.vi.1986, N.C. Nandi; 2 exs. (50-58 mm), Reg. No. KN-615, Nazat, Hingalgunge, 19.vi.1986, N.C. Nandi; 2 exs. (20-30 mm), Reg. No. KN-616, Belekhal, Canning, 17.iii.1987, N.C. Nandi; 8FF (35-115 mm), Reg. No. KN-617, Golabari, Herobhanga, Canning, 23.ix. 1988, R.A. Khan; 6 exs. (50-80 mm), Reg. No. KN-618, Sandeshkhali, 8.xi.1988, R.A. Khan; 3FF (80-90 mm), Reg. No. KN-619, Tooshkhali, Sandeshkhali, 12.xi.1988, R.A. Khan. 1 ex. (42 mm) Reg. No. KN-620, Raidighi, Mathurapur, 3.vii. 1987, N.C. Nandi.

Diagnostic Characters : Rostrum reaching nearly upto or beyond the distal end of antennal scale, dorsal margin convex or slightly sinuous, rostral formula : 2-4 + 7-9/4-7, dorsal teeth unequally spaced, usually with wider gaps near posterior and anterior ends of series ; branchiostegal suture not extending posteriorly beyond hepatic spine ; telson with posterior apex not over-reaching posterolateral spines ; 1st pereopod with chela $1/2$ as long as carpus ; 2nd pereopods subequal in length, similar in form, palm subcylindrical, fingers covered with soft, dense pubescence, not dentate on opposable margins, not gaping (in full-grown males), about $3/4$ as long as palm, latter completely naked, without pubescence, chela longer than carpus, palm $2/3$ - $3/4$ as long as carpus, carpus $1\frac{2}{3}$ - $1\frac{3}{4}$ as long as merus, without longitudinal grooves ; 3rd pereopod over-reaching antennal scale by length of dactyle, propodus partially pubescent, not covered with spines or scales.

Distribution : Africa to South-West New Guinea.

16. *Macrobrachium javanicum* (Heller)

1862. *Palaemon javanicus* Heller, *S.B. Acad. Wiss. Wien*, **45** (1) : 421.
 1950. *Macrobrachium javanicum* : Holthuis, *Siboga Exped.*, **39** (a-9) : 190.

Material : 3MM, 2FF, Reg. No. KN-621, Near the confluence of Matla and Bidya Rivers, 4.xi.1988, R.A. Khan.

Diagnostic Characters : Rostrum not reaching the distal end of antennal scale, dorsal margin somewhat sinuous, rostral formula : 3 + 8 – 10/3-5, dorsal teeth subequally spaced, except posteriormost tooth often more remote ; branchiostegal suture not extending posteriorly beyond hepatic spine ; telson with posterior apex not over-reaching posterolateral spines ; 1st pereopod with chela $\frac{1}{2}$ as long as carpus ; 2nd pereopods subequal in length and rather similar in form, palm somewhat compressed, fingers without dense pubescence, dentate on opposable margins, not widely gaping, $\frac{1}{2} - \frac{3}{4}$ as long as palm, latter not densely pubescent, even in part, chela twice as long as carpus, palm 1–1 $\frac{1}{2}$ times as long as carpus, carpus longer than merus, without longitudinal grooves ; 3rd pereopods over-reaching antennal scale by less than length of dactyl, propodus not covered with spines or scales.

Distribution : India through Burma to Malayan Archipelago and Borneo. In India, in fresh water and estuaries in deltaic Bengal.

17. *Macrobrachium lamarrei* (H. Milne Edwards.)

1837. *Palaemon lamarrei* H. Milne Edwards, *Hist. nat. Crust., Paris*, 2 : 397.

1950. *Macrobrachium lamarrei* Holthuis, *Siboga Exped.*, 39 (a-9) : 119.

Material: 2 exs. (30 mm), Reg. No. KN-622, Kakdwip, 16.iii.1983, J.K. De; 10 exs. (20-40 mm), Reg. No. KN-623, Rakhaskhali, Patharpratima, 15.iv.1984, J.K. De.

Diagnostic Characters : Rostrum with 7-11 dorsal teeth (1 or 2 post orbital) and 4 to 8 ventral teeth, upper margin with a gap between proximal series of 6-9 teeth and distal 1 or 2 subterminal teeth, sometimes the gap interrupted by 1 or 2 teeth ; equal to or slightly surpassing the antennal scale, tilted up distally. Second chelipeds slender, equal or $\frac{1}{3}$ longer than body length with chela shorter than carpus. Second pleopod of male with non-hairy, slender appendix masculina reaching the tip of endopod.

Distribution : India and Pakistan in fresh and brackish waters. In India, mostly in N.E. coast in Chilka Lagoon and Bengal.

18. *Macrobrachium mirabile* (Kemp)

1917. *Palaemon mirabilis* Kemp, *Rec. Indian Mus.*, 13 : 227.

1950. *Macrobrachium mirabile* : Holthuis, *Siboga Exped.*, 39 (a-9) : 174.

1969. *Macrobrachium mirabile* : George, *Bull. cent.mar. Fish. Res. Inst.*, 14 : 41.

Material: 2 exs. (40-50 mm), Reg. No. KN-625, Harwood Point, Kakdwip, 17.x.1979, A.K. Mondal; 2 exs. (50 mm), Reg. No. KN-626, Bhuban Nagar, Kakdwip, 10.x.1982, J.K. De.

Diagnostic Characters : Rostrum not reaching the distal end of antennal scale, with rather high dorsal crest, rostral formula : 4 – 6 + 9 – 10/1–2, dorsal teeth subequally spaced; branchiostegal suture not extending posteriorly beyond hepatic spine ; telson with posterior apex

not over-reaching posterolateral spines ; 1st pereopod with chela more than $\frac{1}{2}$ as long as carpus ; 2nd pereopods subequal in length and similar in form, palm subcylindrical, fingers not concealed by dense pubescence, not dentate on opposable margins, not gaping, fingers $1\frac{2}{3}$ times as long as palm, latter without any dense pubescence, chela $1\frac{3}{4}$ times as long as carpus, palm less than $\frac{3}{4}$ as long as carpus, carpus more than $\frac{3}{4}$ as long as merus, not longitudinally grooved ; 3rd pereopod over-reaching antennal scale by length of dactyle, propodus not profusely spinose or scaly.

Distribution : India through Burma to Malayan Archipelago and Borneo. In India, estuarine species mostly found in Gangetic delta.

19. *Macrobrachium rosenbergii* (de Man)

1879. *Palaemon rosenbergii* de Man, *Notes Leyden Mus.*, 1 : 167.

1910. *Palaemon carcinus* : Henderson & Matthai, *Rec. Indian Mus.*, 5 : 281.

1918. *Palaemon carcinus* : Kemp, *Mem. Asiat. Soc. Bengal*, 6 : 255.

1950. *Macrobrachium rosenbergii* : Holthuis, *Siboga Exped.* 39 (a-9) : 111.

Material: 1 ex. (40 mm), Reg. No. KN-628, Kakdwip, 16.iii.1983, J. K. De; 2M (105-135 mm), Reg. No. KN-629, Chulkati, Chaulkhali, Thakuran River, 24-P.D.F., 9.xi.1988, R. A. Khan; 1 ex., Reg. No. KN-630, Marich Jhanpi, Jhilla-I, BR-STR, 13.xi.1988, R. A. Khan.

Diagnostic Characters : Rostrum over-reaching antennal scale or not, dorsal margin variably sinuous, rostral formula : 2-3 + 9-11/8-15, dorsal teeth unequally spaced ; branchiostegal suture not extending posteriorly beyond hepatic spine ; telson with posterior apex over-reaching posterolateral spines ; 1st pereopod with chela less than $\frac{1}{2}$ as long as carpus ; 2nd pereopods subequal in length and similar in form, palm subcylindrical or somewhat compressed, movable finger clothed in dense pubescence on proximal $\frac{3}{4}$ of length (in adults), fixed finger without pubescence, fingers dentate on proximal $\frac{1}{2}$ of opposable margins (in adults), somewhat gaping in large males, $\frac{3}{4}$ to quite as long as palm, palm without any dense pubescence, chela slightly to $1\frac{3}{4}$ times as long as carpus, palm $\frac{1}{2}$ to quite as long as carpus, carpus slightly to nearly $1\frac{1}{2}$ times as long as merus, with indistinct longitudinal grooves ; 3rd pereopod over-reaching antennal scale by less than length of dactyl, propodus bearing rather numerous spines or sharp scales.

Distribution : Wide distribution in the Indo-Pacific zone, the western limit being the Indus delta area, and extending up to Indo-China in the Asian mainland. Found in fresh and brackish waters. In India, common in lakes and estuaries along coast lines.

20. *Macrobrachium rude* (Heller)

1862. *Palaemon rudis* Heller, *Verh. Zool. bot. Ges. Wien*, 12 : 527.

1950. *Macrobrachium rude* Holthuis, *Siboga Exped.*, 39 (a-9) : 150.

Material: 2 exs. (40-50 mm), Reg. No. KN-631, Purandar, Basanti, 5.iv.1985, R.A. Khan; 2FF, 5MM (65-95 mm), Reg. No. KN-632, Marich Jhanpi, Jhilla-I, BR-STR, 13.xi. 1988, R.A. Khan.

Diagnostic Characters : Rostrum with 9-12 teeth (2 post orbital) and 4-5 ventral teeth, reaching very nearly to the apex of antennal scale, the distal portion sloping slightly downwards. Large chelipeds (2nd pereopods) unequal.

In adult males, the larger cheliped nearly equal to or considerably longer than the total body length with the segments clothed with a fine velvety pubescence ; tubercles on fingers on either side of cutting edge.

Distribution : East Africa, Madagascar, India and Sri Lanka. In India, on the S.W. coast and East coast. Common along deltaic Bengal and Orissa and Andhra Pradesh.

Family : HIPPOLYTIDAE

21. *Hippolysmata (Exhippolysmata) ensirostris* (Kemp)

1914. *Hippolysmata ensirostris* : Kemp, *Rec. Indian Mus.*, **10** (2) : 118.

1916. *Hippolysmata ensirostris* : Kemp, *Rec. Indian Mus.*, **12** : 403.

1947. *Hippolysmata (Exhippolysmata) ensirostris* : Holthuis, *Siboga Exped.*, **39** (a-8) : 74.

Material : 2 exs. (35-50 mm), Reg. No. KN-692, Chhayer Gheri, 15.x.1979, A.K. Mondal.

Diagnostic Characters : Carapace with pterygostomian spine as large as antennal ; rostrum always longer than carapace, with 11-16 dorsal teeth, of which 7-12 are on the elevated crest ; lower margin with 7-16 teeth ; carapace bluntly carinate mid-dorsally in its anterior half and bears 1 or 2 minute spinules behind basal crest of rostrum.

Antennular peduncle hardly reaches to $\frac{2}{3}$ length of antennal scale, the latter variable in form and usually more than thrice as long as broad. Third maxilliped falls short of apex of antennal scale.

Carpus of 1st pereopod a little shorter than chela ; dactylus scarcely $\frac{2}{3}$ length of palm ; merus of 2nd pereopod indistinctly divided into 7-11 segments, while the carpus is composed of 12-17 ; palm of chela shorter than last carpal segment. Last 3 pairs of legs have a variable number of spines on the ventral side of merus. Fifth pair of legs extends to $\frac{2}{3}$ or $\frac{3}{4}$ length of antennal scale ; dactylus with a few spinules posteriorly.

Epipods short and rudimentary at base of first 4 pairs of pereopods and concealed from view by downward growth of pleurobranchs.

Sixth abdominal somite is $\frac{1}{4}$ longer than 5th. Telson about twice the length of 6th somite, has 2 pairs of dorsal spinules. It extends beyond distal end of uropods ; there are no terminal spinules.

Distribution : India, Sri Lanka, Burma and Sumatra.

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SPIDER

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INTRODUCTION

The earliest known species of the family Lycosidae is *Lycosa tarentula* (Rossi). Sundevall (1833) studied the genus *Lycosa* and observed some interesting characteristic features among some members of this genus. On the basis of his observation he established the family Lycosidae in 1933. The first Indian Lycosid spiders were studied by Simon in 1882. Simon (1885) described one species *Lycosa leucostigma* from India. Dyal (1935) described two more species under the same genus *Lycosa* Latreille. Recently Tikader (1980) made a revisionary work on the family Lycosidae and dealt the same family in his "Hand book Indian Spiders" in 1987.

MATERIAL AND METHODS

The collection of Lycosid spiders is very easy as they are available in a variety of marshy lands as well as under logs and stone. The oldest method of collection by using sweep net. Recent method for getting the lycosid spiders is to use the pitfall traps.

SYSTEMATIC ACCOUNT

Order : ARANEAE
Family : LYCOSIDAE
Genus : *Lycosa*

1804. *Lycosa* Latreille, *Nouv. Dist. d'Hist. Nat.*, 24 : 135

1981. *Lycosa* : Tikader & Biswas, *Rec. zool. Surv. India*, occ. paper, No. 30 : 50.

Diagnosis : Carapace long ; facial area vertical and sides of face slanting ; posterior eyes four in numbers, large and arranged in a quadrangle ; labium always longer than wide and basal excavation prominent, usually one-third or more than the length of labium ; clypeus not vertical ; tibiae I and II armed with three pairs of ventral spines.

Remarks : The genus *Lycosa* is similar to genus *Pardosa* in appearance but differ from that of labium which is longer than wide and the posterior eyes more closer than *Pardosa*.

Distribution : Cosmopolitan.

Lycosa choudhuryi Tikader & Malhotra

1980. *Lycosa choudhuryi* Tikader & Malhotra, *Fauna of India*, Spiders : Araneae, 1 (2) : 390-392.

Material examined : 3 (F), beach in Mandirtala, Sagar Island (Type Locality), South 24 Parganas, West Bengal, 3.vii. 1974, Coll. A. Choudhury ; 1 (F), Sibgaunge, Haora, 2. iv. 1989, B. P. Haldar ; 2 (F), Canning, South 24 Parganas, 4. v. 1983, Coll. A. Misra.

Diagnosis : Cephalothorax uniformly deep brown, legs brownish-green, abdomen light brown ; cephalothorax longer than wide, slightly wider in front, convex and clothed with fine hair but ocular area densely clothed with hair ; cephalic region slightly high and sides sloping ; fovea of ocular region centrally placed ; anterior row of eyes nearly straight, anterior medians larger than anterior laterals ; posterior row of eyes arranged in a quadrangle, little wider behind than front ; sternum nearly oval, pale, pointed behind and clothed with spine-like hair ; maxillae much wider in front and provided with conspicuous scopulae ; chelicerae strong, stout and prominent ; inner margin of the fang furrow provided with three and outer margin with two teeth ; legs long and strong, clothed with hair and spines ; abdomen longer than wide, clothed with hair ; longitudinal deep brown inconspicuous spots in two rows on dorsal the dorsum.

Remarks : The species is so far not reported anywhere else other than the Hugli-Matla estuarine belt of West Bengal, India. So far forty example of this species have been collected and studied.

Distribution : India : West Bengal (South 24 Parganas).

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The author is grateful to Dr. A. K. Ghosh, Director, Zoological Survey of India, Calcutta, for his initiative and encouragement throughout the course of study.

SUMMARY

The paper deals with an account of a single species belonging to the genus *Lycosa* Latreille which is so far not reported anywhere else other than the Hugli-Matla estuarine belt of West Bengal, India.

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CHAETOGNATHA

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INTRODUCTION

Chaetognatha, popularly known as “Arrow worms” or “Glass worms” form one of the important constituents of zooplankton which play an important role in the food cycle. Moreover, they act as a good indicator organisms for the origin of watermasses and their movement in the sea.

Marine chaetognaths have received more attention of the planktologists but little is known about their estuarine forms, partly due to fact that most of the species inhabit in neritic and oceanic waters. Works on Indian estuaries of west coast reveal the occurrence of 7 species (Lele & Gae, 1936 ; George, 1958; Rammurthy & Dhawn, 1963; Sails & Srinivasan, 1968; Srinivasan, 1971 and Nair, 1974) out of 24 known from the Indian seas but the figure is very low, only 3 species (Devasundaram & Roy, 1954; Srinivasan, 1977 & 1980; Bhunia & Chaudhury, 1981 ; Baidya & Choudhury, 1984 and Sarkar *et al.*, 1984 & 1985) out of 17 known from the east coast Last three groups of authors reported only 2 species from the Hugli estuary. In the present paper, in addition to the aforesaid species, two more, though rare, are included.

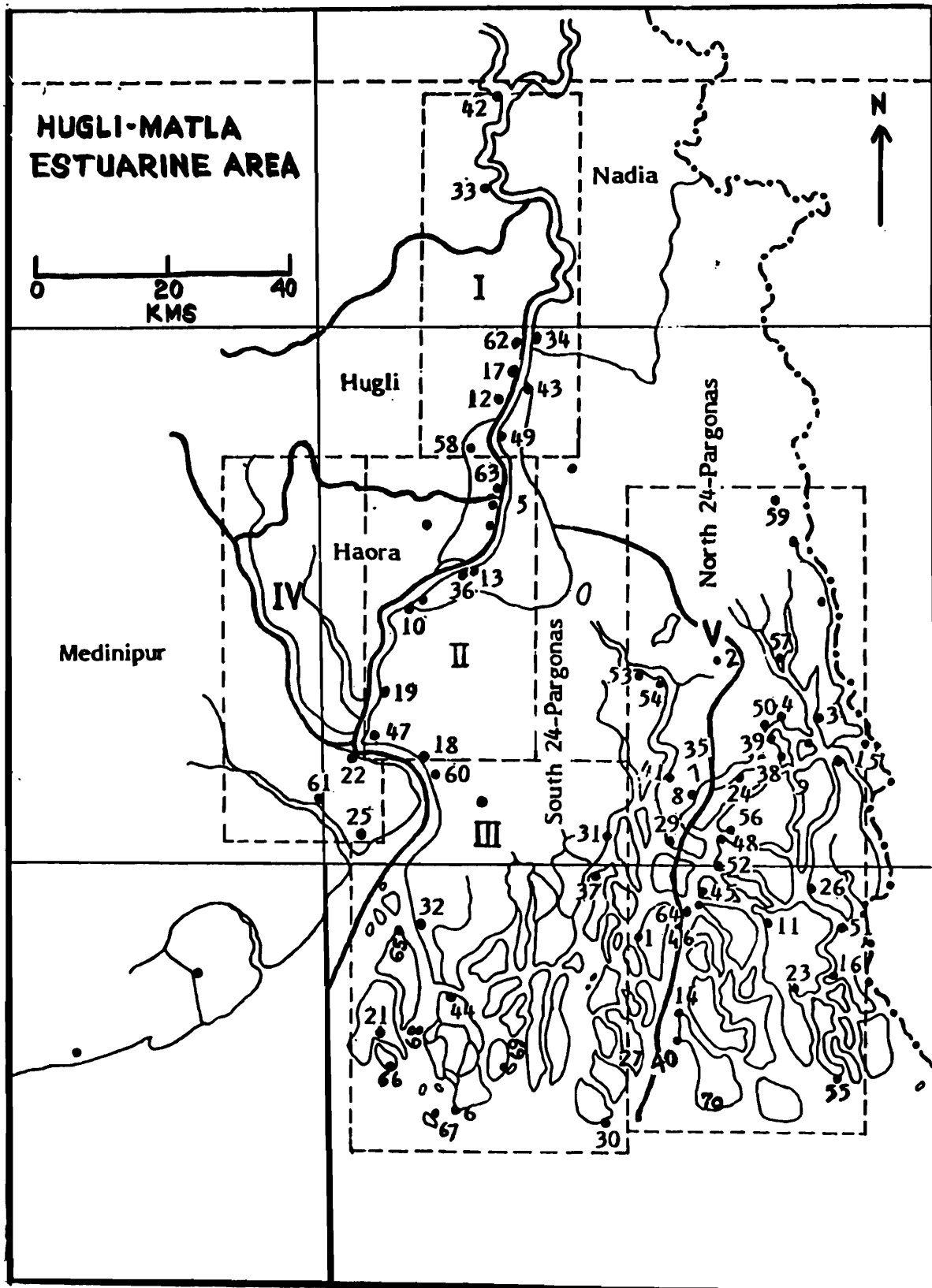
MATERIAL AND METHODS

All the collections were made from country boats. The boat was rowed to the collection site early in the morning and anchored with a long rope line. It was then allowed to drift till the rope line became tight. The tow net was then lowered into water with a short line and tied on to the boat. Now the boat was dragged to the anchored spot by pulling the line and released. The collection was made from surface water for 10 minutes. The contents of the plankton collecting vessel were emptied in a jar and were preserved in 4% buffered formalin in sea water.

Monthly surface zooplankton samples were collected from three aquatic biotopes, one at the northern end of Sagar Island, Kachuberia junction of the Hugli and the Mooriganga river, second at the mouth of Mooriganga river and the third at South Sagar— at the mouth of Hugli river during October, 1980 to Dec., 1981. Some casual surface zooplankton samples were collected from river Saptamukhi, river Vidya and river Matla (Between Gosaba and Kalas & Bhangaduni Island) during survey work (1985-1989).

IDENTIFICATION

From each sample chaetognaths were sorted out, identified species-wise and stage-wise and total number in each species was recorded. Specific differentiation was based upon varying



Collection sites of Chaetognatha in the Hugli-Matla estuarine area

24. Gosaba, 29. Jharkhali, 30. Kalas, 65. Kachuberia, 66. South Sagar, 67. Jambudweep,
68. Mooriganga, 69. Saptamukhi, 70. Bhangaduni

combinations of characters, which differ in the case with which they may be distinguished. However, in well preserved matured specimens the shape and positions of the seminal vesicle is diagnostic. But immature or damaged specimens were determined by the combination of a number of features. In most cases staining was not necessary, temporary mounts or submerged on a watch glass, was sufficient.

DIFFERENT STAGES

- Immature : Gonads have not commenced to develop.
- Stage I : Ovaries are crescent-shaped, testes slightly opaque and run longitudinally along lateral walls from tail septum to the posterior end of tail.
- Stage II : Ova small and all alike; cluster of sperm cells in the tail cavity; seminal vesicles start to develop.
- Stage III : Ova are large in size; sperm cells crowded in the posterior end of tail segment; seminal vesicles fully developed.

LIST OF SPECIES

The chaetognaths are represented in this area by four species under two genera, namely, *Sagitta* and *Krohnitta*.

Phylum : CHAETOGNATHA Leuckart, 1854

Genus I : *Sagitta* Quoy and Gaimard, 1827

Sagitta bedoti Beraneck, 1895

Sagitta enflata Grassi, 1881

Sagitta pulchra Doncaster, 1903

Genus II : *Krohnitta* Ritter-Zahony, 1910

Krohnitta pacifica (Aida, 1897)

Key to Genera and Species

Two pairs of lateral fins *Sagitta* Quoy & Gaimard

Single pair of lateral fins *Krohnitta* Ritter-Zahony

Tail segment 30 % of the animal; ovarian tubes long; lateral fins triangular
*K. pacifica* (Aida)

1. Collarette present; ovarian tubes long, reach up to middle of antero-lateral fins 2

Collarette absent; ovarian tubes short, grow up to antero-lateral fins
 *S. enflata* Grassi

2. Antero-lateral fins twice longer than postero-lateral fins; collarette well developed at neck region and extends up to ventral ganglion *S. pulchra* Doncaster

Antero-lateral fins as long as or slightly longer than postero-lateral fins : collarette present only at neck region *S. bedoti* Beraneck

DESCRIPTION OF SPECIES

Genus *Sagitta* Quoy & Gaimard, 1827

Presence of two lateral fins; two sets of teeth on either side of head.

Sagitta bedoti Beraneck, 1895

1895. *Sagitta bedoti* Beraneck, Les Chaetognathes de la baie d, Amboine. *Rev. Suisse Zool.*, **3** : 39.

Total length of the specimens ranged between 2 and 7 mm; body semitransparent and needle-shaped with strong musculature, hence maintaining the shape; neck well defined with thin collarette extending close to ventral ganglion and separating small-head from body; trunk more or less of uniform width; antero-lateral fins longer and narrower than postero-lateral fins originating at the level of ventral ganglion; postero-lateral fins arising close to antero-lateral ones and extending up to seminal vesicles; seminal vesicles elongated and in close contact with postero-lateral and caudal fins; prehensile hooks ranging between 6 and 8; anterior teeth varying from 6 to 12 and posterior teeth from 13 to 25.

Sagitta enflata Grassi, 1881

1881. *Sagitta enflata* Grassi, Intorno at Chaetognati. *Rend. Inst. Lombardo*, Ser. 2, **14** : 196.

Total length of the specimens ranging from 3.5 to 11.5 mm; body flaccid, thin-walled and transparent giving the specimens an inflated appearance; distinct neck without collarette separating broad and opaque head from trunk ; trunk widest in the middle and tail extremely narrow; antero-lateral fins slightly shorter than or as long as postero-lateral fins starting far below ventral ganglion; postero-lateral fins much broader and longer than antero-lateral ones, mainly lying on trunk; seminal vesicle small and spherical almost touching caudal fins; tail short, less than 20% of the total length; prehensile hooks ranging between 7 and 11; anterior teeth varying from 3 to 7 and posterior teeth from 8 to 13.

Sagitta pulchra Doncaster, 1903

1903. *Sagitta pulchra* Doncaster, Chaetognatha. *Fauna and Geography of Maldive and Laccadive Archipelago*, **1** : 302.

Total length of the specimens varying from 5 to 12 mm; body translucent, elongated, slender with strong body wall and never shrink on preservation; head small and narrow, collarette short, never extending up to ventral ganglion; antero-lateral fins very long, more than 30% of total length, starting at the middle of ventral ganglion; postero-lateral fins shorter, arising close to antero-lateral fins and extending posteriorly close to seminal vesicle; tail fin triangular and fully rayed; prehensile hooks varying from 6 to 7; anterior teeth ranging between 6 and 7 and posterior teeth between 9 and 10.

Genus *Krohnitta* Ritter-Zahony, 1910

1910. *Krohnitta* Ritter-Zahony, *Chaetognatha. Die Fauna Sudwest Australiens*, 3 : 132.

Presence of only one pair of lateral fins on trunk and tail segments like postero-lateral fins of the genus *Sagitta*; one set of teeth on either side of head and spatula-shaped caudal fins.

Krohnitta pacifica (Aida, 1897)

1897. *Krohnitta pacifica* Aida, The chaetognaths of Misaki Harbour. *Annot. Zool. Japan.*, 1 : 18.

1939. *Krohnitta pacifica* : Tokioka, *Chaetognatha* collected from the Bays of Sagami and Suruga. *Rec. Oceanog. Works Japan.*, 10 (2) : 141-142.

Total length of the specimens 3 to 5 mm; body short and broad with prominent neck; head slightly broader than trunk but collarette absent; ventral ganglion lying halfway between neck and lateral fins; major part of lateral fins on the tail segment which is varying 30 to 32 % of total length; tail fin spatula-shaped; prehensile hooks curved and sharply pointed; teeth broad-based and conically arranged.

HYDROGRAPHICAL FACTORS

An attempt has been made to correlate the seasonal fluctuations of chaetognath population with the salinity and temperature of surface waters and the rainfall. In this estuary chaetognaths are found only in lower and middle reaches of Zones III and V. The salinity values fell rapidly with the onset of the monsoon and remained very low during the whole monsoon season i.e. 5.5 ‰ to 10.5 ‰. It remained more or less steady during the occasional rain in October. The salinity was relatively high (8.5 ‰ to 17.6‰) during post-monsoon period and fairly high (12.90‰ to 25.6‰) during pre-monsoon period in the Hugli estuary whereas the corresponding figures for the rivers Vidya and Matla was 2-3 ‰ high. Water temperature of the study area varied between 21°C and 28.2° C during post-monsoon season, 27° C and 30° C during south-west monsoon season and 27° C and 31.2° during pre-monsoon season. The pH remained almost constant (7.6 to 8.3) throughout the year with a minor fluctuations during monsoon period. The sudden lowering of salinity and surface temperature resulted in curious change in the composition of populations of chaetognaths.

DISCUSSION

The present study indicates the fact that salinity plays a major role in controlling the distribution of chaetognaths in the Hugli-Matla estuary. The occurrence and abundance of chaetognaths in this estuary appear to be indicative of the salinity of water.

Out of the four species recorded here, *Sagitta bedoti* was found in abundance and formed 72% of the chaetognath collected from the Zones III and V while *S. enflata* was noted 26% and other two species, namely *S. pulchra* and *Krohnitta pacifica* constituted the rest. Former three species are euryhaline and can tolerate fluctuations of wide range of salinity (3‰—33 ‰) and have been recorded from several Indian estuaries but with retarded growth in size in compare to their marine forms. Earlier studies on breeding of *Sagitta* along east coast (Rao and Kelly, 1962 ; Srinivasan, 1980) indicated that due to inhabitants of tropical waters *S. bedoti* and *S. enflata* are continuous breeders and hence in the present study all the stages of both the species were found and fluctuations in abundance of the immature and mature forms during peak and lean seasons corroborates the above facts. The annual distribution of *S. bedoti* was bimodal with two peaks—abundance was observed in the last quarter of pre-monsoon and post-monsoon at the mouth of Mooriganga and at Jharkhali in the Matla rivers. Immature forms were collected from September to January while specimens of all the stages were found in February.

S. enflata was observed in relatively high salinity period (18‰-25‰) and collected up to middle stretches of Zones III and V and totally absent in their upper stretches. During low salinity (12.5‰-16.3‰) period their occurrence was noted near the mouth of Mooriganga and the Saptamukhi rivers in the Hugli estuary and Jharkhali downwards in the Matla river. So in this estuary salinity tolerance range for this species was 12.5‰ to 25.6‰ instead of 3‰ to 33‰ (Srinivasan, 1977) for other estuaries.

Like *S. bedoti* and *S. enflata* *S. pulchra*, though an oceanic species has been recorded from the estuaries of west coast and even from Ennore estuary, Madras (Srinivasan, 1980) of the east coast of India and this has also been reported to tolerate a wide range of salinity. Some specimens were collected from Jambudweep and mouth of river Mooriganga in the Hugli estuary and at Jharkhali in the Matla river during high salinity period in May and June.

Krohnitta pacifica like *S. pulchra* is an oceanic but stenohaline species and has been noticed in the estuarine waters of west coast (Silas and Srinivasan, 1968; Srinivasan, 1971). A few specimens of stage II were collected near Kalas at the mouth of the Matla and around Jambudweep in the Hugli estuary where salinity was around 30‰.

The above account of the distribution of chaetognaths shows that during the pre-monsoon period they penetrate up to middle reaches of Zones III and V of the Hugli-Matla estuary consequent on the presence of high salinity of water. In the post-monsoon period their population follows the decreasing order in salinity along the estuary.

SUMMARY

The paper deals with the occurrence of four species of Chaetognatha from the middle and lower reaches of Zones III and V of the Hugli -Matla estuarine belt. These are *Sagitta bedoti*, *S. enflata*, *S. pulchra* and *Krohnitta pacifica*. Of these, last two named species are for the first time collected from this estuary. In addition, the present study in relation to hydrographical factors indicates that salinity plays a major role in controlling the distribution of this group in this estuary

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ASTEROIDEA, OPHIUROIDEA AND ECHINOIDEA (ECHINODERMATA)

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Zoological Survey of India Calcutta—700 016

INTRODUCTION

Echinoderms are exclusively marine inhabitants with little or no osmoregulatory capacities and with only limited tolerance to narrow ranges of salinity variations. Hence their occurrence in truly estuarine regions with wide fluctuations in salinity and great dilutions is very rare. However, a few species occur in areas nearby the river mouths, particularly during periods of relatively higher salinity and in subtidal waters. Earlier, Koehler (1910, 1922) reported *Astropecten euryacanthus* of Asteroidea and *Clypeaster rarispinus* and *Echinodiscus auritus* of Echinoidea from the Hugli River Mouth. Subsequent surveys and rummaging of the old collections brought to light some more species from the Hugli and Matla regions. Thus the echinoderm fauna of the Hugli-Matla estuarine system, excluding Crinoidea of which no species has hitherto been reported and Holothuroidea dealt with separately in the present volume, comprises at present of four species of Asteroidea, six species of Ophiuroidea, and five species of Echinoidea as listed below. All these species have recently been dealt with in detail under the FAUNA OF STATES SERIES : WEST BENGAL (Sastry, in press) wherein detailed descriptions, figures and keys for identification have been provided.

Asteroidea, Ophiuroidea And Echinoidea (Echinodermata) of the Hugli-Matla Estuarine System

Class : ASTEROIDEA

Order : PAXILLOSIDA

Family : LUIDIIDAE

1. *Luidia hardwicki* (Gray)

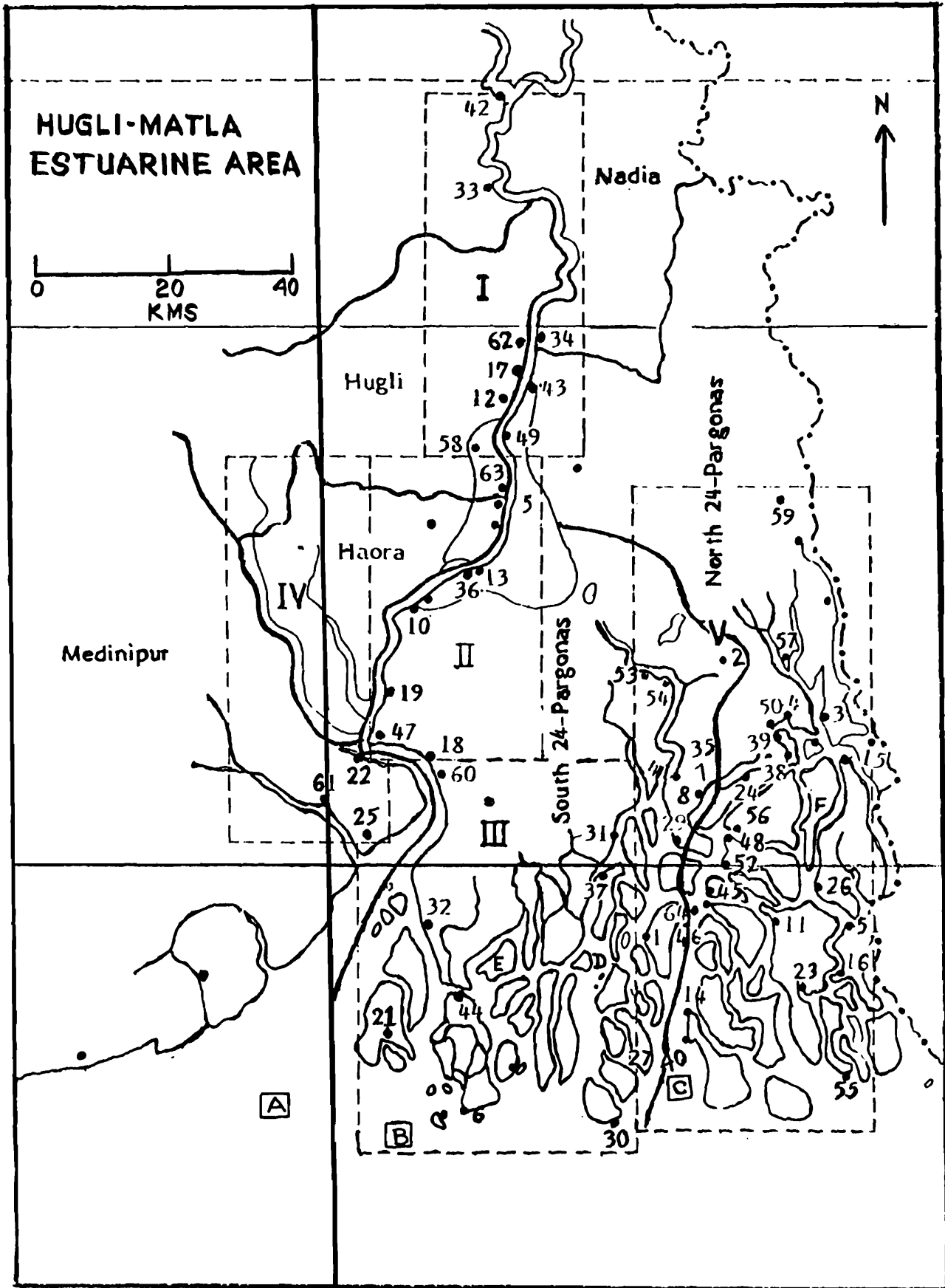
Family : ASTROPECTINIDAE

2 *Astropecten euryacanthus* Luetken

3 *Astropecten indicus* Doederlein

Family : GONIOPECTINIDAE

4 *Goniopecten* sp.



Distribution of species encountered

1. *Luidia hardwicki* (Gray)—A
2. *Astropecten euryacanthus* Luetken—A, 6
3. *Astropecten indicus* Doederlein—A, D, E, 21, 37
4. *Goniopecten* sp.—A
5. *Amphioplus (Lymanella) hastatus* (Ljungman)—A
6. *Amphioplus (Lymanella)* sp.—A
7. *Amphiura (Ophiopeltis) tenuis* (H. L. Clark)—1, 29, 37
8. *Ophiactis delagoa* Balinsky—6, 21, 51
9. *Ophiactis modesta* Brock—F, 53
10. *Ophiocnemis marmorata* (Lamarck)—A
11. *Chaetodidema granulatum* Mortensen—A
12. *Temnopleurus toreumaticus* (Leske)—A
13. *Clypeaster rarispinus* de Meijere—C
14. *Laganum decagonale* (de Blainville)—A
15. *Echinodiscus auritus* Leske—B

A : Sandheads ; B : Estern Chnnel ; C : Matla ; D : Dwarikanagar ; E : Prentice Island ; F : Panchamukhani ; 1 : Ajmalmri ; 6 : Bakkhali ; 21 : Sagar Island ; 29 : Jharkhli ; 37 : Kishorimohanpur ; 51 : Pareymari ; 53 : Port Canning

Class : OPHIUROIDEA
Order : OPHIURIDA
Family : AMPHIURIDAE

5 *Amphiplus (Lymanella) hastatus* (Ljungman)

6 *Amphiplus (Lymanella)* sp.

7 *Amphiura (Ophiopeltis) tenuis* (H.L.Clark)

Family : OPHIACTIDAE

8. *Ophiactis delagoa* Balinsky

9 *Ophiactis modesta* Brock

Family : OPHIOTRICHIDAE

10. *Ophiocnemis marmorata* (Lamarck)

Class : ECHINOIDEA

Order : DIADEMATOIDA

Family : DIADEMATIDAE

11. *Chaetodiadema granulatum* Mortensen

Order : TEMNOPLEUROIDA

Family : TEMNOPLEURIDAE

12. *Temnopleurus toreumaticus* (Leske)

Order : CLYPESTEROIDA

Family : CLYPEASTERIDAE

13. *Clypeaster rarispinus* de Meijere

Family : LAGANIDAE

14. *Laganum decagonale* (de Blainville)

Family : ASTRICLYPEIDAE

15. *Echinodiscus auritus* Leske

SYSTEMATIC ACCOUNT

Class : ASTEROIDEA

Order : PAXILLOSIDA

Family : LUIDIIDAE

1. *Luidia hardwicki* (Gray)1840. *Petalaster hardwicki* Gray, *Ann. Mag. nat. Hist.*, 6 : 1831971. *Luidia hardwicki* : Clark and Rowe, *Monograph of shallow water Indo-west Pacific echinoderms*, 30, 44*Material* : Feb.-Mar. 1928 ; Sandheads, Hugli River Mouth; P.V. *Lady Fraser*, 1 spec.*Description* : Five arms; superomarginal plates paxilliform, not distinguishable from the abactinal plates; oral plates with 4-5 bivalved pedicellariae.*Remarks* : Inhabits sandy areas often burrowing into the subsurface.*Distribution* : India—West Bengal (South 24-Parganas Dt.), Tamil Nadu, and Maharashtra; Indo-west Pacific.

Family : ASTROPECTINIDAE

2. *Astropecten euryacanthus* Luetken1872. *Astropecten euryacanthus* Luetken, *Vidensk. Meddr Dansk naturh. Foren.*, 1871 : 2311971. *Astropecten euryacanthus* : Clark and Rowe, *Monograph of shallow water Indo-west Pacific echinoderms*, 30, 44*Material* : 24.4.1924 Sandheads, Hugli River Mouth; P.V. *Lady Fraser*, 1 Spec ;

2.4.1987 Bakkhali, Hugli River Mouth; B. P. Haldar, 5 specs.

Description : Abactinal plates paxilliform, in regular transverse series laterally on arms; superomarginal plates distinct, with only scaly covering, without superomarginal spines; actinal plates three or more pairs in each interradian area; inferomarginal plates with a single flat blunt spine at the margin and rounded scale-like spinelets on the actinal surface.

Remarks : Generally inhabits sandy areas near river mouths.

Distribution : India—West Bengal (South 24-Parganas and Medinipur Dts.), and Nicobar Is.; Bay of Bengal.

3. *Astropecten indicus* Doederlein

1888. *Astropecten indicus* Doederlein, *Zool. Jb. syst. Bd.*, 3 : 828

1971. *Astropecten indicus* : Clark and Rowe, *Monograph of shallow water Indo-west Pacific echinoderms*, 30,45

Material : Sandheads, Hugli River Mouth; S.P.V. Andrew, 2 Specs. ; 5.8.1974 Sagar Id., Hugli River Mouth; A. Misra, 1 spec. ; 7.3.1989 Kishorimohanpur, Matla; Dr. R. A. Khan, 6 specs. ; 8.3.1989 Prentice Id., Matla; Dr. R.A. Khan, 2 specs. ; 9.3.1989 Dwarikanagar, Matla; Dr. R.A.Khan, 1 spec.

Description : Abactinal paxillae small, closely packed, not in regular transverse series; superomarginal plates distinct, often with a small tubercle-like spinelet; actinal intermediate plates two pairs in each interradius; inferomarginal plates with a single, pointed spine at the margin and pointed spinelets on the actinal surface the middle series of which consists of longer spinelets.

Remarks : Generally inhabits sandy substrata. A very variable species in respect of the shape of the arms and development of superomarginal spines. Usually the arms are blunt at the tips, and the superomarginal plates without a spine. In the specimens from the study area the arms are however pointed slightly and the superomarginal plates are usually with a tubercle-like spinelet.

Distribution : India—West Bengal (South 24-Parganas and Medinipur Dts.) ; Orissa, Andhra Pradesh, Tamil Nadu, and Kerala; Persian Gulf to East Indies.

Family : GONIOPECTINIDAE

4. *Goniopecten* sp.

Material : Sandheads, Hugli River Mouth; S.P.V. Andrew 1 spec.

Description : The genus is characterised by cribriform organs consisting of discrete spinelets overlaid by webbed spinelets along the margins of the marginal plates and limbrate channels overlaid by similar spinelets of the actinal and inferomarginal plates.

Remarks : The single specimen measures 60 mm in R and 13 mm in arm breadth at the base with R = 5r. The abactinal paxillae are larger on the disc and midradial region of the arm. The specimen is closer to the type species *G. demonstrans* from the Atlantic in having only the inferomarginal spines, superomarginal plates of the two sides not meeting distally and no subambulacral spines. It differs in the same characters from *G. asiaticus* from the Philippines.

Class : OPHIUROIDEA

Order : OPHIURIDA

Family : AMPHIURIDAE

5. *Amphioplus (Lymanella) hastatus* (Ljungman)

1867. *Amphipholis hastatus* Ljungman, *Ofversk. vidensk Akad. Forh.*, 1866 : 313

1971. *Amphioplus (Lymanella) hastatus* : Clark and Rowe, *Monograph of shallow water Indo-west Pacific echinoderms*, 80,102

Material : 18.10.1889 Sandheads, Hugli River Mouth; A. Milner, 1 spec.

Description : Disc covered by imbricating plates forming a distinct border along the margin; one infradental and three lateral papillae on each side of the jaw; dorsal arm plates broader than long, distal margin convex; three pointed lateral arm spines; and two tentacle scales.

Remarks : Larger central disc scales and longer radial shields distinguish the species from *A. (L.) depressus*.

Distribution : India—West Bengal (South 24-Parganas Dt.); Arabian Sea and Bay of Bengal.

6. *Amphioplus (Lymanella) sp.*

Material : 20.2.1923 Sandheads, Hugli River Mouth; P.V. Lady Fraser, 1 spec.

Description : The disc of the single specimen is lost; the arm spines and oral papillae as in the subgenus *Lymanella*; arms very long, dorsal arm plates with trilobed distal margin.

Remarks : The specimen appears to be closer to *A. (L.) laevis* in having longer arms.

7. *Amphiura (Ophiopeltis) tenuis* (H.L. Clark)

1938. *Ophionephthys tenuis* H.L. Clark, *Mem. Mus. comp. Zool. Harv.*, 55 : 241

1979. *Amphiura (Ophiopeltis) tenuis* : Baker, *N.Z. J. Zool.* 6 : 43

Material : 24.9.1984 Jharkhali, Matla ; B. P. Haldar, 1 spec. ; 8.11.1988 Ajmalmari, Matla; Dr. R. A.Khan, 2 specs. ; 7.3.1989 Mud flats opp. Kishorimohanpur, Matla; Dr. R.A.Khan, 2 specs.

Description : Disc almost naked with only 2-3 rows of narrow scales around the very long radial shields; one infradental and one lateral distal papilla separated from the former by a wide gap on each side of the jaw; arms very long, dorsal arm plates almost conical; arm spines up to six at the base, reduced to three distally the middle one of which has strong lateral denticles; no tentacle scale.

Remarks : The species appears to be very common in the Matla area where it burrows deep into the hard mud rendering collection of complete specimens extremely difficult.

Distribution : India—West Bengal (South 24-Parganas Dt.) ; Persian Gulf to Australia.

Family : OPHIACTIDAE

8. *Ophiactis delagoa* Balinsky

1957. *Ophiactis delagoa* Balinsky, *Ann. Natal Mus.*, 14 : 12

1971. *Ophiactis delagoa* : Clark and Rowe, *Monograph of shallow water Indo-west Pacific echinoderms*, 82, 104

Material : 10/11.4.1978 Bakkhali, Hugli River Mouth, Dr. G.C. Rao, 17 specs.; 22.3.1981 Sagar Id., Hugli River Mouth; B.P. Haldar, 2 specs. ; 9.11.1988 Pareymari, Matla; Dr. R.A. Khan, 5 specs.

Description : Disc scales with pointed spinelets; dorsal arm plates fan-shaped; four arm spines, as long as the segment; two distal lateral papillae, no infradental papillae; teeth square tipped.

Remarks : Inhabits fine sandy habitats.

Distribution : India—West Bengal (South and North 24-Parganas and Medinipur Dts.) ; Mozambique and India.

9. *Ophiactis modesta* Brock

1888. *Ophiactis modesta* Brock, *Z. weiss. Zool.*, 47 : 482

1981. *Ophiactis modesta* : Guille, *Mem. Orstom*, 91 : 482

Material : 9.1.1858 Port Canning, Matla 1 spec. ; 6.3.1989 Panchamukhani, Matla ; Dr. R. A. Khan, 70 specs.

Description : Disc scales with scattered pointed spinelets; a single thick lateral oral papilla, no infradental papilla; dorsal arm plates broader than long, distal margin concave in the middle; five arm spines, pointed, uppermost or the next longest.

Remarks : The specimens show variation with regard to the number of arm spines and structure of the adoral shields. The specimens differ from *O. maculata* in having dorsal arm plates with straight lateral margins and not more than twice as broad as long, whereas in *O. maculata* the dorsal arm plates are nearly thrice as broad as long and their lateral margins rounded.

Distribution : India—West Bengal (South and North 24-Parganas and Medinipur Dts.), Andamans, and Tamil Nadu ; Arabian Sea to Hawaiian Is.

Family : OPHIOTRICHIDAE

10. *Ophiocnemis marmorata* (Lamarck)

1816. *Ophiura marmorata* Lamarck, *Hist. nat. anim. s. vert.*, 2 : 543

1978. *Ophiocnemis marmorata* : Cherbonnier and Guille, *Faune de Madagascar*, 48 : 154

Material : Sandheads, Hugli River Mouth; Br. Pilot J. Brunnett, 1 spec. ; 17.6.1885 Sandheads; Hugli River Mouth; A. Milner, 1 spec.; 18.10.1889 Sandheads, Hugli River Mouth; A. Milner, 2 specs.

Description : Dorsal disc with large naked radial shields and small rounded granulation; ventral interradial disc with only skin covering; dorsal arm plates as broad as long, keeled in the middle; distal and proximal margins of ventral arm plates concave; arm spines five, blunt, middle one longest; only a cluster of infradental oral papillae, no lateral oral papillae.

Remarks : Inhabits subtidal sandy areas.

Distribution : India—West Bengal (South 24-Parganas Dt.), Andamans, and Tamil Nadu; East coast of Africa to Australia.

Class : ECHINOIDEA

Order : DIADEMATOIDA

Family : DIADEMATIDAE

11. *Chaetodiadema granulatum* Mortensen

1903. *Chaetodiadema granulatum* Mortensen, *Vidensk. Meddr Dansk naturh. Foren.*, 1903 : 1

1971. *Chaetodiadema granulatum* : Clark and Rowe, *Monograph of shallow water Indo-west Pacific echinoderms*, 140, 152

Material : Sandheads, Hugli River Mouth; P.V. *Lady Fraser* , 3 specs.

Description : Test thin, slightly elevated, collapsing immediately after collection; primary tubercles perforate and crenulate; ambulacra abruptly narrowing on oral side with spaced tubercles and spaced pore-pairs in a single series.

Remarks : Inhabits subtidal sandy areas.

Distribution : India—West Bengal (South 24-Parganas Dt.), Andamans, Orissa, and Andhra Pradesh ; Indo-west Pacific.

Order : TEMNOPLEUROIDA

Family : TEMNOPLEURIDAE

12. *Temnopleurus toreumaticus* (Leske)

1778. *Cidaris toreumaticus* Leske, *Add. ad. Klein*, 155

1971. *Temnopleurus toreumaticus* : Clark and Rowe, *Monograph of shallow water Indo-west Pacific echinoderms*, 142, 154

Material : 17.6.1885 Sandheads, Hugli River Mouth; A. Milner, 1 spec.

Description : Test plates with deep transverse pits at the corners; primary tubercles crenulate and imperforate; ambulacral plates each with a primary tubercle; spines banded with reddish grey.

Remarks : Inhabits sandy substrata; large aggregations of juvenile specimens are common near river mouths during summer months.

Distribution : India—West Bengal (South 24-Parganas and Medinipur Dts.), Andamans, Orissa, Andhra Pradesh, Tamil Nadu, Maharashtra and Gujarat; Indo-west Pacific as far east as South Pacific Islands.

Order : CLYPEASTEROIDA

Family : CLYPEASTERIDAE

13. *Clypeaster rarispinus* de Meijere

1903. *Clypeaster rarispinus* de Meijere, *Tijdschr. ned. dierk. Vereen.*, (2) 8 : 7

1971. *Clypeaster rarispinus* : Clark and Rowe. *Monograph of shallow water Indo-west Pacific echinoderms*. 144, 160

Material : Matla ; Capt. J.H. Row, 1 spec.

Description : Test flat, pentagonal, corners rounded, margin slightly thick; oral ambulacral furrows prominent up to the margin of the test; periproct on the oral side, close to the posterior margin, in the posterior interambulacrum; genital pores five.

Remarks : Very common in subtidal silty areas; often caught in large numbers by the trawl nets along the coast line.

Distribution : India—West Bengal (North 24-Parganas Dt.), Orissa, Andhra Pradesh, Tamil Nadu, Kerala, Lakshadweep and Karnataka ; Indo-west Pacific.

Family : LAGANIDAE

14. *Laganum decagonale* (de Blainville)

1827. *Scutella decagonale* de Blainville, *Dict. Sci. Nat.*, 48 : 229

1971. *Laganum decagonale* : Clark and Rowe, *Monograph of shallow water Indo-west Pacific echinoderms*, 144, 162

Material : 17.6.1885 Sandheads, Hugli River Mouth; A. Milner, 2 specs:

Description : Test flat, thin, fragile, decagonal or almost rounded; margin thin; madreporic pores in a sinuous groove; oral furrows distinct up to half the test radius; periproct on the oral side, in the posterior interambulacrum, close to the posterior margin; five genital pores.

Remarks : Very common in the subtidal silt and sandy beds.

Distribution : India—West Bengal (South 24-Parganas Dt.), Orissa, Tamil Nadu and Kerala; Indo-west Pacific.

Family : ASTRICLYPEIDAE

15. *Echinodiscus auritus* Leske

1778. *Echinodiscus auritus* Leske, *Add. ad. Klein*, 138

1971. *Echinodiscus auritus* : Clark and Rowe, *Monograph of shallow water Indo-west Pacific echinoderms*, 144, 162

Material : June 1908 Eastern Channel, Hugli River Mouth; B.F. *Golden Crown*, 1 spec.

Description : Test flat, slightly broader than long; peristome slightly anterior; periproct on the oral side, in the posterior interambulacrum, half-way to the posterior margin; two open lunules in the posterior paired ambulcra; all miliary spines similar, no dark coloured spines; four genital pores.

Remarks : Inhabits fine sandy areas near the river mouths.

Distribution : India—West Bengal (South 24-Parganas Dt.), Andamans, Orissa, Andhra Pradesh, Tamil Nadu and Kerala ; Indo-west Pacific.

SUMMARY

The paper deals with four species of Asteroidea, six species of Ophiuroidea and five species of Echinoidea known from the Hugli-Matla estuarine system (West Bengal, India). The species are dealt with in brief with regard to description, remarks on variation and habitat and distribution.

ACKNOWLEDGEMENTS

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HOLOTHUROIDEA : ECHINODERMATA

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INTRODUCTION

The sea-cucumbers comprising the class Holothuroidea are exclusively marine inhabitants having a few brackish-water representatives, some of them are available in the Hugli-Matla estuarine area of West Bengal.

The first record of the estuarine holothuroids in India was made by Kochler and Vaney (1908) who described three species from the Hugli river mouth. Recently, one more species was reported in 1987 (Anonymous) from the aforesaid area. During the course of present study on the macrobenthos of the Hugli-Matla estuary only two species, one of which was hitherto unknown from the area, has been recorded. Thus, making a total of five species is on record from the region.

The present material deals with the diagnosis and distribution of these five species together with the key for their identification. The list of references has been reduced to avoid over-repetition but include the original description and the current valid names.

MATERIAL AND METHODS

The most common method of collection is to search for them in the intertidal region during low tide. They may be collected from under small stones or hard masses of solid bodies. The smaller cryptic forms are found in small holes and in crevices of boulders. Mud of the mudflats are strained for the collection of burrowing forms. Weeds and decomposed plant bodies are also washed and examined for still smaller forms.

The collected specimens are preserved in rectified spirit after a period of narcotisation with gradually increasing doses of alcohol or menthol. Formalin should never be used as preservative because it dissolves the dermal skeletal elements or spicules and make them useless for taxonomical studies.

Studies of morphology and anatomy are primary important steps for satisfactory identification. During the study colour, shape, size, number of tentacles and podia are examined. Gonadial structures, respiratory organs and organ of defence are examined by dissection. Lastly, a portion of skin and tentacle are treated with caustic potash and examined under microscope for the study of demal spicules which is most important for the correct identification of the species.

SYSTEMATIC ACCOUNT

List of holothuroids hitherto known from the area

Class : HOLOTHUROIDEA
Order : DENDROCHIROTIDA
Family : CUCUMARIIDAE

1 *Stolus rapax* (Koehler and Vaney)

2 *Thorsonia investigatoris* (Koehler and Vaney)

Order : APODIDA

Family : SYNAPTIDAE

3 *Synaptula recta* (Semper)

4 *Labidoplax* sp.

Order : MOLPADIDA

Family : CAUDINIDAE

5 *Acaudina molpadioides* (Semper)

Keys to Orders and Families

1. Podia present; bodywall thick and muscular ; tentacles 10, bush or tree-shaped; dominant spicules in the form of cups, rods and perforated plates
..... DENDROCHIROTIDA & CUCUMARIIDAE

Podia absent; bodywall thin; vermiform; tentacles digitate or pinnate; spicules in the form of cups, plates, anchors and anchor plates 2

2. Tentacles 15, digitate; body stout, sausage-shaped, usually with a distinct caudal appendage; spicules containing tables, cups, fusiform rods or perforated plates.....
.....MOLPADIDA & CAUDINIDAE

Tentacles 10-12, pinnate; caudal appendage absent; spicules consisting of anchors and anchor plates, rods and granulesAPODIDA & SYNAPTIDAE

Order : DENDROCHIROTIDA

Family : CUCUMARIIDAE

Key to Genera

Body straight; spicules consisting of nodular buttons and sometimes large perforated plates: *Stolus*

Body 'U'-shaped, attenuated at each end; spicules consisting of tables and fusiform plates but no button: *Thorsonia*

Genus I. *Stolus* Selenka, 1867

1867. *Stolus* Selenka, Z. wiss. Zool., 17 (20) : 355, figs. 115-116.

1982. *Stolus* : James, *J. mar. biol. Ass. India*, **24** (1&2) : 128.

Type species : *Stolus sacellus* Selenka.

Diagnosis : Tentacles 10, tree-like or branched; body wall without any imbricating plate; calcareous ring with radial and inter-radial plates composed of a mosaic of small plates; spicules consisting of small nodular buttons with few holes, usually four, larger perforated plates present occasionally.

1. *Stolus rapax* (Koehler and Vaney)

1908. *Cucumaria rapax* Koehler and Vaney, *Echinodermata of the Indian Museum*, Part IV : 39.

1980. *Stolus rapax* : Mary Bai, *Mem. zool. Surv. India*, **16** (2) : 4.

Diagnosis : Body 'U'—shaped, tapering at the ends; tentacles 10, dendritic, ventral two of which shorter; calcareous ring tubular having the radial plates composed of several small pieces; spicules consisting of small nodular buttons with a few holes and large perforated plates.

Remarks : This species has so far been recorded from the Hugli river mouth in the entire Indo-west Pacific littoral waters.

Distribution : *In India* : West Bengal : Hugli river mouth. *Elsewhere* : Absent.

Genus II. *Thorsonia* Heding, 1940

1940. *Thorsonia* Heding, *Danish Scient. Inv. Iran*, Part II : 131.

1980. *Thorsonia* : Mary Bai, *Mem. zool. Surv. India*, **16** (2) : 3.

Type species : *Thorsonia adversaria* (Semper) :

Diagnosis : Body 'U'-shaped; calcareous ring stout with short posterior bifurcation of radial plate; spicules consisting of tables with disc forming 2-5 lobes, spires composed of 2-4 pillars, branched rods, buttons or basket absent.

Remarks : This genus is represented by a single species from the area.

2. *Thorsonia investigatoris* (Koehler and Vaney)

1808. *Cucumaria investigatoris* Koehler and Vaney, *Echinoderm of the Indian Museum*, part IV ; 36. -

1980. *Thorsonia investigatoris* : Mary Bai, *Mem. zool. Surv. India*, **16** (2) : 4.

Material examined : 4 exs., Beach near Tourist Bungalow, Bakkhali, S. 24 Paraganas 2.4.1987, B.P. Haldar.

Diagnosis : Body 70-80 mm long, U-shaped, slender and pointed at the ends, bulging in the middle; creamy white in colour; calcareous ring stout and short, having the radials with long posterior bifurcate prolongations composed of small pieces; spicules consisting of large tables with 4 lobed disc and spire of 2-4 pillars joined near their apex and terminating in a few spines, pedicles and papillae having two armed arched disc and small spire.

Remarks : It is an endemic species known only from the Hugli river mouth (Type locality) and its adjoining areas (Bakkhali and Digha). It is a common form at Digha coast but less frequently come across at the area under study.

Distribution : In India : West Bengal : 24 Parganas and Medinipur. Elsewhere : Absent.

Order : APODIDA

Family : SYNAPTIDAE

Key to Genera

Anchor plates having a distinct posterior handle and having only large but regular and smooth holes *Labidoplax*

Anchor plates without posterior handle, but having both small and large, regular and toothed holes *Synaptula*

Genus III. *Synaptula* Orsted, 1849

1849. *Synaptula* Orsted, *Vidensk. Meddr dansk naturh. Kjr.*, 1849-1850 : 7.

1988. *Synaptula* : Mukhopadhyay, *Rec. zool. Surv. India*, **85** (1) : 15.

Type species : *Synaptula hydriformis* Lesueur.

Diagnosis : Tentacles 10-15, pinnate with at least 5 digits on each side; calcareous plates present; stalk of anchors finely toothed but not branched, arms smooth, anchor plates with a large central hole surrounded by six big toothed holes.

3. *Synaptula recta* (Semper, 1868)

1868. *Synapta recta* Semper, *Holothurien*, : 14.

1988. *Synaptula recta* : Mukhopadhyay, *Rec. zool. Surv. India*, **85** (1) : 15.

Material examined : 4 exs., Saimari, Bhangaduni Is., Matla river mouth, 11.3.1989, B.P.Haldar; 3 exs., Ajmalmari, Thakuran river, 6.3.1989, B.P.Haldar.

Diagnosis : Length 15-22 mm; vermiform, thin and transparent body wall; light yellowish brown in colour; tentacles 15, number of digits of each tentacle varies and their size is proportional to the size of the specimen, digits webbed; calcareous ring with a large hole at anterior end, inter-radial piece with conical projections; spicules consisting of anchors having two flukes of equal sizes, anchor plates oval and symmetrical, the broad anterior end having six large toothed holes of uniform sizes while the posterior end having three small holes, the central one being largest, miliary granules present.

Remarks : The species has so far been reported only from marine habitat. This is for the first time collected from an estuary. According to the collector they are available in huge numbers in the aforesaid localities.

Distribution : *In India* : West Bengal : 24 Parganas; Tamil Nadu : Madras, Pamban, Krusadai Island. *Elsewhere* : Red Sea; Sri Lanka; Mergui (Burma); East Indies; North Australia; Philippines; South Pacific Is.

Genus IV. *Labidoplax* Ostergren, 1998

1898. *Labidoplax* Ostergren, *Ofv. Kong. Vet. Akad. Forhandl.*, **55** : 110-120.

1982. *Labidoplax* : James, *J. mar. biol. Ass. India.*, **24** (1 & 2) : 8, fig 1.

Diagnosis : Tentacles 11 or 12, digitate with 3 or 4 digits; calcareous ring absent; spicules consisting of anchors having the plates abruptly narrowed posteriorly, the bow rudimentary or wanting, each plate has three large holes in addition to an elongated hole at the handle.

Remarks : An unidentified species under this genus was reported from Sagar Island (Anonymous, 1987). No representative of this genus is available with the author.

Order : MOLPADIDA

Family : CAUDINIDAE

Genus V. *Acaudina* H.L. Clark, 1907

1907. *Acaudina* H.L. Clark, *Smithson. Contr. Knowl.* **35** : 178

1988. *Acaudina* : Mukhopadhyay, *Rec. zool. Surv. India*, **85** (1) : 15.

Types species : *Acaudina demissa* Sluiter.

Diagnosis : Tentacles 15, digitate with one pair of lateral digits ; caudal portion absent; calcareous ring with very conspicuous posterior bifurcated prolongations; spicules consisting of smooth thick or spinose plates with a few holes.

5. *Acaudina molpadioides* (Semper, 1868)

1868. *Haplodactyla molpadioides* Semper, *Reisen in Archipel der Philippinen*, 2, wissen Resultat : 41.

1983. *Acaudina molpadioides* : Soota, Mukhopadhyay and Samanta, *Rec. zool. Surv. India*, 80 : 521.

Diagnosis : Body stout, sausage-shaped; tentacles 15, digitate with only one pair of lateral digits and without caudal appendage ; podia absent, skin more or less opaque; spicules when present small and oval bodied, more or less irregular perforated plates daught-nut-like with a single perforation.

Remarks : This species occurs both in estuarine and marine habitat in India. Though it is not represented in the present collection, however, it is reported from the Hugli river mouth by Koehler and Vaney (1908) and from the Andamans by the present author (1983). In this estuarine belt its occurrence is said to be rare.

Distribution : In India : West Bengal : Hugli river mouth; Tamil Nadu; Andaman and Nicobar Islands. Elsewhere : East Indies; Philippines; South China Sea.

SUMMARY

The paper deals with five species of holothuroids occurring in the Hugli-Matla estuarine area. It incorporates the classified list of the species, key to orders, families, and genera together with the diagnostic features of the genera and species. It also includes the distribution of all the species dealt in here.

ACKNOWLEDGEMENTS

The author is thankful to Dr. A.K. Ghosh, Director, Zoological Survey of India, Calcutta, for providing laboratory facilities and to Dr. B.P. Haldar, Zoologist, for the collection of material for study and going through the manuscript.

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INTERTIDAL FISHES

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INTRODUCTION

The Hugli-Matla estuarine belt is one of most magnificent mangrove ecosystem in the world. This belt experiences inundation and exposure twice in 24-hours. Among the macrobenthos known from this area the fishes are the most important component. Fishes of the Ganga system including the Hugli and its associated creeks have been dealt by Hamilton-Buchanan (1822), Annandale (1907; 1922), Kemp (1917), Hora (1933; 1934a, b; 1935; 1940; 1943), Pearse (1932), Prasad, Hora and Nair (1940), David (1954), Gupta (1966, 1967), Babu-Rao (1969), Talwar and Joglekar (1970a, b), Talwar and Sinha (1973), Chatterjee (1978), Dhanje (1981), Talwar and Mukherjee (in press), and Talwar *et al.* (in press).

This paper deals with fishes which are available in fresh to hyper saline waters mainly of the intertidal zone and mud flats where inundation and exposure have occurred twice in every twenty four hours. The fishes inhabit in the above zone are of three categories viz. Gobiids, Blenniids and Eels. The fishes belonging to Gobiids and Blenniids have not commercial value, but the Eels have some commercial value and are taken as food mainly by the people of low income group.

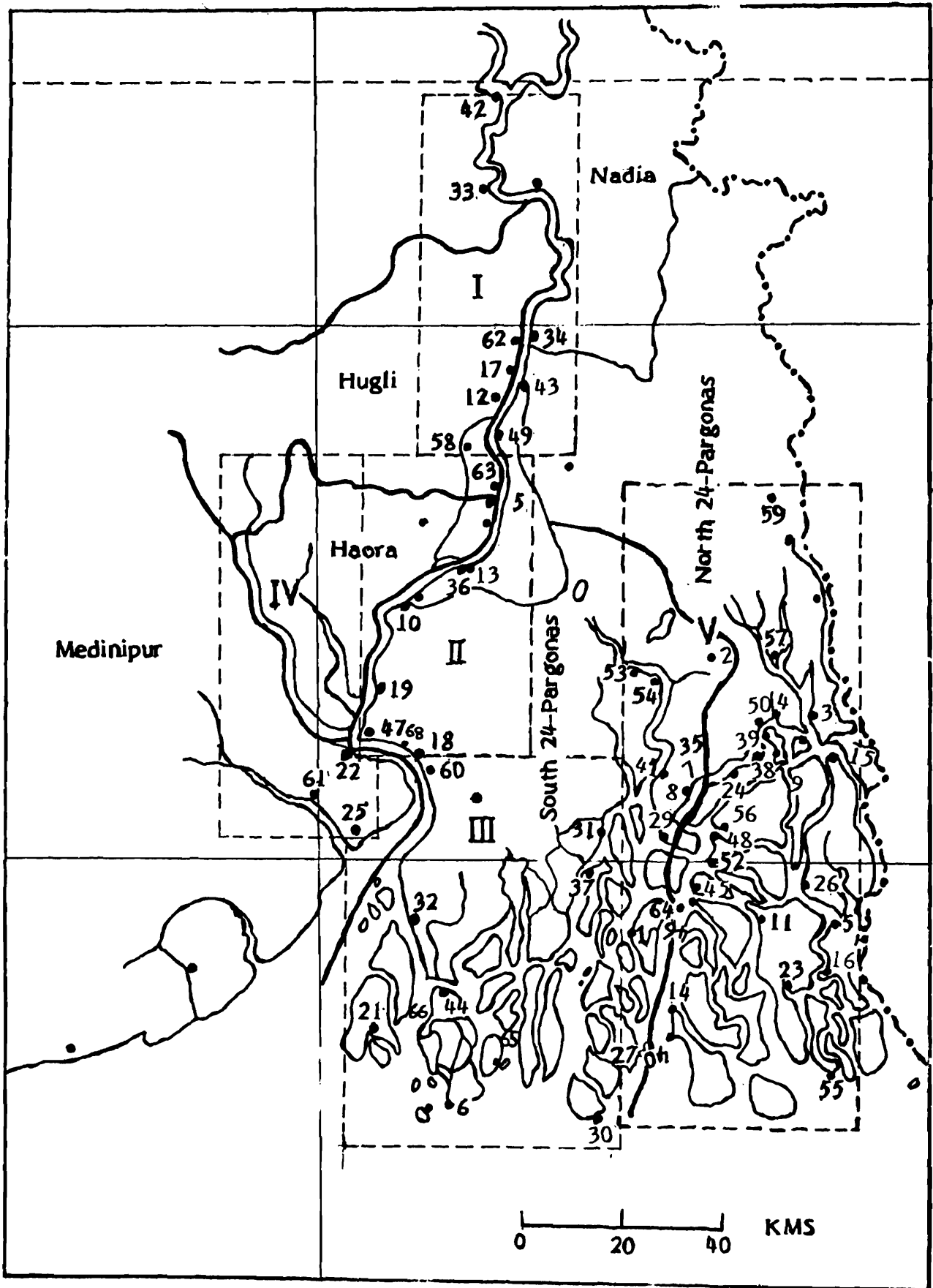
Three species, viz. *Periophthalmus malaccensis* and *Pseudapocryptes borneensis*, family Gobiidae ; *Taenioides eruptionis* family Taenioididae are recorded for the first time from India and four species, viz. *Petroscirtes breviceps*, *P. variabilis* of family Blenniidae; *Trypauchenichthys typus*, family Taenioididae and *Periophthalmus vulgaris*, family Gobiidae are newly recorded from the area under study.

Under material examined name of the collector other than author is mentioned.

MATERIAL AND METHODS

Fish specimens were collected through regular field trips from September, 1984 to March, 1989 at different localities of vast stretches of the Hugli-Matla estuarine belt. The materials are mainly collected from the intertidal regions down the shore starting from highest high tide to lowest low tide mark as well as along the shore following the river course during the low tide period. Gobiids are mainly under the soft mud, some from crab holes along banks of pools and narrow channels which have two or three openings. During low tides, the mud skippers were found on twigs of plants. Eels were collected only under soft mud but the largest eel *Thyrsoidea macrura* (Bleeker) were collected under the deep hole about 1 meter depth on the shore of narrow channel. The Blenniids were collected from the hole of soft rotten wood laying in the intertidal zone.

After collection specimens are to wash properly by clean water. Then an incision is to be



Distribution of Fish Fauna In The Hugli-Matla Estuarine Area

DISTRIBUTION OF FISH FAUNA IN THE HUGLI-MATLA ESTUARINE AREA

I. Species commonly occurring in the study area

Name of species	Locality
1. <i>Siderea picta</i> (Ahl)	44 (Narayangunge), 25 (Haldi river), 22 (Geonkhali)
2. <i>Uropterygius tigrinus</i> (Lesson)	68 (Roychock), 44 (Narayangunge), 32 (Kakdwip), 58 (Sibgunge), 17 (Bandel Church), 58 (Phuleswar).
3. <i>Pisodonophis boro</i> (Hamilton- Buchanan)	32 (Kakdwip), 7 (Sonakhali), 66 (Muriganga), 65 (Sptamukhi river), 6 (Bakkhali), 18 (Diamond Harbour), 25 (Haldia). 58 (Sibgunge), 58 (Phuleswar).
4. <i>Periophthalmodon schlosseri</i> (Pallas)	59 (Basirhat), 25 (Haldia), 19 (Falta), 7 (Sonakhali), 18 (Gadiyara), 29 (Jharkhali), 58 (Sibgunge), 44 (Iswesripur).
5. <i>Periophthalmodon tredecemaradius</i> (Hamilton-Buchanan)	59 (Basirhat), 6 (Bakkhali), 32 (Kakdwip), 25 (Haldia)
6. <i>Periophthalmus chrysopilos</i> Bleeker	59 (Basirhat), 7 (Basanti), 32 (Kakdwip), 18 (Diamond Harbour), 58 (Dingkhali), 65 (Saptamukhi river). 12 (Chandanagar)
7. <i>Apocryptes bato</i> (Hamilton-Buchanan)	22 (Geonkhali), 19 (Falta), 18 (Diamond Harbour).
8. <i>Pseudapocryptes borneensis</i> (Bleeker)	50 (Pergumti), 7 (Sonakhali), 25 (Haldia).
9. <i>Boleophthalmus boddarti</i> (Pallas)	50 (Pergumti), 32 (Kakdwip), 7 (Basanti), 7 (Sonakhali), 18 (Diamond Harbour), 58 (Sibgunge).
10. <i>Pseudapocryptes lanceolatus</i> (Bloch & Scneider)	32 (Kakdwip), 7 (Basanti), 29 (Jharkhali).
11. <i>Scartelaos histophorus</i> (Valenciennes)	50 (Pergumti), 15 (Chotomollakhali), 7 (Basirhat), 24 (Gosaba), 32 (Kakdwip), 22 (Geonkhali), 18 (Diamond Harbour), 25 (Haldia), 19 (Falta), 7 (Sonakhali), 29 (Jharkhali), 58 (Sibgunge).
12. <i>Odontamblyopus rubicundus</i> (Hamilton-Buchanan)	59 (Basirhat), 24 (Gosaba), 61 (Bakkhali), 25 (Haldia), 22 (Geonkhali), 19 (Falta), 7 (Basanti), 58 (Digakhali), 20 (Gadiyara), 17 (Bandel Church), 58 (Sibgunge), 58 (Fuleswar).
13. <i>Taenioides cirratus</i> (Blyth)	32 (Kakdwip), 68 (Raychock), 53 (Canning), 22 (Geonkhali).
14. <i>Trypauchen vagina</i> (Bloch & Schneider)	29 (Jharkhali), 15 (Chotomollkhali). 32 (Kakdwip), 19 (Falta).

Explanation of Map (Conted.)

15. *Trypauchenichthys typus* Bleeker 32 (Kakdwip), 25 (Haldia).

II. Species collected only once from the study area

Name of species	Locality
1. <i>Muraenesox cinereus</i> (Forsskal)	32 (Kakdwip)
2. <i>Petroscirtes breviceps</i> (Valenciennes)	53 (Matla river)
3. <i>Petroscirtes variabilis</i> Cantor	6 (Bakkhali)
4. <i>Periophthalmus vulgaris</i> Eggert	19 (Falta)
5. <i>Periophthalmus weberi</i> Eggert	18 (Diamond Harbour)
6. <i>Taenioides anguillaris</i> (Linnaeus)	32 (Kakdwip)
7. <i>Taenioides eruptionis</i> (Bleeker)	68 (Raychock)
8. <i>Ctenotrypauchen microcephalus</i> (Bleeker)	53 (Matla river)

III. Species not available during present investigation

Name of species	Locality
1. <i>Anguilla bengalensis bengalensis</i> (Gray & Hardwicke)	67 (Hugli, Calcutta)
2. <i>Anguilla bicolor bicolor</i> McClelland	(Bengal)
3. <i>Periophthalmus koelreuteri</i> (Pallas)	21 (Mouth of River Hugli)
4. <i>Apocryptodon madurensis</i> (Bleeker)	28 (Jambu Island)
5. <i>Boleophthalmus dussumieri</i> (Valenciennes)	28 (Jambu Island)
6. <i>Brachyamblyopus multiradiatus</i> (Hardenberg)	21 (Mouth of River Hugli)
7. <i>Brachyamblyopus urolepis</i> (Bleeker)	
8. <i>Oxuderces dentatus</i> Eydoux & Souleyet	28 (Jambu Island)
9. <i>Taenioides buchaani</i> (Day)	21 (Sagar Island)
10. <i>Amblyotrypauchen arctocephalus</i> (Alcock)	21 (Sandhead)
11. <i>Trypauchenichthys sumartrensis</i> Hardenberg	21 (Sandhead)
12. <i>Muraenesox bagio</i> (Hamilton-Buchanan)	

given into belly and afterwards the sample are to place in 4% formalin for 2-3 days and permanent preservation is done in 70% alcohol.

List of Fishes from the intertidal zone of the Hugli-Matla estuary

Order A. ANGUILLIFORMES

Family I. ANGUILLIDAE

Genus 1. *Anguilla Shaw*

(1) *Anguilla bengalensis bengalensis* (Grey and Hardwicke)

(2) *Anguilla bicolor bicolor* McClelland

Family II. MURAENIDAE

Genus 2. *Siderea Kaup*

(3) *Siderea picta* (Ah1)

Genus 3. *Thyrsoidea Kaup*

(4) *Thyrsoidea macrura* (Bleeker)

Genus 4. *Uropterygius Ruppell*

(5) *Uropterygius tigrinus* (Lesson)

Family III. MURAENESOCIDAE

Genus 5. *Muraenesox McClelland*

(6) *Muraenesox bagio* (Hamilton-Buchanan)

(7) *Muraenesox cinereus* (Forsskal)

Family IV. OPHICHTHIDAE

Genus 6. *Neenchelys Bamber*

(8) *Neenchelys buitendijki* Weber and de-Beaufort

Genus 7. *Pisodonophis Kaup*

(9) *Pisodonophis boro* (Hamilton-Buchanan)

Order B. PERCIFORMES

Family V. BLENNIIDAE

Genus 8. *Petroscirtes* Ruppell

(10) *Petroscirtes breviceps* (Valenciennes)

(11) *Petroscirtes variabilis* Cantor

Family VI. GOBIIDAE

Sub-Family a. GOBIINAE

Genus 9. *Stigmatogobius* Bleeker

(12) *Stigmatogobius sadanundio* (Hamilton-Buchanan)

Sub-family b. PERIOPHTHALMINAE

Genus 10. *Periophthalmodon* Bleeker

(13) *Periophthalmodon schlosseri* (Pallas)

(14) *Periophthalmodon tredecemradiatus* (Hamilton-Buchanan)

Genus 11. *Periophthalmus* Bloch and Schneider

(15) *Periophthalmus chrysospilos* Bleeker

(16) *Periophthalmus koelreuteri* (Pallas)

(17) *Periophthalmus malaccensis* Eggert

(18) *Periophthalmus pearsi* Eggert

(19) *Periophthalmus vulgaris* Eggert

(20) *Periophthalmus weberi* Eggert

Sub-family c. APOCRYPTEINAE

Genus 12. *Apocryptes* Valenciennes

(21) *Apocryptes bato* (Hamilton-Buchanan)

Genus 13. *Apocryptodon* Bleeker

(22) *Apocryptodon madurensis* (Bleeker)

Genus 14. *Boleophthalmus* Valenciennes

- (23) *Boleophthalmus boddarti* (Pallas)
- (24) *Boleophthalmus dussumieri* Valenciennes
- (25) *Boleophthalmus sculptus* Gunther

Genus 15. *Oxuderces* Eydoux and Souleyet

- (26) *Oxuderces dentatus* Eydoux and Souleyet

Genus 16. *Parapocryptes* Bleeker

- (27) *Parapocryptes macrolepis* (Bleeker)
- (28) *Parapocryptes serperaster* (Richardson)

Genus 17. *Pseudapocryptes* Bleeker

- (29) *Pseudapocryptes borneensis* (Bleeker)
- (30) *Pseudapocryptes lanceolatus* (Bloch and Schneider)

Genus 18. *Scartelaos* Swainson

- (31) *Scartelaos histophorus* (Valenciennes)

Family VII. TAENIOIDIDAE

Sub-family d. TAENIOINAE

Genus 19. *Brachyamblyopus* Bleeker

- (32) *Brachyamblyopus multiradiatus* (Hardenberg)
- (33) *Brachyamblyopus urolepis* (Bleeker)

Genus 20. *Odontamblyopus*

- (34) *Odontamblyopus rubicundus* (Hamilton-Buchanan)

Genus 21. *Taenioides* Lacepede

- (35) *Taenioides anguillaris* (Linnaeus)
- (36) *Taenioides buchanani* (Day)
- (37) *Taenides cirratus* (Blyth)

(38) *Taenioides eruptionis* (Bleeker)

Sub-family e. TRYPACHENINAE

Genus 22. *Amblyotrypauchen* Hora(39) *Amblyotrypauchen arctocephalus* (Alcock)Genus 23. *Ctenotrypauchen* Steindachner(40) *Ctenotrypauchen microcephalus* (Bleeker)Genus 24. *Trypauchen* Valenciennes(41) *Trypauchen vagina* (Bloch and Schneider)Genus 25. *Trypauchenichthys* Bleeker(42) *Trypauchenichthys sumartrensis* Hardenberg(43) *Trypauchenichthys typus* Bleeker

Order A. ANGUILLIFORMES

Body elongate and cylindrical, usually naked or with minute embedded scales; no pelvic fins; pectoral fins some time absent; dorsal and anal fins often concealed by skin; no fin spines; gill opening usually much reduced; lateral line present.

Key to the families

- 1 Body with minute embedded scales; dorsal, anal and caudal fin well developed; pectoral fin present ANGUILLIDAE
Body naked (without scales). 2
2. Large canine teeth on vomer. 3
Large canine teeth on vomer absent. OPHICHTHIDAE
3. Pectoral fin well developed. MURAENESOCIDAE
Pectoral fin absent..... MURAENIDAE

Family I ANGUILLIDAE

Body snake like, with embedded scales. Dorsal, caudal and anal fin confluent. Pectoral fin well developed, eyes covered by skin. Gill openings vertical slits below the origin of pectoral fins.

Genus 1. *Anguilla* Shaw

1803. *Anguilla* Shaw, General Zoology, 4.

1984. *Anguilla* Talwar and Kacker, *Commercial Sea Fishes of India* : 216.

Body elongate, cylindrical, with embedded rudimentary scales. Head long. Eyes covered by skin. Gill openings are vertical slits. Dorsal caudal and anal fin confluent. Pectoral well developed. Jaws equal, villiform teeth on jaws and palate. Tongue free. Lateral line distinct.

Key to species

1. Dorsal fin originating nearly above anus; no edentulous groove in tooth bands.
..... *A. bicolor*

Dorsal fin originating about mid way between gill opening and anal fin; edentulous groove in tooth bands. *A. bengalensis*

(1) *Anguilla bengalensis bengalensis* (Gray and Hardwicke)

1834. *Muraena bengalensis* Gray and Hardwicke, *Illust. Indian Zool.* : 95, fig. 5.

1984. *Anguilla bengalensis bengalensis* : Talwar and Kacker, *Commercial sea fishes of India* : 216.

Material examined : 4 exs., Hugli river, Dr. J. Anderson; 3 exs., Calcutta, F. Day.

Diagnosis : Body snake like, with minute embedded scales. Mouth extending beyond the eyes. Teeth small, conical; edentulous groove in teeth band. Dorsal fin originating about midway between gill-openings and anal fin origin; Lateral line distinct. Dorsal side of the body brownish, belly yellowish. Fins yellowish mottled with brown.

Habit : Usually catadromous. It is not a common one found in fresh water, estuaries and sea. It prefers muddy habitat.

Remarks : It is a fresh water form. During breeding season they used to migrate towards sea. It is also found in hill area, Neilgherry hills, Madras.

Distribution : *India* : Fresh water and seas around India. *Outside India* : Pakistan; Bangladesh; Srilanka, Burma; Malay Archipelago ; Formosa ; Pacific islands.

(2) *Anguilla bicolor bicolor* McClelland

1845. *Anguilla bicolor* McClelland, *Calcutta Journ. Nat. Hist.*, 5 : 178.

1984. *Anguilla bicolor bicolor* : Talwar and Kacker, *Commercial Sea fishes of India* : 216.

Material examined : 1 ex., Bengal, F. Day.

Diagnosis : Snake-like body, with minute embedded scales. Head 6--8 in length. Mouth

slightly oblique, extends beyond the eyes. Snout rather broad. Teeth small, conical; no edentulous grooves in teeth bands. Dorsal fin originating nearly above anus. Colour dark olive superiorly, becoming yellowish beneath.

Habit : It is found in fresh water, estuaries and seas. They prefers muddy areas.

Remarks : It is a very rare form. At breeding time they used to move towards sea water.

Distribution : *India* : Marine and fresh water all over India; Andaman. *Outside India* : Srilanka ; Malay Archepelago.

Family II. MURAENIDAE

Key to Genera

- 1 Dorsal fin originating above anus or more posteriorly. *Uropterygius*
Dorsal fin originating above gill opening or forward on head. 2
2. Anus to tip of 1.5 to 2.0 times the body length. *Thyrsoidea*
Anus to tip of tail less than 1.5 times the body length. *Siderea*

Genus 2. *Siderea* Kaup

1856. *Siderea* Kaup, *Arch. Naturgesch*, **22** (1) : 58.

1984. *Siderea* : Talwar and Kacker, *Commercial Sea fishes of India* : 226.

Body snake like, robust and moderately compressed. Dorsal and anal fins within skin fold, confluent round tail. Pectoral fin absent, dorsal fin low, its origin slightly before gill-opening. Teeth mostly fang-like; two series of low conical teeth on vomer.

(3) *Siderea picta* (Ahl)

1789. *Muraena picta* Ahl, *De Muraena ophichthoin* : Thunberg, *Dissert.*, **3** : 6, Pl. 2, fig. 2.

1984. *Siderea picta* : Talwar and Kacker, *Commercial Sea Fishes of India* : 227.

Material examined : 1 ex., Narayangunge, 24-Parganas, 5. 4. 1987; 1 ex., Haldi river, Haldia; 13. 4. 1987; 1 ex., Geonkhali, Midnapore, 20. 4. 1987.

Diagnosis : Snake like body, snout-bluntly conical, depth of body 15-20 in total length, 2.2-2.4 in head length; head 2.7 to 3 in trunk, 7-8 in total length, vent about in middle of length. Anterior nostril tubes moderate; posterior nostril with low rim. Jaws more or less equal. Teeth conical, uniserial in jaws. Colour grayish or whitish with darker marks that vary with age, youngs

are yellow with single row of blotches on dorsal.

Habit : They are marine form. During low tide they are found to live under the soft mud.

Remarks : It is a rare form. In India so far the species is known from the marine zone, this for the first time reported from estuarine body. It is not common form.

Distribution : *India* : Seas of India. *Outside India* : East coast of Africa; Madagascar; Bourbon ; Malay-Archipelago.

Genus 3. *Thyrsoidea* Kaup

1856. *Thyrsoidea* Kaup, *Cat. Apodal Fish. Br. Mys.* : 73.

1984. *Thyrsoidea* : Talwar and Kacker, *Commercial Sea Fishes of India* : 227.

Body elongate, slightly compressed. Anus to tip of tail 1.5 to 2.0 times as long as rest of body. Eyes nearer to tip of snout than angle of mouth. Teeth fang-like, sharp and slender. Dorsal and anal fin confluent with caudal fin. Pectoral fin absent.

(4) *Thyrsoidea macrura* (Bleeker)

1854. *Muraena macrurus* Bleeker, *Nat. Tijds. Ned.-Indie*, 7 : 324.

1984. *Thyrsoidea macrura* : Talwar and Kacker, *Commercial Sea fishes of India* : 228.

Material examined : 4 exs., Gosaba, 17. 9. 1984; 6 exs. Jharkhali, 21. 1. 1987.

Diagnosis : Snake like body, depth of body about 40 times in total length; 3-4 in head length; Posterior nostril with low rim, anterior nostril short tubes. Teeth slender, frang-like. Pectoral fin absent. Dorsal and anal fin confluent with caudal fin. Colour : dark to olive brown above, lighter below, fin tinged with black.

Habit : It is marine form. They live in deep holes about 2-3 feet deep in the soft muddy bottom mid and lower intertidal zone.

Remarks : This is the largest known eel, attaining a length of 3.5 m. It is a very common form, though not collected from all the places, but observed in many areas of Sundarban. Poor people usually consume this fish.

Distribution : *India* : West Bengal. 24-Parganas. *Outside India* : Bangladesh; Srilanka; Java; and wide spread in the tropical Indo-West Pacific region.

Genus 4. *Uropterygius* Ruppell

1835. *Uropterygius* Ruppell, *Neue Wirbelth. Fische Rothen Meeres* : 83.

1984. *Uropterygius* : Talwar and Kacker, *Commercial Sea fishes of India* : 228.

Body elongate, slightly compressed. Dorsal and anal fins reduced to rudiments. Mouth extends far behind the eye. Teeth usual in several series, fang-like; teeth on vomer. Anterior nostril with tube; Posterior nostril above front of eye.

(5) *Uropterygius tigrinus* (Lesson)

1828. *Ichthyophis tigrinus* Lesson, *Mem. Soc. Hist. Nat. Paris*, 4 : 399.

1984. *Uropterygius tigrinus* : Talwar and Kacker, *Commercial Sea fishes of India* : 229.

Material examined : 2 exs., Roychock, 7. 12. 1983; 2 exs., Naryangunge, 5. 4. 1987; 1 ex., Kakdwip, 6. 4. 1987; 1 ex., Dingakhali near Sibgunge, 3. 1. 1989; 3 exs., Bandelchurh, Hugli, 8. 1. 1989; 1 ex., Shibgunge, 31. 3. 1989; 1 ex., Phuleswar, 5. 9. 1989.

Diagnosis : Snake like body, height 27-30 in total length; head 12-13.5 in total length. Eye 15 in head. Snout somewhat rounded 7 times in head. Anterior nostril in a conspicuous tube, longer than the posterior nostril. Gill opening smaller than eye. Body brown with irregular dark blotches or spots.

Habit : It is marine form dwelling in the soft mud in the intertidal areas.

Remarks : This species is so far known in India from marine zone. This is the first record from estuarine body. Present collection represent only small form.

Distribution : *India* : West Bengal : 24-Parganas, Howrah, Hugli, Midnapore.

Family III MURAENESOCIDAE

Snake like body. Mouth large, its gape extends beyond eye. Snout often markedly elongate; anterior nostril tubular, posterior nostril a simple opening in front of eye. Teeth prominent, dorsal and anal fin long, confluent with caudal fin. Pectoral fins developed. Pelvic fins absent. No scales.

Genus 5. *Muraenesox* McClelland

1843. *Muraenesox* McClelland, *Calcutta Jour. nat. Hist.*, 4 (15) : 408.

1984. *Muraenesox* : Talwar and Kacker, *Commercial Sea fishes of India* : 237.

Snake like body without scales, Mouth large, beyond eye. Teeth in jaws raptorial in several rows. Principal teeth on lower jaw. Vomerine teeth blade like. Pectoral fins well developed. Pelvic fins absent.

Key to species

- 1 Eye diameter about 3 times in snout length. Lateral line with 33-39 pores.*M. bagio*

Eye diameter 2-2.5 times in snout length. Lateral line with 40-47 pores.....*M. cinereus*

(6) *Muraenesox bagio* (Hamilton-Buchanan)

1822. *Muraenesox bagio* Hamilton-Buchanan, *Fishes of Ganges* : 364.

1984. *Muraenesox bagio* : Talwar and Kacker, *Commercial Sea fishes of India* : 238, fig. 100.

Material examined : Nil.

Diagnosis : Body elongate, robust fish without scales. Snout long; eye diameter about 3 times in snout length. Mouth large, its upper jaw extending well behind the eye. Teeth in jaws in 2 or 3 series. Lateral line with 33 to 39 pores. Dorsal fin origin in front of gill openings. Pectoral fins well developed. Head and body greyish colour.

Habit : Inhabits soft bottom down to about 100 meters in Gangetic delta.

Remarks : Any material neither collected during the present study nor available in National Zoological collection of the Z.S.I. The diagnostic character mentioned here is from the literature. It is a rare form.

Distribution : *India* : West Bengal, 24-Parganas. *Outside India* : Wide-spread in tropical Indo-West Pacific region.

(7) *Muraenesox cinereus* (Forsskal)

1775. *Muraena tala cinera* Forsskal, *Descript. Animal.* 22.

1984. *Muraenesox Cinereus* : Talwar and Kacker, *Commercial Sea fishes of India* : 239, fig. 101.

Material examined : 1 ex., Kakdwip, 9. 3. 1985.

Diagnosis : Body elongate, robust fish without scales. Snout short, depth 20 in head. Eye diameter 2 to 2.5 times in snout length. Mouth large, its upper jaw extending well beyond eyes. Teeth in jaw in 2-3 series. Dorsal origin slightly in front of gill openings. Pectoral 3.2 in head. Lateral line with 40-47 pores. Colour silvery becoming dull white below. Fins with black edged. Pectoral fin yellow or black.

Habit : They live inside the hole of soft bottom down to about 100 m. They also found in estuaries.

Remarks : It is very common form found in the Indian coast and widely used as food.

Distribution : India : West Bengal : 24-Parganas; Orissa; Coromandel coast; Cochin; Bombay. *Outside India* : Africa; Arabia; Pakistan; Srilanka; Burma; Malaya; Siam; Philippines; China; Korea; Japan; Australia; Melanesia; Polynesia.

Family IV OPHICHTHIDAE

Body snake like. Mouth large, its cleft usually beyond eye. Teeth variable. Nostrils widely separated; gill opening small. No spine in fin. Pectoral fin present or absent, pelvic fin absent. Scaleless forms.

Key to genera

1. Tail tip flexible, a fringe of fin present around the tip; pectoral fin present.
..... *Neechelys*
- Tail tip finless; pectoral fin absent. *Pisodonophis*

Genus 6. *Neechelys* Bamber

1915. *Neechelys* Bamber, *J. Linn. Soc. Lond. Zoology*, **31** : 479.

1984. *Neechelys* : Talwar and Kacker, *Commercial Sea fishes of India* : 244.

Body elongate, shorter than tail; Snout subconical. Gill openings mid lateral. Anterior nostril tubular; posterior nostril lateral. Pectoral fin present, longer than eye, caudal fin present.

(8) *Neechelys buitendijki* Weber and deBeaufort

1916. *Neechelys buitendijki* Weber and deBeaufort, *Fishes of Indio-Australian Archipelago* **3** : 268, fig. 117.

1984. *Neechelys buitendijki* : Talwar and Kacker, *Commercial Sea fishes of India* : 245, fig. 102.

Material examined : 3 exs., Kakdwip, 9. 3. 1985; 1 ex., Shibgunge, 31. 3. 1989.

Diagnosis : Body snake like; depth 19-21 in total length; 2. 4-2.6 in head length. Head 8 in total length. Pectoral fin moderately developed; 4-4.5 in length of head. Gill openings vertical, slightly shorter than eye. Body yellowish pink, with brown pigmented spots on dorsal surface of the body.

Habit : It lives inside the hole or soft muddy bed in mid tidal zone. They are also found inshore water from 5 to 20 m.

Remarks : This is small-sized specimen, though not common available in the lower part of this estuary.

Distribution : *India* : West Bengal : 24-Parganas, Howrah. *Outside India* : Java.

Genus 7. *Pisodonophis* Kaup

1956. *Pisodonophis* Kaup, *Arch. Naturges*, **22** (1) : 47.

1984. *Pisodonophis* : Talwar and Kacker, *Commercial Sea fishes of India* : 248.

Elongated body, snout moderately developed. Anterior nostril tubular, posterior before the eye. Teeth multiserial on jaws and vomer. Dorsal fin origin above or behind gill openings. Pectoral fin moderate. No fin on tip of tail.

(9) *Pisodonophis boro* (Hamilton-Buchanan)

1822. *Ophisurus boro* Hamilton-Buchanan, *Fishes of Ganges* : **20**, Pl. 5, fig. 5.

1984. *Pisodonophis boro* : Talwar and Kacker, *Commercial Sea fishes of India* : 249, fig. 103.

Material examined : 2 exs., Kakdwip, 9. 3. 1985; 1 ex., Sonakhali, 17. 1. 1987; 3 exs., Murigonga, 5. 4. 1987; 4 exs., Kakdwip, 6. 4. 1987; 4 exs., Sapt Mukhi river; 7. 4. 1987; 1 ex., Bakkhali Coast, 9. 4. 1987; 1 ex., Diamond Harbour, 10. 4. 1987; 1 ex., Haldia, 13. 4. 87; 1 ex., Dingakhali 31. 1. 89; 2 exs., Sibgunge, 31. 3. 1989. 2 exs., Phuleswar, 5. 4. 1989.

Diagnosis : Body elongate and cylindrical, its depth 30-36 in total length, 2.6 to 3.6 in head. Head Length 9-12 times in total length. Mouth large, its cleft extend behind eye. Lower jaw shorter. Dorsal fin considerable behind tip of pectoral fin. Body uniform brownish olive above, Pinkish or yellowish on side and belly.

Habit : They are semiaquatic and intertidal form found in abundance in the mud and in burrows between the tidal marks in the channels.

Remarks : It is found all the places in the lower stretches of Hugli-Matla estuary. It occurs in the marine and estuarine water.

Distribution : *India* : West Bengal : 24-Parganas; Midnapore, Howrah. *Outside India* : South Africa; Pakistan; Srilanka; Bangladesh; Burma; Siam; Malaya; Philippines; China; Formosa; Melanesia.

Order B. PERCIFORMES

Diagnosis : Most have two fins which may or may not be united at least basally. The ventrals have not more than 6 rays and are usually, although not always thoracic.

Key to families

1. Body naked, pelvic fins separated with a hidden spine. BLENNIIDAE
 Body scaled, pelvic fins united and no hidden spine. 2
2. Dorsal fin two numbers separated or connected at their bases. GOBIIDAE
 Dorsal fin one and very long. TAENIOIDIDAE

Family V BLENNIIDAE

Diagnosis : Body elongate, smooth and without scales. Dorsal fin long, consist of flexible spine and articulated rays. Pectoral present. Ventral jugular, well before pectorals, with a hidden spine and 2-4 rays. Teeth generally in a single series. Lateral line absent or much reduced.

Genus 7. *Petroscirtes* Ruppell

1828. *Petroscirtes* Ruppell, *Atlas. Reise Nordl. Afrika. Fische des roihen Meeres* : 110

1951. *Petroscirtes* : de-Beaufort and Chapman, *Indo-Aust. arch.* 9 : 355.

Diagnosis : Body elongate, without scales. Mouth small, Jaws with a single row of teeth with lateral canines. dorsal and anal fin long. Anal shorter than dorsal with 15-32 rays. Pectoral more or less rounded. Ventral jugular with two or three rays.

Key to species

1. Head 4.0 to 4.25 in the total length; a wide dark band from eye to caudal fin.
 *P. variabilis*
- Head 5.0 to 5.25 in the total length; black band along the head and side of the body.
 *P. breviceps*

(10) *Petroscirtes breviceps* Valenciennes (Fig. 1)

1836. *Petroscirtes breviceps* Valenciennes, *Hist. Nat. Poiss.*, 11 : 286.

1876. *Petroscirtes breviceps* : Day, *Fishes of India* : 328.

Material examined : 1 ex., Matla river. Nowbankichar (Mouth of Netidhopani), 30. 8. 1987, S. Barua.

Diagnosis : Body elongate. Head 4.25 in total length, depth 5.5 in total length. Eye diameter 3.6 in head. Large canine on either side of lower jaw. Dorsal with 30 rays, anal fin with 19 rays. Pectoral equal to the head behind the middle of the eye. Colour 5-6 black band along the head and side of the body; dorsal fin dotted with black spots; caudal yellowish. 5-6 round black blotch on both the side.

Habit : This fish dwells inside the hole of a rotten log laying in side the muddy bottom at low tidal zone.

Remarks : This is the first record of this species from the Hugli-Matla estuary.

Distribution : India : West Bengal : 24-Parganas.

(11) *Petroscirtes variabilis* Cantor (Fig. 2)

1850. *Petroscirtes variabilis* Cantor, *J. Asiat. Soc. Bengal*, 18 : 1182.

1951. *Petroscirtes variabilis* : de Beaufort and Chapman, *Fish. Indo-Aust. arch.*, 9 : 369.

Material examined : 2 exs., Bakkhali, 5. 3. 1985.

Diagnosis : Elongated body; depth 5.0 to 5.3 in total length. Head 3.7 to 3.8 in total length. Eye 3.0 to 3.3 in head. Mouth terminal. Dorsal fin with 28-31 rays; anal fin with 17-22 rays. Caudal fin slightly rounded. A broad black or bluish black band extend to eye to caudal. A row of light blotches along the bodies. The outer edge of dorsal fin is red; edge of anal fin is white and end of caudal fin is red in life condition.

Habit : It lives in the hole of rotten wood laying inside the mud at low tidal zone.

Remarks : It is a rare form. It is a new record from the Hoogly-Matla estuary. So far no blennids is recorded from the east coast of India.

Distribution : India : West Bengal : 24-Parganas; Kerala ; Calicut; Nicobar. *Outside India* : Zanzibar; Mozambique; Scycheles; Percian Gulf; Singapore; Penang; Borneo; Philippines.

Family VI. GOBIIDAE

Diagnosis : Body elongate, ventral fin united, basal membrane present or absent. Two dorsal fins, separate or connected with their bases, Body with ctenoid or cycloid scales.

Key to Subfamilies

1. Teeth of lower jaw arranged in more than one row..... GOBIINAE
- Teeth of lower jaw arranged in one row..... 2
2. Second dorsal fin elongated, eye not prominent..... APOCRYPTEINAE

Second dorsal fin not elongated, eye prominent..... PERIOPHTHALMINAE

Subfamily a. GOBIINAE

Diagnosis : Body oblong to elongate. Head naked, between and before the eye. Teeth simple, teeth in upper jaw in one to several rows, in lower jaw in two to several rows. The second dorsal fin is longer than first dorsal, ventral fins totally or nearly united.

Genus 9. *Stigmatogobius* Bleeker

1874. *Stigmatogobius* Bleeker, *Arch. neerl. Sci.*, 9 : 323.

1953. *Stigmatogobius* : Koumans, *Fish Indo-Aust. Arch.*, 10 : 108, Fig. 24.

Diagnosis : Body elongate, head scaled behind the eye. Snout blunt, shorter than eye. Anterior nostril in a short tube. Teeth in both jaws in several rows. Dorsal fin separate. Caudal fin obtuse.

(12) *Stigmatogobius sadanundio* (Hamilton-Buchanan)

1822. *Gobius sadanundio* Hamilton-Buchanan, *Fish. Ganges* : 52, 366.

1977. *Stigmatogobius sadanundio* : Visweswara Rao, *Matsya* (2) : 60.

Material examined : 1 ex., Frasergunge, 11. 9. 1974, T.K. Chatterjee; 5 exs., Sagar Island, 5. 2. 1981.

Diagnosis : Body elongate, height 3.7-4 in head, head 5 in length. Eye 3-4 in head; snout shorter than eye. Teeth in several rows. Head scaled above or behind the eye. First dorsal with 6 rays, second dorsal fin with 8 rays. Anal fin with 9 rays. Pectoral fin about as long as head. Caudal fin a little longer than head. Body with number of black spots in one or a few lines, caudal fin with small black spots.

Habit : Abundant in carb holes along the banks of pools and narrow channels. During high tide they live under water for most of the time, but they are often exposed to areial condition during low tide.

Remarks : It is the only inter-tidal and semiaquatic form of the family Gobiidae. It is not very common one in this area.

Distribution : *India* : West Bengal : Calcutta, 24-Parganas, Midnapore; Tamilnadu. *Outside India* : Srilanka, Bangladesh, Thailand, Malay peninsula, Fiji Island, Borneo, Java, Siam.

Sub-Family b. PERIOPHTHALMINAE

Diagnosis : Body elongate, eyes prominent, lower eyelid well developed. Teeth in upper jaw 1-2 rows, in lower jaw one row. Pectoral fin with a muscular base, used as locomotory organ on land. Ventral fins totally united.

Key to Genus

1. Teeth of upper jaw in two rows. *Periophthalmodon*
 Teeth of upper jaw in single row. *Periophthalmus*

Genus 10. *Periophthalmodon* Bleeker

1874. *Periophthalmodon* Bleeker, *Arch. neerl. Sci.*, **9** : 326.

1953. *Periophthalmodon* : Koumans, *Fish. Indo-Aust. arch.*, **10** : 216, fig. 51.

Diagnosis : Body elongate, covered with cycloid scales. Eyes prominent above the dorsal profile. Lower eye-lid well developed. Snout blunt. Teeth in upper jaw in two rows. Ventral fin nearly to totally united. Pectoral fin with a muscular base.

Key to Species

1. Ventral fin totally united ; basal membrane well developed.....*P. schlosseri*
 Ventral fin nearly separated, only a narrow membrane at the base; basal membrane absent.*P. tredecemradiatus*

(13) *Periophthalmodon schlosseri* (Pallas)

1770. *Gobius schlosseri* Pallas, *Spicilegia zool.* **8** : 3, Pl. 1, figs. 3-4.

1972. *Periophthalmodon schlosseri* : Menon *et al.*, *Sci. Cult.* **38** : 342.

Material examined : 1 ex., Basirhat, 6. 9. 1984; 1 ex., Haldia, 17. 3. 1985; 2 exs., Falta, 25. 3. 1985; 3 exs., sonakhali, 17. 1. 1987; 3 exs., Diamond-harbour, 9. 4. 1987; 1 ex., Gadiyara, 22. 4. 1987; 4 ex. ; Jharkhali, 5.1.1989 1 ex., Shibgunge, 31.3.1989, 1 ex., 2.4.1989 ; Shibgunge, 2. 4. 1989; 5 exs., Iswesripur, 7. 4. 1989.

Diagnosis : Body elongate, depth 6 in total length. Head 4 in total length. Teeth in upper jaw in two rows. First dorsal fin convex not higher than the body. Second dorsal and anal fin with 12-15 rays. Ventral fin totally united. Pectoral fin with a muscular base. Colour dark brown, lighter below. Blue spots or shiny spots on head and body, ventral and anal fin yellowish.

Habit : It is terrestrial form. They can survive without water. They live in the hole of high tide level.

Remarks : Muscular fin base used as locomotory organ in the dry land. The species is so far

known from West Bengal only and found in abundance in the lower and middle estuarine region.

Distribution : India : West Bengal : 24-Parganas, Howrah, Midnapore. Outside India : Singapore; Sumatra; Java; Borneo; Siam; Philippines; Melanesia; Queensland; Fiji.

(14) *Periophthalmodon tredecemradiatus* (Hamilton-Buchanan)

1822. *Gobius tredecemradiatus* Hamilton-Buchanan, *Fish. Ganges* : 48.

1953. *Periophthalmodon tredecemradiatus* : Koumans, *Fish. Indo-Aust. arch.*, 10 : 218.

Material examined : 1 ex., Basirhat, 15. 9. 1984 1 ex., Bakkhali, 7. 3. 1985; 3 exs., Kakdwip, 6. 4. 1987; 1 ex., Hugli and Haldi river junction, 14. 4. 1987.

Diagnosis : Body elongate with cycloid scales, depth 6-7.5 in total length, head 4.3 to 5 in total length. Teeth small, in two rows in upper jaw. Eyes prominent close together. Ventral fin nearly separate, basal membrane absent. Colour dark brown, lighter below.

Habit : It is terrestrial form. They can survive without water. They live in the hole of high tide level.

Remarks : Muscular pectoral fin base used as locomotory organ. They collect food material at the time of low tide.

Distribution : India : West Bengal : 24-Parganas; Andamans. Outside India : Bangladesh; Burma; Thailand; Sumatra.

Genus 11. *Periophthalmus* Bloch and Schneider

1801. *Periophthalmus* Bloch and Schneider, *Syst. Ichth.* 63.

1953. *Periophthalmus* : Koumans, *Fish. Indo-Aust. arch.*, 10 : 200. fig 50.

Diagnosis : Body elongate, covered with cycloid scales. Eyes prominent, Snout blunt, as long as eye. Ventral fins united with their base. Pectoral fin with a muscular base.

Key to species

- 1 D. I and D. II in male more or less contiguous, in female D. I reduced to 4-6 rays. Separated from D. II. *P. weberi*
- D. I and D. II not contiguous and D. I not reduced in females. 2
2. Basal membrane moderately well developed. 3

- Basal membrane moderately weak or very weak. 4
3. Ventral fins totally united not emarginate. *P. chrysozilos*
 Ventral fins united, totally or about to half way the fin, emarginate. 5
4. D. I convex, back margin not-parallel to front margin. *P. koelreuteri*
 D. I. higher, strongly convex, the foremost rays are longest. *P. vulgaris*
5. Pectoral fin as long as head. *P. malaccensis*
 Pectoral fin less than head. *P. pearsi*

(15) *Periophthalmus chrysozilos* Bleeker

1853. *Periophthalmus chrysozilos* Bleeker, *Nat. Tijdschr. Ned. Indie.*, **3** : 728.

1953. *Periophthalmus chrysozilos* : Koumans, *Fish. Indo-Aust. arch.* **10** : 202, fig. 50.

Material examined : 1 ex., Basirhat, 15. 9. 1984; 1 ex., Basanti, 19. 6. 1986; 1 ex., Kakdwip, 6. 4. 1987; 9 exs., Diamond Harbour, 10. 4. 1987; 4 exs., Dingakhali, 3. 1. 1989; 2 exs., Saptamukhi river, 7. 4. 1989; 8 exs., Chandannagar, 9. 4. 1989.

Diagnosis : Body elongate, depth 6 in length, head truncate, 3.7. to 4 in length. Eyes close together, 4.3-5 in head. Teeth in upper jaw in one row. Pectoral fin with muscular fin base about as long as head. Ventral fin totally united. Caudal fin rounded, about as long as head. Colour yellowish green to brownish above, smokey white below. Head and body with orange dots.

Habit : It is a terrestrial form and can survive without water for pretty long period. They live above the inter-tidal zone of the rivers and channels along the Hugli-Matla belt.

Remarks : Muscular pectoral fin base used as locomotory organ. They collect food material during low tide among mangrove roots and aquatic plants detecting the prey mainly by sight. During high tide many of individual were seen on twigs of plants.

Distribution : India : West Bengal : 24-Parganas, Howrah ; Hugli ; Andhra Pradesh.
Outside India : Malay peninsula; Singapore; Sumatra; Java.

(16) *Periophthalmus koelreuteri* (Pallas)

1770. *Gobius koelreuteri* Pallas, *Spicilegia zool.*, **8** : 8, Pl.2, figs. 1-3.

1977. *Periophthalmus koelreuteri* : Careasson *Field guide coral Reef Fish Indian W. Pacific Ocean* : 240.

Material examined : 1 ex., mouth of river Hugli, 1911, S.W. Kemp.

Diagnosis : Body elongate, depth 6-7.3 in total length. Head truncate, 4.5 to 5 in total length. Teeth in upper jaw in one row. Dorsal fin separate. Ventral fin only united at their base by a narrow membrane. Pectoral fin with muscular base. Colour blackish brown, lighter below. Irregular transverse band. Second dorsal fin with broad white margin, anal fin white.

Habit : It is also a terrestrial form and can survive without water for a pretty long period. They live above the inter-tidal zone of the rivers and channels along the Hugli-Matla belt.

Remarks : It is very rare species. No specimen was found during the course of study. Muscular pectoral fin base used as locomotory organ. They collect food material during low tide.

Distribution : *India* : West Bengal : 24-Parganas; Andamans and Nicobar Island. *Outside India* : Madagascar; Burma; Sumatra; Java; New Guinea; Fiji Island; Australia.

(17) *Periophthalmus malaccensis* Eggert (Fig. 3)

1935. *Periophthalmus malaccensis* Eggert. *Zool. Jahrb. Syst.* **67** : (1/2) : 62, figs. 3-4.

1953. *Periophthalmus malaccensis* : Koumans, *Fish. Indo-Aust. arch.* **10** : 205.

Material examined : 1 ex., Gosaba (tiger project jetty), 18. 9. 1984; 8 exs. Sarisapara (Chandannagar), 9. 4. 1989.

Diagnosis : Body elongate, depth 7.0 in total length, head 4.5 in total length. Teeth in upper jaw in one row. Pectoral fin with muscular base, as long as head. Ventral fins united by a narrow membrane. Colour gray with dark irregular transverse stripes, belly lighter. Dorsal fin brown. Ventral fin white, anal fin light gray, caudal fin white with dark spots.

Habit : They are terrestrial form and can survive without water for a pretty long period. They live above the inter-tidal zone of the river and channels along the Hugli-Matla belt.

Remarks : It is recorded for the first time from India. The muscular pectoral fin base used as locomotory organ during low tide. They collect food material during low tide among mangroves and aquatic plants.

Distribution : *India* : West Bengal : 24-Parganas, Hugly. *Outside India* : West coast of Malay peninsula.

(18) *Periophthalmus pearsi* Eggart

1835. *Periophthalmus pearsi* Eggart, *Zool. Jb. Syst.*, **67** : 57; Pl.3, fig. 10.

1972. *Periophthalmus pearsi* : Menon, *et al.*, *Sci. Cult.*, **38** : 342.

Material examined : 3 exs., Jharkhali, 22. 4. 1984; 4 exs., Bakkhalikhal, 4. 3. 1987, 2 exs., Bakkhali, 7. 3. 1987; 2 exs., Gadiyara, 4. 1. 1989; 1 ex., Gadiyara, 22. 4. 1989.

Diagnosis : Body elongate, snout slightly longer than or as long as eye. Teeth in upper jaw in one row. First dorsal with 20-22 rays, anal fin with 12-13 rays. Pectoral rounded, ventral fin united. Scales cycloid. Colour brownish, lighter below. Head with irregular dark spots.

Habit : They are common terrestrial form. They are abundant on the muddy banks between tidal marks in the channels along Hugli-Matla estuary.

Remarks : During low tide, the mud-skippers were found to hunt for food from mangrove roots and aquatic plants. The strong pectoral with muscular base are used as locomotory organ during low tide. So far this species known from West Bengal only.

Distribution : *India* : West Bengal : 24-Parganas; Midnapur. *Outside India* : Bangladesh, Burma.

(19) *Periophthalmus vulgaris* Eggert (Fig. 4)

1852. *Periophthalmus argentilineatus* Bleeker, *Nat. Tijdschr. Ned. Indie*, **3** : 276 (Not of C. V.)

1935. *Periophthalmus vulgaris* : Eggert, *Zool. Jahrb. Syst.* **67** (1/2), : 80 Pl. 6 figs. 25-26, Pl. 7 figs. 27-30.

1953. *Periophthalmus vulgaris* : Koumans, *Fish. Indo-Aust. arch.* 210.

Material examined : 1 ex., Falta near Kella, 25. 3. 1985.

Diagnosis : Body elongate, depth 6.5 in total length, head 5 in total length. Teeth in upper jaw in one row. Dorsal fin separate with 26 rays anal fin with 12 rays. Caudal fin rounded. Colour light brown to blackish brown, light below, transverse stripes on body. First dorsal fin with broad white margin.

Habit : They are found on the muddy banks in between tidal marks in the channels along the Hugli estuary. They are terrestrial form.

Remarks : It is the first record from the Hugli-Matla estuary as well as West Bengal. It appears to be a rare form.

Distribution : *India* : West Bengal : 24-Parganas : Andhra Pradesh; Andamans. *Outside India* : Burma; Siam; Sumatra; Java; Australia.

(20) *Periophthalmus weberi* Eggert

1935. *Periophthalmus weberi* Eggert, *Zool. Jahrb. Syst.* **67** (1/2) : 55, Pl.2. figs. 6-7.

1976. *Periophthalmus weberi* : Chatterjee and Siddiqi, *Matsya* (1) : 82.

Material examined : 1 ex., Diamond Harbour, 10. 4. 1987.

Diagnosis : Body elongate, depth 5.5 in length. Head 3.75 in length. Teeth in one row in

upper jaw, anteriorly caninoid. Dorsal fin in male more or less contiguous, in female dorsal fin separate. Pectoral fin with muscular fin base. Ventral fin united at their base, colour gray brown to black brown, ventral part lighter. At the back black strip or blotches are present. Pectoral fin with black transverse stripe on base. Caudal fin dark.

Habit : It is terrestrial form and can survive without water for pretty long period. They live above the intertidal zone of the river and channels along the Hugli-Matla belt.

Remarks : This species is known from West Bengal only. It appears to a rare species. Here I find female specimen possesses 7 fin rays in the 1st dorsal but Koumans (1953) has mentioned fin rays of 1st dorsal 6 in number.

Distribution : India : West Bengal : 24-Parganas. *Outside India* : New Guinea.

Subfamily C. APOCRYPTEINAE

Diagnosis : Body very elongate, covered with cycloid scales. Teeth in upper jaw in one row. Second dorsal fin very elongated. Ventral fin totally united.

Key to Genus

- 1 Free lower eyelid present. 2
Free lower eyelid absent..... 3
2. Mandibular teeth obliquely notched; scales small; no barbel on head *Boleophthalmus*
Mandibular teeth pointed; scales minute to rudimentary; lower side of head with barbels. *Scartelaos*
3. Teeth in lower jaw truncate or bilobate..... 4
Teeth in lower jaw pointed. 6
4. Front teeth in upper jaw not caninoid; scales in longitudinal series ± 100 *Apocryptes*
Front teeth in upper jaw caninoid; scales in longitudinal series 40-90. 5
5. Lateral body with indistinct blotches; second dorsal without blotches.
..... *Apocryptodon*
Lateral body without blotches; second dorsal with a brownish blotch at its posterior

- extremity..... *Oxyderces*
6. Scales in longitudinal series ± 200 *Pseudapocryptes*
- Scales in longitudinal series ± 80 *Parapocryptes*

Genus 12. *Apocryptes* Valenciennes

1837. *Apocryptes* Valenciennes, *Hist. Nat, Poiss.*, **12** : 142.

Diagnosis : Body elongate, covered with cycloid scales. Teeth in upper jaw in one row. A pair of canines behind symphysis. Ventral fins united, dorsal fin with 25-26 rays. Anal with 21-23 rays. Caudal long, pointed, chin and snout without barbels.

(21) *Apocryptes bato* (Hamilton-Buchanan)

1822. *Gobius bato* Hamilton-Buchanan, *Fishes of Ganges* : 40, 365; Pl.37, fig. 10.

1972. *Apocryptes bato* : Menon *et al.*, *Sci. Cult.* **38** : 342.

Material examined : 1 ex. Gconkhali, 22. 3. 1985; 6 exs., Falta, 24. 3. 1985; 1 ex., Diamond Harbour; 9. 4. 1987; 3 exs., Diamond Harbour, 10. 4. 1987.

Diagnosis : Body elongate, snout longer than eye. Mouth sub-horizontal. Anterior margin of tongue rounded. Teeth in jaws in one row. Canines in lower jaw. First dorsal with 5 spine, second dorsal with 21-22 rays, anal fin 21-22 rays. Pectoral fin pointed. Ventral fin united. Colour brownish white with 10-12 indistinct brownish oblique bands. Fins are white with brown dots.

Habit : Intertidal forms which are materially affected by tides. They generally live in a burrow between tide marks, some in crab holes along the banks of pools and narrow channels and some in spring tide pools.

Remarks : This is common species. Usually found associated with *Odontamblyopus rubicundus* on the muddy slopes of the estuarine creeks. It lives in deep burrows which contains water even during ebb tides. This species cannot withstand draught condition for a long period.

Distribution : *India* : West Bengal : Calcutta, 24-Parganas, Hugli, Nadia. *Outside India* : Bangladesh ; Burma

Genus 13. *Apocryptodon* Bleeker

1874. *Apocryptodon* Bleeker, *Arch. neerl. Sci.*, **9** : 327.

1953. *Apocryptodon* Koumans, *Fish. Indo-Aust. arch.*, **10** : 253.

Diagnosis : Body elongate, covered with deciduous cycloid scales. Teeth in both jaws in one

row. Dorsal fin close together, first dorsal with 6 rays, 2nd dorsal with 23 to 27 rays. Anal fin with 22-27 rays. Ventral fin united, oblong, caudal fin pointed.

(22) *Apocryptodon madurensis* (Bleeker)

1849. *Apocryptes madurensis* Bleeker *Verh. batav. genoot.*, **22** : 35.

1953. *Apocryptodon madurensis* : Koumans, *Fish. Indo-Aust. arch.*, **10** : 254, fig. 63.

Material examined : Nil.

Diagnosis : Body elongate, covered with cycloid scales, height 5.5-6.5 in length, head 4 in length. Eye 6 in head, interorbital half of the eye diameter. Snout as long as eye. Lateral line scales 50-55. Dorsal with 29-30 rays. Anal with 23 rays. Caudal fin pointed a little longer than head. Colour grayish, laterally with 5 indistinct red blotches. Head with numerous black spots. Anal fin dark.

Habit : They are semiaquatic intertidal form. It lives in deep burrows which contain water even during ebb tides. This species cannot withstand draught conditions for a long period.

Remarks : This is very rare form in West Bengal. The author is unable to collect any specimen during the present survey work. The species is listed here as per Koumans (1941 : 278) collection which is at present not traceable.

Distribution : *India* : West Bengal : 24-Parganas; Andhra Pradesh, Tamilnadu. *Outside India* : Thailand; Philippines; north to Japan.

Genus 14. *Boleophthalmus* Valenciennes

1837. *Boleophthalmus* Valenciennes, *Hist. nat. Poiss.* **12** : 198.

1953. *Boleophthalmus* : Koumans, *Fish. Indo-Aust. arch.* **10** : 257.

Diagnosis : Body elongate, covered with 60-100 cycloid scales, eyes close together, movable to above the dorsal profile of head. Lower eyelid well developed. Snout blunt as long as eye. Teeth in both jaws in single row. No barbel on head, ventral fin united. Pectoral fin base muscular.

Key to Species

- 1 Lateral body with dark spots or oblique bands; first dorsal without blue spots.
 *B. sculptus*
- Lateral body with or without dark spots or oblique band; first dorsal greyish with blue or

black spots.2

2. Lateral body with dark spots or oblique band; first dorsal greyish with blue spots.
..... *B. boddarti*

Lateral body without dark spots or bands; first dorsal purplish with black spots.
..... *B. dussumieri*

(23) *Boleophthalmus boddarti* (Pallas)

1770. *Gobius boddarti* Pallas, *Spicilegia*, 8 : 11, Pl.1, figs. 4-5.

1977. *Boleophthalmus boddarti* : Rama Rao, Chakrapany and Chatterjee, *Indian J. Zool.* 16 (3) : 237.

Material examined : 1 ex., Pergumti, 9. 9. 1984; 10 exs., Kakdwip, 9. 3. 1985; 1 ex., Sonakhali, 17. 1. 1987; 19 exs., Basanti, 21.1.1987 ; 2 exs., Sonakhali, 21.1.1987 ; 1 ex., Kakdwip, 6. 4. 1987; 1 ex., Diamond Harbour, 10. 4. 1987; 1 ex., Sibgunge, 31. 3. 1989.

Diagnosis : Body elongate, height 6-7 in total length, head 5-5.3 in total length, eye close together, 6 in head, snout obtuse, not longer than eye. Teeth in upper jaw in front 4-6 canines. First dorsal 7 rays, second dorsal fin with 25-27 rays. Colour darkishgreen with 6-7 dark spots or oblique bands. Head with blue or brown spots. First dorsal fin with blue spots.

Habit : Found in abundance in shallow burrows on the muddy banks between tidal marks in channel and in regions near the mangroves bush where the mud does not dry out, even during long exposed to sunlight.

Remarks : This species was collected in such community tubes, in association with polychaete worm and red corals. *Boleophthalmus boddarti* is apparently more terrestrial in habit than other semiaquatic gobiids.

Distribution : *India* : All seas and estuaries of India. *Outside India* : Thailand; Malaya; Singapore; Sumatra; Java; Borneo; China, New Guinea.

(24) *Boleophthalmus dussumieri* Valenciennes

1837. *Boleophthalmus dussumieri* Valenciennes, *Hist. nat. Poiss.* 22 : 207, Pl.354.

1941. *Boleophthalmus dussumieri* : Koumans, *Mem. Indian Mus.*, 13 (3) : 282.

Material examined : 2 exs. Jambu Island, 9. 7. 1974; T. K. Chatterjee.

Diagnosis : Body elongated, head subcylindrical, snout longer than eye. Mouth slightly oblique, Gill opening a narrow slit. Teeth in both jaws, uniserial, a curved canine on each side of symphysis. Pectoral fin pointed. Ventral fin united, caudal fin pointed. Colour grayish violet. First dorsal with small black spots. Second dorsal lighter with 2 longitudinal rows of oblong white spots. Pelvic and anal yellowish. Caudal brownish.

Habit : They live a shallow burrows on the muddy banks between tidal marks in the channel and in region near the mangroves bush where the mud does not dry out even during the long exposure to sunlight.

Remarks : They are though semi-aquatic, the species is apparently more terrestrial in habit than any other genus of semiaquatic gobiis. It is one of the rare form in this estuarine belt.

Distribution : *India* : West Bengal : 24-Parganas; Bombay; Gujarat. *Outside India* : Iraq; Baluchistan; Pakistan.

(25) *Boleophthalmus sculptus* Gunther (Fig. 5)

1861. *Boleophthalmus sculptus* Gunther, *Cat. Fishes.* 3 : 104.

1953. *Boleophthalmus sculptus* : Koumans, *Fish. Indo-Aust. arch.*, 10 : 258.

Material examined : 2 exs., Gosaba, 18. 9. 1984; 1 ex., Kakdwip, 10. 3. 1985.

Diagnosis : Body elongate, covered with cycloid scales. Depth 6.5 in total length. Head 4.5 in total length. Eye 4.5 in head, close together, snout as long as eye. Six canines in front of upper jaw. Dorsal 31 rays, anal fin with 24 rays. Pectoral fin short, caudal fin rhomboid. Colour body greenish olive yellow on belly; six rather distinct darker bands. Anterior dorsal greyish, other fins reddish.

Habit : They live in shallow burrows on the muddy banks between tidal marks in the channels and the region near the bush mangroves where the mud does not dry out, even during long exposure to sunlight.

Remarks : This species appears to be a rare form. It is a new record from the Hugli-Matla estuary as well as from east coast of India.

Distribution : *India* : West Bengal : 24-Parganas; Bombay. *Outside India* : Sumatra.

Genus 15. *Oxuderces* Eydoux and Souleyet

1842. *Oxuderces*: Eydoux and Souleyet, *Zoologie*, 1 (2) : 181.

Diagnosis : Body elongate, covered with cycloid scales. Head scaled above the eyes. Mouth almost horizontal. Teeth is uniserial in both jaws. Upper jaw with 1-2 canine on each side. Dorsal fin continuous, with 31-33 fin rays. Ventral fin united, anal fin with 24-27 fin rays. Caudal fin lanceolate, chin and snout without barbels.

(26) *Oxuderces dentatus* Eydoux and Souleyet

1842. *Oxuderces dentatus* Eydoux and Souleyet, *Zoologie*, 1 (2) : 182; P1.8, fig. 2.

1978. *Oxuderces dentatus* : Spinger, *Simthsonian contr. zool.*, (270) : 4-8, figs. 1-4.

Material examined : 2 exs., Jambu Island near Frasersgunge, 7. 9. 1974, T. K. Chatterjee.

Diagnosis : Body elongate, snout much longer than eye. Mouth wide, nearly horizontal; posterior end of maxillary reaching far beyond eye. Teeth in both jaws in single row. Dorsal fin continuous, with 33 rays, anal with 26 rays, ventral fin united, pectoral fin pointed, colour light violet, fins are yellowish, first dorsal somewhat darker, caudal deep brown.

Habit : They are semiaquatic intertidal forms live in burrows between tide marks and materially affected by tides. Some live in carb holes along the bank of pools and narrow channels and others in spring tide pools.

Remarks : The species appears to be rare form. No specimen was available during present survey work.

Distribution : *India* : West Bengal : 24-Parganas; Madras. *Outside India* : Thailand; Indonesia; China; Macao.

Genus 16. *Parapocryptes* Bleeker

1874. *Parapocryptes* Bleeker, *Arch. neerl. Sci.*, **9** : 327.

1953. *Parapocryptes* : Koumans, *Fish. Indo-Aust. arch.*, **10** : 250.

Diagnosis : Body very elongate, with about 80 cycloid scales. Snout as long as eye. Nostril not tribular, Mouth little oblique. Teeth in both jaws in one row. Dorsal fin close together with 26-36 fin rays. Ventral fin united, oblong, caudal fin pointed.

Key to Species

1. Side of body with large brownish blotches. *P. macrolepis*
- Side of body with irregular bands. *P. serperaster*

(27) *Parapocryptes macrolepis* (Bleeker)

1851. *Apocryptes macrolepis* Bleeker, *Nat. Tijdschr. Ned. Indie*, **2** : 66.

1953. *Parapocryptes macrolepis* : Koumans, *Fish. Indo-Aust. arch.*, **10** : 251.

Material examined : 2 exs., Basirhat, 6. 9. 1984; 2 exs., Gosaba, 18. 9. 1984.

Diagnosis : Body very elongate, height 6.5-7 in length, head 5 in length. Eyes 5 in head. In upper jaw anteriorly 6-8 caninoid teeth. Pectoral and ventral fin a little shorter than head. Caudal

fin lanceolate. Colour green above, silvery to yellowish below. Back and side with smoky reddish blotches.

Habit : The are semiaquatic intertidal forms live in burrows between tide marks and affected by tides. Some live in crab holes along the bank of pools and narrow channels and others in spring tide pools.

Remarks : It is a new record from the Hugli-Matla estuary as well as east of Indian main land, previously it was reported from the Andamans.

Distribution : *India* : West Bengal : 24-Parganas; Andamans. *Outside India* : Sri Lanka; Singapore; Java; Borneo.

(28) *Parapocryptes serperaster* (Richardson)

1846. *Apocryptes serperaster* Richardson, *Rep. Ichth. China. Japan* : 206.

1945. *Parapocryptes serperaster* : Smith, *Bull. U.S. natn. Mus.*, (188) : 561.

Material examined : 1 ex., Frasergunj, 5. 9. 1974, T. K. Chatterjee; 1 ex., Sagar Island, 1977, A. Khud Buksh.

Diagnosis : Body elongate, head subcylindrical, snout longer than eye. Teeth in each jaws uniserial, front teeth in upper jaw enlarged. 2-4 symphysial canines teeth in lower jaw. First dorsal fin lower than body, middle fin rays longest. Ventral fin united, caudal lanceolate. Colour greyish above, whitish below. Five to six irregular bands descant from back half way the sides.

Habit : They are semiaquatic intertidal forms live in burrows between tide marks and affected by tides. Some live in crab holes along the bank of pools and narrow channels and others in springs tide pools.

Remarks : This species appears to be a rare form. No collection was available during the present survey.

Distribution : *India* : West Bengal : 24-Parganas; Andhra Pradesh, Tamilnadu. *Outside India* : Burma; Thailand; China.

Genus 17. *Pseudapocryptes* Bleeker

1874. *Pseudapocryptes* Bleeker, *Arch. neerl. Sci.* 9 : 328.

1953. *Pseudapocryptes* : Koumans, *Fish. Indo-Aust.*, 10 : 241.

Diagnosis : Body very elongate, covered with very small cycloid scales. Eyes small, snout about to eye diameter. Teeth in both jaws in one row. Dorsal fin nearly continuous. First dorsal fin with 5 rays, second dorsal with 28-30 rays. Ventral fin united, caudal fin long, pointed.

Key to Species

1. Dorsal fins separate, the membrane of last ray of first dorsal fin ends far before insertion of the second dorsal fin. A.I.26-27; eye 4-5 in head. *P. borneensis*

Dorsal fin nearly continuous, the membrane of last ray of first dorsal fin scarcely united with second dorsal fin. A.I.29; eye 6-7 in head. *P. lanceolatus*

(29) *Pseudapocryptes borneensis* (Bleeker) (Fig. 6)

1855. *Apocryptes borneensis* Bleeker, *Nat. Tijdschr. Ned. Indie*, **9** : 421

1953. *Pseudapocryptes borneensis* : Koumans, *Fish. Indo-Aust. arch.* **10** : 247

Material examined : 3 exs., Pergumti, 9. 9. 1984; 1 ex., Purandar, Sonakhali, 17. 1. 1987; 3 exs., Hugli and Haldi river junction, 13. 4. 1987.

Diagnosis : Body very elongate, height 10-12 in total length. Head 6.5-7 in total length. Eye 4-5 in head. Dorsal fin separate, 33-38 in number. Anal fin with 26-27 rays. Pectoral fin rounded little shorter than head. Caudal fin pointed much longer than head. Colour greenish violet. Pearl colour below, Posteriorly angular transverse bands.

Habit : They are semi-aquatic form, found in spring-tide pools dry up between the spring tide or for longer periods the fish retires to depth of about 1.5 meters and the burrow may straight or somewhat oblique or narrow deep one.

Remarks : It is the first record from India. Previously it is known only from Borneo.

Distribution : *India* : West Bengal : 24-Parganas. *Outside India* : Borneo.

(30) *Pseudapocryptes lanceolatus* (Bloch and Schneider)

1801. *Eleotris lanceolatus* Bloch and Schneider, *Syst. Ichth.* 1801, p. 67, pl. 15

1977. *Pseudapocryptes lanceolatus* : Visweswara Rao, *Matsya* (2) : 60.

Material examined : 2 exs., Kakdwip, 9. 3. 1985; 1 exs., Basanti, 19. 6. 1986; 6 exs., Jharkhali, 25. 6. 1986.

Diagnosis : Body very elongate, height 7 in length. Head 5.5 in length. Eyes 6-7 in head. Snout .5 in eye diameter. Teeth in each jaw. Dorsal fin much lower than body. Dorsal fin with 37 rays. Anal fin with 30 rays. Caudal fin pointed. Colour brownish gray with brown marking on back and cheek, belly yellowish.

Habit : They are semi-aquatic forms, found in spring-tide pools. When the pools dry up between the spring tide or for longer periods the fish retires to depth of about 1.5 meters and the burrow may be straight or somewhat oblique or narrow deep one.

Remarks : They are moderately available in the intertidal zone. The aforesaid specimens was collected from the crab holes along the bank of pools and narrow channels. It has a good commercial value.

Distribution : *India* : West Bengal : 24-Parganas, Nadia, Midnapore ; Tamilnadu; Andamans. *Outside India* : West coast of Malaya; Penang; Singapore; Java; Borneo; China; Japan.

Genus 18. *Scartelaos* Swainson

1839. *Scartelaos* Swainson, *Nat. Hist. Class. Fish.*, **2** : 183, 279.

1953. *Scartelaos* : Koumans, *Fish. Indo-Aust. arch.*, **10** : 262.

Diagnosis : Body elongate with minute rudimentary scales. Eyes close together, lower eyelid well developed, snout about as long as eye. Barbel present. Teeth in both jaws in a single row. Dorsal fin separate. Caudal fin pointed.

(31) *Scartelaos histophorus* (Valenciennes)

1822. *Gobius viridis* Hamilton-Buchanan, *Fish. Ganges* : 42, 366; P1.32, fig.12.

1977. *Scartelaos histophorus* : Visweswara Rao, *Matsya*, (2) : 60.

Material examined : 2 exs., Pergumti, 9. 9. 1984; 1 ex., Chotomollakhali, 12. 9. 1984; 1 ex., Basirhat, 15. 9. 1984; 6 exs., Gosaba, 18. 9. 1984; 2 exs., Geokhali, 7. 3. 1985; 1 ex., Kakdwip, 10. 3. 1985; 1 ex. Diamond Harbour, 11. 3. 1985; 1 ex., Haldia, 16. 3. 1985; 1 ex., Falta, 27. 3. 1985; 5 exs., Purandar Kheya Ghat, 18. 6. 1986; 2 exs., Basanti, 19. 6. 1986; 2 exs., Sonakhali, 21. 6. 1986; 2 exs., Jharkhali, 24. 6. 1986; 4. exs., Jharkhali Lonch Ghat, 25. 6. 1986; 3 exs., Jharkhali, 21. 1. 1987; 5 exs., Kakdwip, 6. 4. 1987; 3 exs., Haldi river, 13. 4. 1987; 5 exss., Patikhal, 15. 4. 1987; 6 exs., Geonkhali I.B., 20. 4. 1987; 1 exs., Basanti, 7. 3. 1989; 3 exs., Sibgunge, 2. 4. 1989.

Diagnosis : Body elongate, height 6.5 to 9 in length, 8.7 to 10 in total length. Head 3.5-4.5 in length. Eyes close together 5.7 to 6.5 in head, snout 3.5-4 in head, upper jaw prominent. A row of barbules along the lower jaw. Dorsal fin separate, with 31-42 rays. 3rd ray is longest. Anal fin with 24-27 rays. Pectoral fin rounded, much shorter than head, base muscular, Ventral fin as long as pectoral fin. Caudal fin longer than head. Colour slaty blue above, lighter below. Dorsal fin black spots on the lower half of the body, 4-6 short transverse brownish bar present. Caudal fin with dark band, tip black.

Habit : They are semiaquatic, intertidal forms, found in shallow burrows on the muddy banks between tidal marks in the channel all over the Hugli-Matla estuary. Sometimes the species are found in association with stomatopod and crabs.

Remarks : This species are very abundant in all over Hugli-Matla estuary.

One Example collected from Gosaba, SL 35 mm, on 18. 9. 1984, the longest ray of first dorsal is less than head length but generally should be more than head length.

Again, one example from Jharkhali Khal dated 24. 6. 1986, SL 56 mm where 1st dorsal is short not like other specimens.

Another example collected from Falta on 27. 3. 1985, SL 105 mm. Here length of first dorsal very long about 2 times in head length and three times in depth of body. Generally, is equal to body depth, little more than head.

Distribution : *India :* West Bengal : 24-Parganas, Midnapore, Howrah, Hughly; almost in all estuarine mud flat in India. *Outside India :* Srilanka; Java; Philippines; China; New Guinea; Australia; Melanesia.

Family VII TAENIOIDIDAE

Diagnosis : Body very elongate, with naked or cycloid scales; united ventral fins, one very elongated dorsal fin with a distinct short spinous part; eye small to indistinct.

Key to the sub-families

1. A pit in upper margin of opercle, opening to cavity, which is separated from the gill cavity. TRYPAUCHENINAE
- Pit in upper margin of opercle absent, opening to a cavity which is separated from the gill cavity. TAENIOININAE

Sub-family d. TAENIOININAE

Diagnosis : Body very elongate and eel like, with naked to rudimentary scales; pit at the upper margin of opercle absent, opening to a cavity, which is separated from the gill cavity; eyes small or rudimentary.

Key to the Genera

1. Barbels on head, canines in both jaws. 2
Barbels on head absent, no canine on jaws. ***Brachyamblyopus***
2. Pectoral fin much shorter than ventral fin, about 3 in head, mouth nearly vertical.
..... ***Taenioides***
Pectoral fin as long as ventral fin about 1.5 in head, mouth very oblique.
.....***Odontamblyopus***

Genus 19. ***Brachyamblyopus*** Bleeker

1874. *Brachyamblyopus* Bleeker, *Arch. neerl. Sci.*, **9** : 329.

1953. *Brachyamblyopus* : Koumans, *Fish. Indo-Aust. arch.*, **10** : 266.

Diagnosis : Body very elongate, with rudimentary scale or naked. Eye rudimentary, teeth in jaws in 2-3 rows, no canines, no barbels, dorsal fin continuous; with 32-51 rays, anal fin with 26-30 rays. Dorsal and anal fin connected with caudal fin.

Key to Species

1. Scales on body including caudal part, anal fin with 28-32 rays, height 5 in length.
..... ***B. multiradiatus***
Scales only developed on caudal part, whereas anterior part naked, anal fin 33 rays, height 9 in length. ***B. urolepis***

(32) ***Brachyamblyopus multiradiatus*** (Hardenberg)

1931. *Pseudotrypauchen multieradiatus*, Hardenberg, *Treubia* **13** : 146, 418, fig.8.

1953. *Brachyamblyopus multiradiatus* : Koumans, *Fish. Indo-Aust. arch.*, **10** : 267.

Material examined : 1 ex., Mouth of Hugli river, 17. 6. 1885, A. Millner; 3 exs., Mouth of Hugli river, 1929, (Lady fraser).

Diagnosis : Body elongate, height 5 in length, 7 in total length, head 6 in length; depth and head length equal, eyes very small. Teeth in jaws in two rows, dorsal fin with 36-40 rays, Anal fin with 29-33 rays. Head and body scaled. Colour pale rosa.

Habit : They are semiaquatic, intertidal forms which are materially affected by tides. They generally live in burrows between tide marks.

Remarks : No material was available during present survey. It appears to be a rare form.

Distribution : *India :* West Bengal : 24-Parganas. *Outside India :* Sumatra.

(33) *Brachyamblyopus urolepis* (Bleeker)

1852. *Amblyopus urolepis* Bleeker, *Nat. Tijdschr, Ned-Indie*, 3 : 581.

1953. *Brachyamblyopus urolepis* : Koumans, *Fish. Indo-Aust. arch.*, 10 : 268, fig.66.

Material examined : None.

Diagnosis : Body elongated, height 9 in length, head 5.5 in length. Snout longer than eye. Teeth in upper jaw in two rows, lower jaw more than two rows, no canines. Small scales present only caudal part of the body. Dorsal fin with 38 rays; anal fin with 34 rays, pectoral 5.5 in head length. Colour reddish green, fins are reddish.

Habit : They are semiaquatic, intertidal forms which are materially affected by tides. They generally live in burrows between tide marks.

Remarks : They are very rare form. Neither the material is available for study not collected during present study. Diagnostic characters given here is form Koumans' (1941).

Distribution : *India :* West Bengal : 24-Parganas. *Outside India :* Sumatra.

Genus 20. *Odontamblyopus* Bleeker

1874. *Odontamblyopus* Bleeker, *Arch. neerl. Sci.*, 9 : 330.

1953. *Odontamblyopus* : Koumans, *Fish. Indo-Aust. arch.*, 10 : 274.

Diagnosis : Body very elongate, Eyes very small, Teeth in upper jaw in two rows. Two rows of barbels on head. Dorsal fin continuous, with 40-46 rays, anal fin with 33-38 rays. Pectoral fin as long as ventral fin. Caudal fin long, pointed.

(34) *Odontamblyopus rubicundus* (Hamilton-Buchanan)

1822. *Gobioides rubicundus* Hamilton-Buchanan, *Fish. Ganges* : 37, 365, Pl.5, fig.9.

1973. *Odontablyopus rubicundus* : Talwar, *Rec. zool. Surv. India*, **67** : 224.

Material examined : 1 ex., Basirhat, 6. 9. 1984; 1 ex., Gosaba, 16. 9. 1984; 8 exs., Bakkhali, 7. 3. 1985; 2 exs., Haldia, 18. 3. 1985; 5 exs., Terapekha (Haldi river), 19. 3. 1985; 3 exs., Rupnarayan river (Geonkhali), 21. 3. 1985; 1 ex., Geonkhali, 22. 3. 1985; 6 exs., Geonkhali, 23. 3. 1985; 1 ex., Falta, 26. 3. 1985; 2 exs., Flata (near Fort), 27.3.1985 ; 1 ex. Basanti, 19.6.1986 ; 4 exs., Digakhali, 3. 1. 1989; 1 ex., Gadiyara, 4. 1. 1989; 1 ex., Bandel Charch, 8. 1. 1989; 3 exs., Sibgunge, 31. 3. 1969; 2 exs., Sibgunge, 2. 4. 1989; 2 exs., 1 Fuleswar, 5. 4. 1989.

Diagnosis : Body very elongate, height 8-13 in length, head 5-7 in length, Teeth in upper jaw in two rows, 4 canines on each side. 3 barbels on head. Dorsal fin continuous with 41-46 rays, anal fin with 31-40 rays, pectoral fin about as long as ventral fin, about 1.5 in head, caudal fin pointed much longer than head, colour green to red above, red to whitish below, fins are green red.

Habit : They are semiaquatic and intertidal form. Live in deep burrows in the muddy bottom of the tide pools and the side of stream near low tide marks.

Remarks : It is very common in the Hugli-Matla estuary. This species is one of the most out standing mud loving forms. They are occasionally exposed to aerial conditions for short period.

Distribution : *India* : West Bengal : Calcutta, 24-Parganas, Midnapore, Howrah, Hugli, Nadia. *Outside India* : Bangladesh; Singapore; Malya; Sumatra; Borneo; Java; China; Japan.

Genus 21. *Taenioides* Lacepede

1798. *Taenioides* Lacepede, *Hist. nat. Poiss*, **2** : 580.

1953. *Taenioides* : Koumans, *Fish. Indo-Aust. arch.*, **10** : 269.

Diagnosis : Body very elongate, with rudimentary scales or naked. Eyes rudimentary. Teeth in both jaws, Teeth pointed. Gill opening not very wide. No groove on the upper gill cover. Barbels on head. Dorsal fin continuous, ventral fin large and united. Pectoral fin small, caudal fin pointed.

Key to Species

1. Length of head shorter than distance from base of ventral fin to vent. 2
 Length of head longer than distance from base of ventral fin to vent. 3
2. Teeth in upper jaw about 5 on each side but in lower jaw about 4.
 *T. cirratus*

Teeth in upper jaw 7 on each side but in lower jaw about 3 to 4
 *T. eruptionis*

3. Scales present, 4-5 canines in outer row of each side of upper jaw, height of body 10-10.5 in length. *T. buchanani*

Scales absent, 7 canines in outer rows of upper jaw on each side, height of the body 13-15 in length. *T. anguillaris*

(35) *Taenioides anguillaris* (Linnaeus)

1758. *Gobius anguillaris* Linnaeus, *Syst. Nat. ed.*, 10 : 264.

1953. *Taenioides anguillaris* : Koumans, *Fish. Indo-Aust. arch.*, 10 : 273.

Material examined : 1 ex., Calcutta, F. Day; 3 exs., Uttarbhag, 23. 2. 1934, S.L. Hora; 1 ex., Kakdwip, 10. 9. 1980.

Diagnosis : Elongated body, with naked body, height 13-15 in length, head 6.5-7.5 in length. 7 canines in outer row in upper jaw on each side, 3 short barbels on each side below the head. Dorsal fin with 46-50 rays, anal fin with 38-45 rays. Pectoral fin short, about 3 in head. Colour pinkish, caudal fin darker.

Habit : They are semiaquatic, intertidal forms which are materially affected by tides. They generally live in mud or in burrow between tide marks or in the channel near mangroves bush.

Remarks : It is a rare form. During the course of present investigation only one specimen at the channel of Kakdwip from soft mud was collected.

Distribution : *India* : West Bengal : 24-Parganas; Calcutta; Andamans. *Outside India* : Java; Philippines; China; New-Guinea.

(36) *Taenioides buchanani* (Day)

1873. *Amblyopus buchanani* Day, *Proc. zool. Soc. London* : 110.

1953. *Taenioides buchanani* : Koumans, *Fish. Indo-Aust. arch.*, 10 : 272.

Material examined : 1 ex., Sagar Island, 1977, A. Khuda Buksk.

Diagnosis : Body with rudimentary scales, height 10 in length, head 6 in length, Teeth on each side 4-5 canines of outer row in upper jaw, 3 barbels on each side below head. Dorsal fin with 48 rays, anal fin with 36 rays, caudal fin pointed. Pectoral fin short about 3 in head. Colour brownish olive above, below reddish, ventral fin black.

Habit : They are semiaquatic, inter-tidal forms which are materially affected by tides. They

generally live in mud or in burrows between tide marks or in the channel near mangroves bush.

Remarks : During the course of present investigation no material was available. Study is based on the collection present in the N.Z.C. of Zoological Survey of India.

Distribution : *India* : West Bengal : 24-Parganas. *Outside India* : Burma; Sumatra.

(37) *Taenioides cirratus* (Blyth)

1860. *Amblyopus cirratus* Blyth, *J. Asiat. Soc. Beng.*, **29** : 147.

1953. *Taenioides cirratus* : Koumans, *Fish. Indo-Aust. arch.*, **10** : 270, fig.67.

Material examined : 4 exs., Kakdwip, 10. 9. 1980; 3 exs., Raychock, 7. 12. 1983; 1 ex., Port canning, 26. 9. 1984; 1 ex., Kakdwip, 9. 3. 1985; 1 ex., Geonkhali, 23. 3. 1985.

Diagnosis : Body elongated with rudimentary scales. Height 11-14 in length. Head 6.5 to 7.5 in length. Teeth strong on each side about 5 in outer row in upper jaw, about 4 canines on each side in lower jaw. 3 short barbels on each side of chin. Dorsal fin with 49-55 rays. Anal fin with 43-48 rays. Caudal fin rhomboid. Pectoral fin short about 3 in head. Colour grayish.

Habit : They are semiaquatic and intertidal form. They live in shallow depressions in between tidal marks.

Remarks : They are rather common in comparison to other *Taenioids*. This species builds a tube home with other exists. The degenerate eyes in this species are in accordance with the burrowing mode of life.

Distribution : *India* : West Bengal : Calcutta, 24-Parganas, midnapore; Madras; Andaman and Nicobar Islands. *Outside India* : Zanzibar; Indo-Australian archipelago.

(38) *Taenioides eruptionis* (Bleeker)

1849. *Amblyopus eruptionis* Bleeker, *Verh. Bat. Gen.*, **22** : 38.

1953. *Taenioides eruptionis* : Koumans, *Fish. Indo-Aust. arch.*, 272.

Material examined : 1 ex., Raichock, 7.12. 1983.

Diagnosis : Elongated body, height 15-24 in total length. Head 10-12 in total length. 7 canines in upper jaw on each side, 3-4 teeth in outer row in lower jaw on each side. Dorsal fin and anal fin connected with caudal fin. Pectoral fin short. Colour of body, fins greenish, belly lighter.

Habit : They are semi-aquatic and intertidal form usually affected by tides. They generally live in mud or burrows between tide marks.

Remarks : This is for the first time it is recorded from India. It is closely related to *T.*

cirratus but mainly differs by the number of teeth in the upper jaw.

Distribution : India : West Bengal : 24-Parganas. *Outside India* : Java, Ambon.

Sub-Family : e. TRYPACHENINAE

Diagnosis : Body elongate eel-like; a pit at upper margin of opercle which open to a cavity, separated from gill cavity; eyes rudimentary, small in size.

Key to Genera

1. Ventral fins united. 2
 Ventral fins separated at base. *Trypauchenichthys*
2. Ventral fins totally united, forming a funnel shaped disk. *Trypauchen*
 Ventral fins united but emarginated posteriorly. 3
3. Canines present. *Amblyotrypauchen*
 Canines absent. *Ctenotrypauchen*

Genus 22. *Amblyotrypauchen* Hora

1924. *Amblyotrypauchen* Hora, : *Rec. Indian Mus.*, 26 : 160.

Diagnosis : Body elongated, with cycloid scales. A small groove on the upper gill cover. Jaw teeth in bands, 2 canines on each side of upper jaw. Dorsal fin with 46-55 rays, anal fin with 40-42 rays. Chin and snout without barbels.

¹
(39) *Amblyotrypauchen arctocephalus* (Alcock)

1890. *Amblyopus arctocephalus* Alcock, *Ann. Mag. nat. Hist.* (6) 6 : 432.

1959. *Amblyotrypauchen arctocephalus* : Smith, *Ichth. Bull. Rhoden Univ.*, (13) : 220.

Material examined : 1 ex., Mouth of river Hugli (Sand head), 'P.V. Fraser', Feb. 1923.

Diagnosis : Body elongate, head compressed; eye hidden, snout longer than eye. A pit at the upper margin of the opercle. Teeth in both jaws, in upper jaw 2 canines on each side. Dorsal fin with 48 rays anal with 40 rays, both connected with caudal. Ventral fin united. Colour brownish.

Habit : They are semi-aquatic and intertidal forms which are materially affected by tides. They generally live in mud or in burrows between tide marks or in channel near mangroves bush.

Remarks : It is a rare species, only once reported from the area under study. No specimen available during present study.

Distribution : *India* : West Bengal : 24-Parganas; Orissa. *Outside India* : Gulf of Mastaban; Burma; Philippines.

Genus 23. *Ctenotrypauchen* Steindachner

1867. *Ctenotrypauchen* Steindachner, *Silz. ber. Akad. wiss. wien.* 55 : 530.

1953. *Ctenotrypauchen* : Koumans, *Fish. Indo-Aust. arch.*, 10 : 281.

Diagnosis : Body very elongated, covered with cycloid scales. Mouth very oblique, lower jaw prominent. At the upper margin of opercle a pit which open to a cavity. No barbels on head. Dorsal fin with 56 rays, anal fin with 44-50 rays. Caudal fin pointed. Pectoral fin small, ventral fin united.

(40) *Ctenotrypauchen microcephalus* (Bleeker)

1860. *Trypauchen microcephalus* Bleeker, *Act. Soc. Indo-Neerl.*, 8 : 62.

1976. *Ctenotrypauchen microcephalus* : Talwar and Chatterjee, *News. Zool, Surv. India*, 2 (3) : 90.

Material examined : 1 ex., Mouth of Hugli river, R.M. Daby; 1 ex., Matla river (Sundarban), 17. 11. 1909.

Diagnosis : Body very elongated, height 8 in length; head 7 in length. Eyes very small covered by skin. Snout 4 in head. No canines. Head, nape, breast and belly naked. Dorsal fin continuous with 56 rays. Anal fin with 50 rays, Pectoral fin about 1/3 of head length. Colour reddish.

Habit : They are intertidal and semiaquatic forms which are usually affected by tides. They generally live in mud or in burrows between the tide marks.

Remarks : Study based on the named collection available in N.Z.C. of the Z.S.I. Attempts made hard to collect the specimen but failed.

Distribution : *India* : West Bengal : 24-Parganas, Madras, Andamans; Travancore; Goa. *Outside India* : Percian Gulf; Siam; Singapore, Sumatra; Java; Borneo; Philippines.

Genus 24. *Trypauchen* Valenciennes

1837. *Trypauchen* Valenciennes, *Hist. nat. Poiss.*, 12 : 152.

1953. *Trypauchen* : Koumans, *Fish. Indo-Aust. arch.*, **10** : 277.

Diagnosis : Body very elongate, covered with cycloid scales. Eyes small, Teeth in both jaws in 2-3 rows. A pit present at the upper margin of the operculum. No barbel on head. Dorsal fin continuous, ventral fin totally united forming a funnel shaped disk. Caudal fin rounded.

(41) *Trypauchen vagina* (Bloch and Schneider)

1801. *Gobius vagina* Bloch and Schneider, *Syst. Ichth.*, : 73.

1973. *Trypauchen vagina* : Talwar, *Rec. Zool. Surv. India*, **67** : 225.

Material examined : 1 ex., Jharkhali 22. 4. 1984; 2 exs., Chottomollah Khali, 12. 9. 1984; 2 exs., Kakdwip, 9. 3. 1985; 1 ex., Falta, 24. 3. 1985.

Diagnosis : Body elongate, covered with cycloid scales. Depth 10-11.5 in total length, head 6.5 to 7.26 in total length. Eyes very small, covered by skin, teeth in 2-3 rows. A pit present at the upper margin of opercle. Dorsal fin continuous, with 47-55 rays, anal fin with 40-46 rays, both connected with caudal, Pectoral fin small about half of head. Ventral fin 2.5 to 3 in head, caudal fin rounded about as long as head, colour reddish.

Habit : They are semiaquatic and intertidal forms which are usually affected by tides. They live in the soft mud in the crab's hole or in the soft part of the narrow channel.

Remarks : They are easily available in the Hugli-Matla estuary. Collection made in soft mud at the time of low tide.

Distribution : *India* : West Bengal : Calcutta, 24-Parganas, Hugli, Andamans and Nicobar Island; Goa. *Outside India* : Pakistan; Srilanka; Thailand; Malaya, Singapore; Sumatra; Java; China; Taiwan; Vietnam.

Genus 25. *Trypauchenichthys* Bleeker

1860. *Trypauchenichthys* Bleeker, *Act. Sci. Indo-Neerl.*, **8** : 63.

1953. *Trypauchenichthys* : Koumans, *Fish. Indo-Aust. arch.*, **10** : 280, fig.70.

Diagnosis : Body very elongate, head compressed, naked, with a median crest on occiput. Eyes small, snout about 2 in eye diameter. Teeth in both jaws. At the upper margin of opercle a pit, which open to a cavity. No barbel on head, dorsal fin continuous.

Key to the Species

- 1 Dorsal fin with 5 simple rays and 37-41 branched rays; anal fin 35-39 rays.
 *T. sumartrensis*

Dorsal fin with 6 simple rays and 56-59 branched rays; anal fin with 50-52 rays
 *T. typus*

(42) *Trypauchenichthys sumartrensis* Hardenberg

1931. *Trypauchenichthys sumartrensis* Hardenberg, *Treubia*, **13** : (3-4); 146, 417, fig.7.

1953. *Trypauchenichthys sumartrensis* : Koumans, *Fish. Indo-Aust. arch.*, **10** : 280, fig.70.

Material examined : 3 exs., Sandheads, 1927, 'P.V. Lady Fraser'; 2 exs., Sandheads (Mouth of Hugli river), 1928, 'P.V. Lady Fraser'

Diagnosis : Body elongated, covered with cycloid scales, head 5-5.3 in length. Eyes very small; some pore on head. Snout much longer than eye. Dorsal fin with 5 simple and 37-41 branched ray, anal with 35-39 rays. Ventral fin totally separate, caudal fin oblong, about 6 in total length. Colour pink.

Habit : They are intertidal and semiaquatic form. They live in the mud of low tide mark or in the soft part of the narrow channel.

Remarks : They are very rare form. No species was collected during the course of study.

Distribution : *India* : West Bengal : 24-Parganas. *Outside India* : Sumatra.

(43) *Trypauchenichthys typus* Bleeker (Fig.8)

1860. *Trypauchenichthys typus* Bleeker, *Act. Soc. Indo-Neerl.* **8** : 63.

1953. *Trypauchenichthys typus* : Koumans, *Fish. Indo-Aust. arch.*, **10** : 281.

Material examined : 1 ex., Kakdwip, 10. 3. 1985; 1 ex., Kakdwip (Mainapara), 6. 4. 1987; 1 ex., Haldi river, 13. 4. 1987.

Diagnosis : Body elongate, height 9 in length, head 6.25 in length. Eyes small covered by skin. Snout 4 in head. Dorsal fin continuous, with 6 simple rays and 56-59 rays, anal with 52-55 rays. Head, nape, breast and belly naked. Pectoral fin half of head, ventral fin separate; caudal fin 7 in head. Colour reddish.

Habit : They are semiaquatic and intertidal forms. They live in mud or in the soft part of the narrow channel.

Remarks : It is the first record from Hugli-Matla estuary. Here I have found head is 5 in length but Koumans (1953) has mentioned head 6.25 in length. They are very rare in population and available only in West Bengal.

Distribution : India : West Bengal : 24-Parganas, Midnapore. Outside India : Riouw Archipelago; Borneo, Philippines.

SUMMARY

This paper deals with the occurrence of 43 species of fish belonging to 25 genera and 7 families. The fishes inhabiting in the area, comprise of three groups viz. Gobiids, Blenniids and eels.

Among the 43 species three species viz. *Periophthalmus malaccensis* and *Pseudapocryptes borneensis*, family Gobiidae ; *Taenioides eruptionis*, family Taenioididae are recorded for the first time from India and four species, viz. *Petroscirtes breviceps*, *P. variabilis* of family Blenniidae ; *Trypauchenichthys typus*, family Taenioididae and *Periophthalmus vulgaris*, family Gobiidae are new recorded from the area under study.

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Estuarine Ecosystem Series : Hugli Matla Estuary

MUKHERJEE

PLATE I

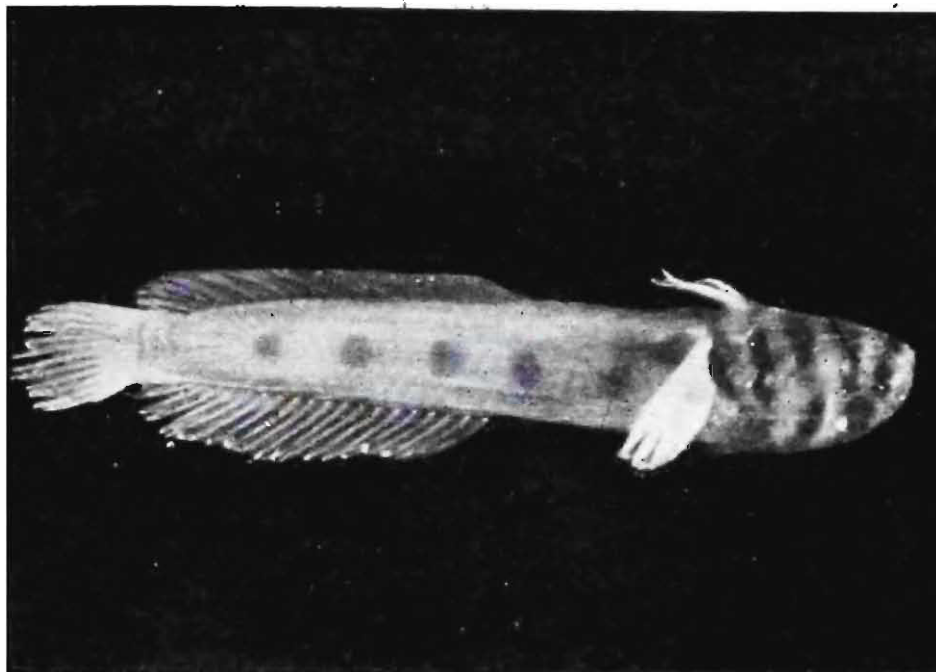


Fig. 1 : *Petrosirtes breviceps* Valenciennes

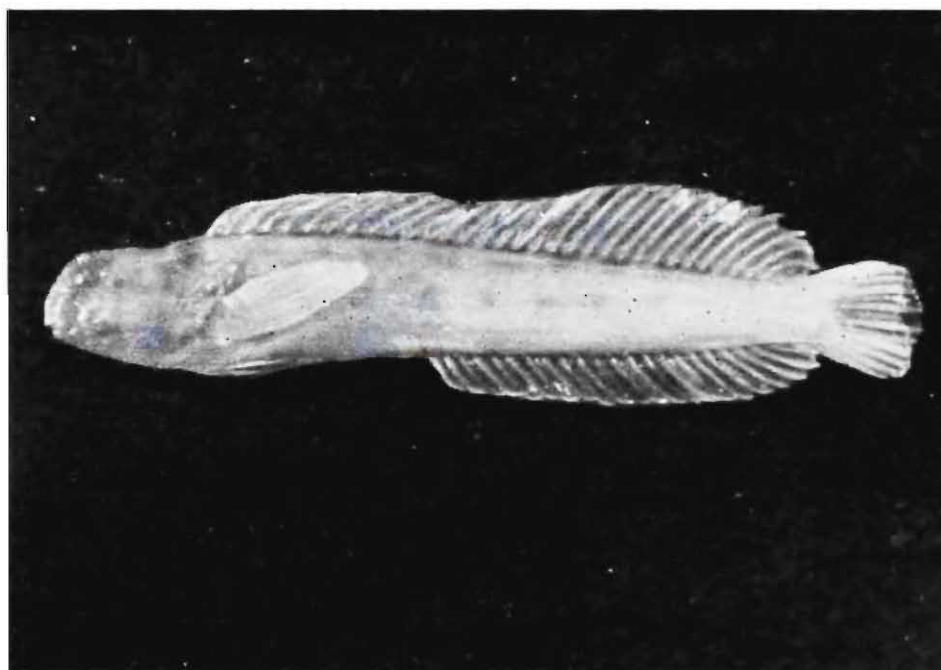


Fig. 2 : *Petrosirtes variabilis* Cantor

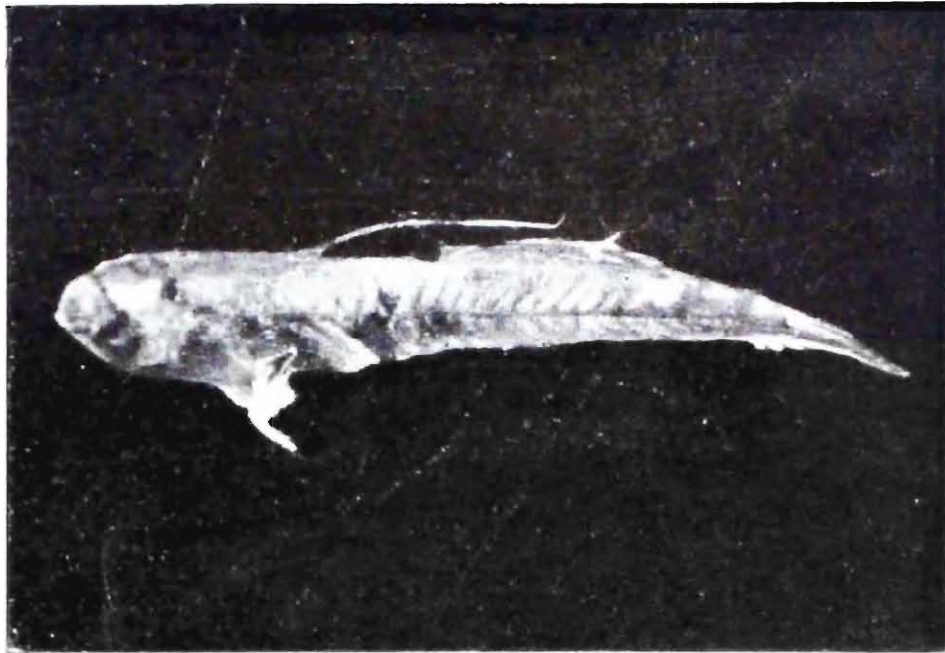


Fig. 3 : *Periophthalmus malaccensis* Eggert



Fig. 4 : *Periophthalmus vulgaris* Eggert

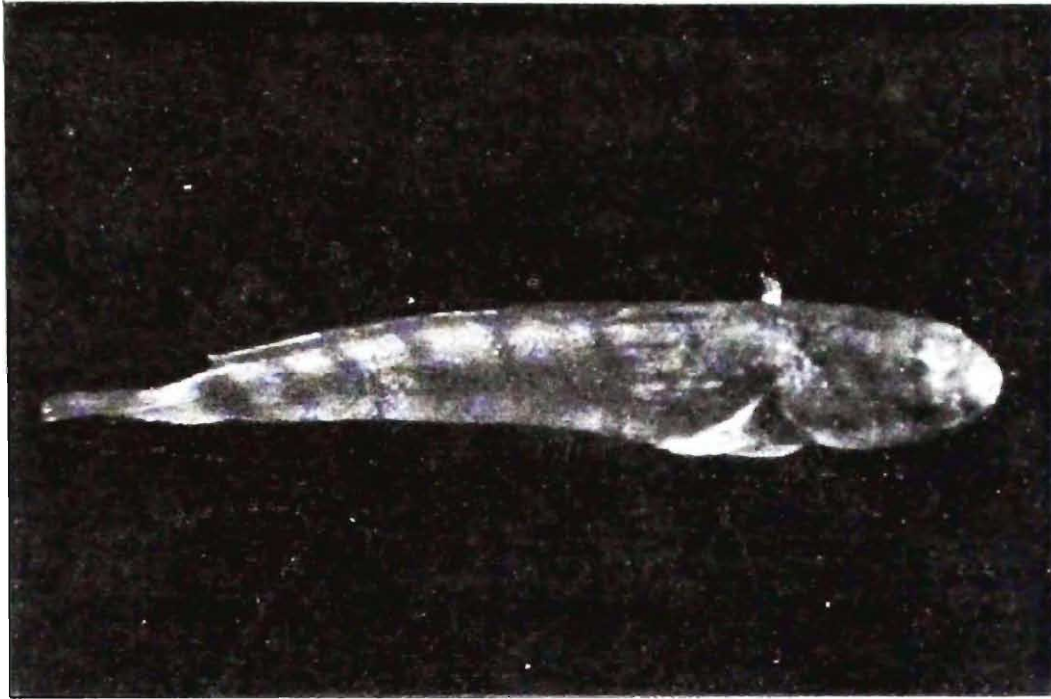


Fig. 5 : *Boleophthalmus sculptus* Gunther



Fig. 6 : *Pseudapocryptes borneensis* (Bleeker)



Fig. 7 : *Taenioides eruptionis* (Bleeker)



Fig. 8 : *Trypauchenichthys types* Bleeker

ANURA : AMPHIBIA

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INTRODUCTION

Amphibian fauna of India have been studied by a number of workers from mid-nineteenth century. Works of Boulenger (1890-1920), Annandale (1907-1919), Rao (1915-1937), Bhadury (1929-1980), Daniel (1962-1975), Satyamurthy (1967), Pillai (1978-1981), Pillai and Chanda (1973-1981) and Chanda (1985-1990) are noteworthy.

Perusal of literature shows that a little attention has been paid to this group available in Hugli-Matla estuarine areas. Only seven species of amphibians have so far been reported from Sundarban area (Mukherjee, 1975).

Present report is based on a small collection made from Hugli-Matla estuarine area during the period 1984-1989. A total of five species under three genera and three families have been identified from the aforesaid material.

Mention may be made here that from the Ganga river basin of upper Bengal (Calcutta to Malda) Chanda (1991) reported 12 species which include all the species of the present material and they have been dealt herewith as the author anticipates all of them if the study area would have been surveyed extensively with special attention to this group. Furthermore, the anticipated number is much below the number of known species from West Bengal.

In the present paper key to the genera and species for ready identificaion in the field has been provided. Further, status of all the species has been included.

LIST OF SPECIES

Class : AMPHIBIA

Order : ANURA

Family I. : BUFONIDAE

Genus 1. : *Bufo* Laurenti

(1) *Bufo melanostictus* Schneider

* (2) *Bufo stomaticus* Lutken

Family II. : MICROHYLIDAE

Genus 2. : *Microhyla* Tschudi

(3) *Microhyla ornata* Dum. & Bibron

Genus 3. : *Uperodon* Dum. & Birbron

* (4) *Uperodon globulosum* Gunther

Genus 4. : *Kaloula* Gray

* (5) *Kaloula pulchra* Gray

Family III. RANIDAE

Genus 5. : *Rana* Linnaeus

(6) *Rana cyanophlyctis* Schneider

* (7) *Rana crassa* Jerdon

* (8) *Rana erythraea* Schlegel

(9) *Rana hexadactyla* Lesson

(10) *Rana limnocharis* Boisduval

(11) *Rana tigerina* Daudin

Genus 6. : *Tomopterna* Dum.& Bibron

* (12) *Tomopterna brevipes* Dum. & Birbron

Family IV. RACHOPHORIDAE

Genus 7. : *Polypedates* Tschudi

(13) *Polypedates leucomystax* (Gravenhorst)

* denotes species not known from the area under study but as per anticipation of Chanda (1991)

Key to the Families of Anura

- 1 Upper jaw toothed..... 2
- Jaws toothless..... 5

- 2. Digits with intercalary cartilage RHACOPHORIDAE
 Digits without intercalary cartilage..... RANIDAE
- 3. Pupil vertical and circular MICROHYLIDAE
 Pupil horizontal BUFONIDAE

Family I. BUFONIDAE

Genus 1. *Bufo* Laurenti

1768. *Bufo* Laurenti, *Synopsis Rept.*, Vienna : 25.

1985. *Bufo* : Frost, *Amphibian species of the world* : 29.

Diagnosis : Skin rough and tuberculated; tongue elliptical and entire; vomarine teeth absent; pupil horizontal; tympanum distinct; fingers free, toes more or less webbed; diapophyses of sacral vertebra more or less dilated; terminal phalanges obtuse or triangular.

Distribution : Throughout the world except Australia, Madagascar, New Guinea and the Islands of the Pacific.

Key to the species of Bufo

- Head with prominent cranial ridges
 Parotoid gland present ; tympanum distinct; tibiotarsal articulation reaches tympanum or up to eye; toes half or less than half webbed.....*melanostictus* Schneider
- Head without cranial ridges ; Tympanum distinct; tibiotarsal articulation reaching between shoulder and eyes; toes two-third webbed.....*stomaticus* Lutken

(1) *Bufo melanostictus* Schneider

1799. *Bufo melanostictus* Schneider, *Hist. Amph.*, I, Jena : 216.

1986. *Bufo melnostictus* : Frost, *Amphibian species of the world* : 32.

Material examined : 1 ex., Nurpur, South 24 Parganas, 7.xii.1984, A. Misra.

Diagnosis : Large sized toad attaining a length of 160 mm from tip of snout to vent; head with prominent cranial ridges; two large and distinct parotoid glands; tympanum distinct;

tibiotarsal articulation reaching tympanum or up to eyes; toes half or less than half webbed; skin heavily tuberculated; colour uniformly grey of various shades.

Distribution : *India* : Throughout Indian region including West Bengal. *Outside India* : Sri Lanka; Burma; Malay Archipelago; Southern China.

Remarks : It is generally found in damp places, and in the banks of rivers and streams. This species lay eggs in stagnant and often in muddy water.

Status : This is a very common species and found to occur in almost all the biotopes.

(2) *Bufo stomaticus* Lutken

1863. *Bufo stomaticus* Lutken, *Vidensk. Meddr dansk Naturh Foren*, 14 : 305.

1986. *Bufo stomaticus* : Frost, *Amphibian species of the world* : 61.

Material examined : None

Diagnosis : A medium sized toad attaining a length of 78 mm from tip of snout to vent; head without cranial ridges; tympanum distinct; parotoid gland present; tibiotarsal articulation reaching between shoulder and eyes; toes two-third webbed; skin on dorsal side slightly tuberculate; but that on ventral side granular; colour greyish dorsally and white ventrally.

Distribution : *India* : West Bengal (all the districts); Bihar; Andhra Pradesh; Rajasthan; Uttar Pradesh; Maharashtra. *Outside India* : Pakistan; Arabia; Nepal; Burma; Sri Lanka.

Remarks : This is a nocturnal species. It can burrow in moist loose and sandy soil. Eggs are laid in translucent strings and pale yellowish green in colour. The call of male can easily be distinguished from that of the common toad *Bufo melanostictus*.

Status : Common form in West Bengal but it is not available in the present collection.

Family II. MICROHYLIDAE

Key to the genera of Microhylidae

1. Tongue oval or elliptical 2
 Tongue oblong entire and free behind *Kaloula* Gray
2. Tongue subcircular and scarcely free behind; digits not dilated distally
 *Microhyla* Tschudi
 Tongue elliptical, entire and free behind; digits with terminal dilations
 *Uperodon* Dum. & Bibron

Genus 2. *Microhyla* Tschudi

1838. *Microhyla* Tschudi, *Mem. Soc. Sc. nat. Neuchatel.*, 2 : 28.

1986. *Microhyla* : Frost, *Amphibian species of the world* ; 81.

Diagnosis : Skin smooth or with small warts; tongue narrow, elliptical, entire and free behind; vomerine teeth absent; pupil vertical and circular; tympanum hidden; parotoid gland absent; fingers and toes free, webbed to a greater or lesser extent; digits not dilated distally; sternum cartilagenous and omosternum absent.

Distribution : India; Sri Lanka; Burma; Malayasia; Indonesia; China.

(3) *Microhyla ornata* (Dum. & Bibron)

1841. *Engystoma ornata* Dum. & Bibron, *Erp. Gen.*, 8 : 745.

1986. *Microhyla ornata* : Frost, *Amphibian species of the world* : 84.

Material examined : 1 ex., Nurpur, South 24 Parganas, 7.xii.1984, A Misra.

Diagnosis : Slender frog, rarely exceeding 28 mm in length from tip of snout to vent; head small and pointed; fingers free and toes with rudimentary web; tibiotarsal articulation reaching between shoulder and eyes; skin smooth; colour greyish brown dorsally and uniformly coloured ventrally.

Distribution : *India* : West Bengal (all the districts); Arunachal Pradesh; Nagaland; Manipur; Mizoram; Tripura; Meghalaya; Assam. *Outside India* : Sri Lanka; Burma; South-east Asia; South China; Taiwan.

Remarks : It is nocturnal in habit and generally found under leaves, stones and decaying logs. This species is mainly insectivorous and feeds on specially small coleopteran insects and ants. It is abundantly found in heavy rainfall areas.

Status : Common form in West Bengal

Genus 3. *Uperodon* (Dum. & Bibron)

1841. *Uperodon* Dumeril and Bibron, *Exp. Gen.* : 749.

1986. *Uperodon* : Frost, *Amphibian species of the world* : 92.

Diagnosis : Skin smooth or slightly tuberculated; tongue subcircular and scarcely free behind; vomerine teeth absent; tympanum indistinct, sometimes hidden; fingers free, toes webbed at base; digits with terminal dilations; sternum large and cartilagenous.

Distribution : India; Sri Lanka.

(4) *Uperodon globulosum* (Gunther)

1864. *Cacopus globulosum* Gunther, *Rept. Brit. India* : 416.

1986. *Uperodon globulosum* : Frost, *Amphibian species of the world* : 391.

Diagnosis : Large microhylid frog attaining a length of 76mm from tip of snout to vent; head broader than long; tympanum hidden; forelimbs moderately long and hindlimbs short with two large shovel-shaped metatarsal tubercles; toes with rudimentary webs; skin smooth or slightly tuberculated on the dorsum; but smooth on the ventral; dorsal surface uniformly brown or grey and ventral surface white.

Distribution : India : West Bengal (all the districts); Assam; Orissa; Madhya Pradesh; Karnataka; Maharashtra; Gujarat. *Outside India* : Absent.

Remarks : Only two species of the genus have so far been recorded and both of them are endemic to India. It is a fossorial species and generally found to occur inside the soil. They are very often found on termite nests and it would appear that this sluggish species restricts its movement in finding and burrowing into the nests of termites—their main food.

Status : Rarely occur in lower Bengal.

Genus 4. *Kaloula* Gray

1831. *Kaloula* Gray, *Zool. Misc.*, 1 : 88.

1986. *Kaloula* : Frost, *Amphibian species of the world* : 384.

Diagnosis : Pupil vertical; tongue oblong, entire and free behind; palatine bone forming a sharp, sometimes a toothed ridge across the palate; tympanum hidden; fingers free and toes free or webbed; outer metatarsal united; diapophyses of sacral vertebrae moderately dilated; terminal phalanges triangular or T-shaped.

Distribution : South India; Sri Lanka; Burma; Malay Peninsula; Indo-China; Southern China.

(5) *Kaloula pulchra* Gray

1831. *Kaloula pulchra* Gray, *Zool. Misc.* (1) : 38.

1986. *Kaloula pulchra* : Frost, *Amphibian species of the world* : 384.

Diagnosis : Medium sized microhylid not exceeding 65mm from snout to vent; head short and round; fingers slender and free; finger-tips bearing well developed triangular discs; toes nearly

one third webbed; metatarsal tubercles two, strongly compressed; tibiotarsal articulation reaching shoulder or slightly beyond it.

Distribution : *India* : West Bengal (in some districts); Tamil Nadu; Madhya Pradesh; Karnataka. *Outside India* : Sri Lanka.

Remarks : This is a rare and nocturnal species. It can inhale air and swells like a balloon keeping the head a little downwards and secretes a milky fluid through the epidermal pores of the skin.

Status : It is found in less number and not available in the present collection.

Family III. RANIDAE

Genus 5. *Rana* Linnaeus

1758. *Rana* Linnaeus, *Syst. Nat.*, 10th ed. : 210.

1986. *Rana* : Frost, *Amphibian species of the world* : 510.

Diagnosis : Skin moist, slimy and smooth; pupil either horizontal or roundish-subtriangular; vomarine teeth present; parotoid gland absent; dorsal surface often somewhat warty, granular or tuberculate, wrinkled with ridges and longitudinal parallel folds of varying lengths with various colour pattern; terminal phalanges obtuse or T-shaped; omosternum and sternum with a bony style.

Distribution : Cosmopolitan, except the southern part of South America, Australia and New Zealand.

Key to the species of Rana

1. Head as long as broad or longer than broad 2
 Head broader than long..... 3
2. Toes two-third webbed ; tibiotarsal articulation reaching tip of snout.....
 *erythraea*
- Toes entirely webbed ; tibiotarsal articulation reaching beyond the tip of
 snout.....*tigerina*
3. Toes fully webbed..... 4
 Toes half webbed ; fingers free ; tympanum distinct.....*limnocharis*
4. Tibiotarsal articulation reaching posterior border of eye (in between eyes and nostril) ; a
 digitiform inner metatarsal tubercle present.....*cyanophlyctis*

- Tibiotarsal articulation not reaching posterior border of eye.....5
5. Tympanum distinct..... *hexadactyla*
 Tympanum not distinct.....*crassa*.

(6) *Rana cyanophlyctis* Schneider

1799. *Rana cyanophlyctis* Schneider, *Hist. Amph.*, I : 137.

1986. *Rana cyanophlyctis* : Frost, *Amphibian species of the world* : 487.

Material examined : 3 exs. Nurpur, South 24 Paraganas, 7. xii.1984, A. Mishra.

Diagnosis : Medium sized frog rarely exceeding 60 mm from tip of snout to vent; head slightly broader than long; tympanum distinct, more than half the diameter of eyes; fingers pointed, free ; subarticular tubercles small and pointed; tibiotarsal articulation reaching between eyes and nostril; toes fully webbed; tips of toes dilated into small discs; a digitiform inner metatarsal tubercle present; dorsal skin warty.

Distribution : *India* : All over Indian region including West Bengal. *Outside India* : South Arabia; Afghanistan; Pakistan; Sri Lanka.

Remarks : It is almost entirely aquatic and is active during day and night. It has been reported as a fairly hardy species, tolerant even to water polluted by industrial effluents. It has remarkable ability to camouflage. The black or dark olive spots on the dorsal surface are predominant when in water, specially if the pond contains aquatic vegetation, e.g. Hydrilla.

Status : This is the commonest species of the Indian frogs and found to occur throughout the year.

(7) *Rana crassa* Jerdon

1853. *Rana cassa* Jerdon, *J. Asiat. Soc. Bengal*, 22 : 531.

1986. *Rana crassa* : Frost : *Amphibian speices of the world* : 487.

Material examined : None.

Diagnosis : Large sized frog exceeding 130 mm in length from tip of snout to vent; head broader than long; tympanum indistinct; tibiotarsal articulation reaching anterior border of eye or slightly beyond it; toes entirely webbed ; subarticular tubercles small; an elongated inner metatarsal tubercle present but outer metatarsal tubercle absent; dorsal skin with numerous transverse folds.

Distribution : *India* : West Bengal; Bihar; Orissa; Andhra Pradesh; Tamil Nadu; Kerala; Uttar Pradesh. *Outside India* : Nepal; SriLanka.

Remarks : This species is found in wells and tanks. In situation where the water dries up it buries itself deep in the earth soon after the rain and reappears again at the bank on the next monsoon. They lay eggs in small puddles as transparent jelly. This species has a great commercial importance.

Status : It is found in less number and not available in the present collection.

(8) *Rana erythraea* Schlegel

1837. *Rana erythraea* Schlegel, *Abbilded* : 27.

1986. *Rana erythraea* : Frost, *Amphibian species of the world* : 490.

Material examined : None.

Diagnosis : Medium sized frog rarely exceeding 50 mm in length from tip of snout to vent; head longer than broad; tympanum distinct, two-thirds of eyes; fingers free, tips of fingers dilated into small discs with grooves separating upper from the lower surface; tibiotarsal articulation reaching tip of snout; toes two-thirds webbed; tips of toes dilated into small discs with grooves like finger tips; inner metatarsal tubercle present but outer metatarsal tubercle absent.

Distribution : *India* : West Bengal (in some districts); Mizoram; Meghalaya; Assam. *Outside India* : Burma; Malayasia; Indo-China; Indonesia.

Remarks : it is found to occur in thick floating marshy vegetation and in the bushes grown at the edge of stream.

Status : It is not a common species and not available in the present collection.

(9) *Rana hexadactyla* Lesson

1834. *Rana hexadactyla* Lesson, *Voy. Ind. Or. Rept.* : 331.

1986. *Rana hexadactyla* : Frost, *Amphibian species of the world* : 495.

Material examined : None.

Diagnosis : Large sized frog exceeding 125 mm in length from tip of snout to vent; head slightly broader than long; tympanum distinct; tibiotarsal articulation reaching eyes; fingers free; toes fully webbed; subarticular tubercles small and distinct; a small but prominent inner metatarsal tubercle present but outer metatarsal tubercle absent.

Distribution : *India* : West Bengal; Tripura; Tamil Nadu; Maharashtra. *Outside India* : Sri Lanka.

Remarks : It is almost aquatic in habit and prefers ponds with dense aquatic vegetation while resting on the surface its colour merges with the green of the plant.

Status : This is a common species and is found to occur in almost all the biotopes but unfortunately not available in the present collection.

(10) *Rana limnocharis* Boisduval

1835. *Rana limnocharis* Boisduval, *Nova. Acta Acad. Leop.* : 255.

1986. *Rana limnocharis* : Frost, *Amphibian species of the world* : 500.

Material examined : 2 exs., Nurpur, South 24 Parganas, 7.xii.1984, A Misra.

Diagnosis : Medium sized frog exceeding 60 mm in snout to vent length; head broader than long ; tympanum distinct; fingers pointed, free; tibiotarsal articulation reaching tip of snout; toes pointed, half webbed; both inner and outer metatarsal tubercle present; skin rough with longitudinal tubercles; colour usually grey or brown with dark markings.

Distribution : *India* : All over India including West Bengal. *Outside India* : Sri Lanka; Malaysia; Indonesia; China; Philippines.

Remarks : It is abundantly found in the vicinity of tanks and streams, and generally frequent at the edges of ponds and marshes. During the dry season large number of them are found under stones, logs, etc., in damp places during the day and come out at dusk. During the monsoon they wander far and wide in the grass and are found both during the day and night.

Status : This is the commonest and most widely distributed of the Indian frogs.

(11) *Rana tigerina* Daudin

1803. *Rana tigerina* Daudin, *Hist. Rain. Gren. Carp.* : 64.

1986. *Rana tigerina* : Frost, *Amphibian species of the world* :

Material examined : None.

Diagnosis : Large sized frog rarely exceeding 160 mm in snout to vent length ; head as long as broad; tympanum very distinct, two-third of eye; tibiotarsal articulation reaching beyond tip of snout; fingers free; toes entirely webbed; tips of fingers and toes dilated into rounded tips ; colour yellowish to olive green and longitudinal folds on the dorsal skin.

Distribution : *India* : All over India including West Bengal. *Outside India* : Sri Lanka; Nepal; Burma; Indo-China; China.

Remarks : It is widely distributed from the fringes of the desert to ca 2000 m elevation in the hills. During hibernation period they sometimes bury themselves three to five meter below the surface. During the monsoon a large number of them may be found all over the surface of the fields and around the tanks and ponds. It has a great commercial importance.

Status : It is the largest among the Indian frogs and widely distributed from the fringes of the desert to ca 2000 m elevation in the hills.

Genus 6. *Tomopterna* Dumeril & Bibron

1841. *Tomopterna* Dumeril & Bibron, *Exp. Gen.*, 8 : 443.

1986. *Tomopterna* : Frost, *Amphibian species of the world* : 523.

Diagnosis : This genus constitutes 'Burrowing frogs' Outer metatarsals either united completely or are separated feebly at distal end; inner metatarsal tubercle crescentic, sickle or shovel-shaped and enlarged structure; head fairly large; tympanus distinct.

Distribution : India ; Madagascar; Africa.

(12) *Tomopterna breviceps* Schneider

1799. *Tomopterna breviceps* Schneider, *Hist. Amph.*, 1 : 140.

1986. *Tomopterna breviceps* : Frost, *Amphibian species of the world* : 523.

Diagnosis : Medium sized frog, rarely exceeding 56mm in snout to vent length; head broader than long; tympanum distinct, three-fifth the diameter of eye; finger free; tibiotarsal articulation reaches the shoulder; toes partially webbed; subarticular tubercles prominent; inner metatarsal compressed and crescentic-shaped but outer metatarsal absent.

Distribution : India : West Bengal; Andhra Pradesh; Tamil Nadu; Karnataka; Kerala; Madhya Pradesh; Uttar Pradesh; Himachal Pradesh; Rajasthan; Maharashtra; Gujarat.
Outside India : Sri Lanka; Nepal; Burma.

Remarks : This species is burrowing in nature and can be seen during early monsoon. Its strong shovel-shaped metatarsal tubercles are used for digging the soil in search of food and shelter. It leads a solitary life and congregates only during breeding season.

Status : Poorly known species.

Family IV. RHACOPHORIDAE

Genus 7. *Polypedates* Tschudi

1838. *Polypedates* Tschudi, *Classif. Batr.* : 34.

1986. *Polypedates* : Frost, *Amphibian species of the world* : 540.

Diagnosis : Skin smooth, sometimes tuberculated; fingers free or webbed; toes webbed; circum-marginal grooves present on tips of fingers and toes; tympanum generally distinct; vomarine teeth present.

Distribution : Throughout tropical Asia; Philippines; China ; Japan.

(14) *Polypedates leucomystax* Gravenhorst

1829. *Polypedates leucomystax* Gravenhorst, *Delic. Mus. Zool., Vratislav*, 1 : 26.

1986. *Polypedates leucomystax* : Frost, *Amphibian species of the world* : 541.

Material examined : 1 ex., Nurpur, South 24 Parganas, 7 xii.1984, A. Misra.

Diagnosis : Head broader than long; tympanum very distinct; forelimb moderately long, with rudiment of web and well developed disc with circum-marginal grooves; hind limbs long; tibiotarsal articulation reaching anterior corner of eyes; tips of toes dilated into well developed discs with circum-marginal groove and two-third webbed; inner metatarsal tubercle small but prominent while outer metatarsal tubercle absent.

Distribution : *India* : West Bengal; Arunachal Pradesh; Assam; Sikkim.
Outside India : Southern China to Philippines.

Remarks : This species is purely nocturnal species and prefers dark and moist atmosphere of lavatory and also found under the leaves of plants like pine and roofs of thatched village huts.

Status : It is not a very common species.

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SUMMARY

The author reports here a total of five species under four families and five genera. In addition eight more species have been dealt herewith which are supposed to occur in the study area. Further, keys to the genera and species for field identification have been provided and status of all the species has been included.

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REPTILIA

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INTRODUCTION

Reptilian fauna of India have been studied by a number of workers from Mid-nineteenth century. Works of Boulenger (1890), Annandale (1906-1915), Acharji and Mukherjee (1964), Mukherjee (1975), Chaudhuri (1912), Daniel (1983), Das (1987 and 1991), Frazier (1987), Kar and Bhaskar (1982), Moll (1983 and 1985), Moll and Vijaya (1986), Murthy and Pillai (1986), Saha (1982), Sanyal *et al* (1990), Sharma (1991), Smith (1931-43), Tikadar and Sharma (1985), Vijaya and Manna (1982) and Vijaya (1983) are noteworthy.

Perusal of literature shows that a little attention has been paid to this group available in Hugli-Matla estuarine areas.

Present report is based on a small collection made from Hugli-Matla estuarine area during the period 1955 and 1974-1986. Some earlier collection made from the said area have also been included. A total of 16 species under 12 genera and 6 families have been identified from the aforesaid material. Only aquatic fauna have been dealt with.

The authors anticipate that if the study area would have been surveyed extensively with special attention to this group, the number should have gone more.

In the present paper key to the genera and species for ready identification in the field has been provided. Further, status of all the species has been included.

LIST OF SPECIES KNOWN

SYSTEMATIC LIST

Class : REPTILIA
Order I : CROCODYLIA
Family 1 : CROCODYLIDAE
Genus (1) : *Crocodylus*

1. *Crocodylus porosus* (Schneider)

Order II : TESTUDINES
Suborder I : CRYPTODIRA
Family 2. : CHELONIIDAE
Genus (2) : *Lepidochelys*

2. *Lepidochelys olivacea* (Eschscholtz)

Family 3. : EMYDIDAE

Genus (3) : *Geoclemys*3. *Geoclemys hamiltonii* (Gray)Genus (4) : *Batagur*4. *Batagur baska* (Gray)

Family 4. : TRIONYCHIDAE

Genus (5) : *Pelochelys*5. *Pelochelys bibroni* (Owen)Genus (6) : *Lissemys*6. *Lissemys punctata andersoni* (Webb.)Genus (7) : *Aspideretes*7. *Aspideretes gangeticus* (Cuvier)8. *Aspideretes hurum* (Gray)

Order III. : SQUAMATA

Suborder II : SAURIA

Family 5. : VARANIDAE

Genus (8) : *Varanus*9. *Varanus bengalensis* (Daudin)10. *Varanus flavescens* (Gray)11. *Varanus salvator* (Laurenti)

Suborder III : SERPENTES

Family 6. : COLUBRIDAE

Subfamily (A) : COLUBRINAE

Genus (9) : *Xenochrophis*12. *Xenochrophis piscator* (Schneider)

13. *Xenochrophis cerasogaster* (Cantor)

Subfamily (B) : HOMALOPSINAE

Genus (10) : *Cerberus*14. *Cerberus rhynchops* (Schneider)Genus (11) : *Enhydris*15. *Enhydris enhydris* (Schneider)Genus (12) : *Fordonia*16. *Fordonia leucobalia* (Schlegel)*Systematic Account*

Class : REPTILIA

Order 1 : CROCODYLIA

Family 1 : CROCODYLIDAE

Genus (1) : *Crocodylus* Gronovius, 17631. *Crocodylus porosus* Schneider

(Estuarine or Salt water crocodile)

1801. *Crocodylus porosus* Schneider, *Hist. Amphib.* 2 : 159.1931. *Crocodylus porosus* : Smith, *Fauna Brit. Ind.* 1 : 42.*Material examined* : 2 exs., Matla, Feb., 1878.

Diagnostic characters : 17-19 upper teeth on each side, four in each premaxillary in the adult. Snout $1\frac{2}{3}$ to $2\frac{1}{6}$ times as long as broad at the base. Four large nuchals forming a square, with a smaller one on each side. Dorsal armour of 6 to 8 longitudinal series of scutes. A strong ridge in front of eye, nearly half the length of the snout. No enlarged post-occipital scales. Colour dark olive or brownish above, interspersed with yellow which is distinctive of this species.

Distribution : Hugli-Matla Estuary : *as stated in the material.* *Elsewhere* : It has an extensive distribution, ranging from Sri Lanka, the east coast of India, also the Andaman and Nicobar Islands and also the countries of south-east Asia.

Remarks : It inhabits tidal estuaries of the larger continental rivers, marine swamps and coastal and brackish lakes. The species is seriously endangered, largely from loss of habitat, particularly breeding sites.

Status : Protected under Schedule I of the Indian Wildlife (Protection) Act, 1972. Several breeding centres in Andhra Pradesh, Tamil Nadu, Orissa and West Bengal are successfully rearing this species. This crocodile breeds readily in captivity.

Order II TESTUDINES

Suborder (i) CRYPTODIRA

Keys to Families of order Testudines

1. Digits elongated.....CHELONIIDAE
 Digits not elongated 2
2. Forelimbs semi-paddle-shaped with 3 claws; carapace covered with smooth skin TRIONYCHIDAE

 Forelimbs paddle-shaped with more than 3 claws; carapace covered with horny shields
 EMYDIDAE

FAMILY 2. CHELONIIDAE

Genus (2) *Lepidochelys*, Fitzinger, 1843.

2. *Lepidochelys olivacea* (Eschscholtz) (Olive Ridley Turtle)

1829. *Chelonia olivacea* Eschscholtz, *Zool. Atlas* : 2 Pl. 3

1843. *Lepidochelys olivacea* : Fitzinger, *Syst. Rept.* : 30.

Material examined : 1 ex., Matla estuary, Asiatic Society of Bengal collection.

Diagnostic characters : Carapace with 6 or more scutes; bridge with 4 inframarginals; each inframarginal is provided with pores on the hinder margin; single claw present on each flipper. Dorsal colour grey to olive-green.

Distribution : Hugli-Matla estuary : *as stated in the material*. *Elsewhere* : The olive ridley is widely distributed in the tropics and subtropics, especially along shallow coastal waters with muddy bottom, high in detritus and low in salinity. It is the commonest turtle along the Indian coasts.

Remarks : There is a little information about its habits and behaviour. In captivity it feeds on dead fish, crabs and other crustacea, and soft parts of molluscs.

Status : Common. Protected under Schedule I of the Indian Wildlife (Protection) Act of 1972.

Family 3. EMYDIDAE

Genus (3) *Geoclemys*, Gray, 18553. *Geoclemys hamiltonii* (Gray)
(Spotted pond turtle)1831. *Emys hamiltoni* Gray, *Syn. Rept.* : 21,1931. *Geoclemys hamiltonii* Smith, *Fauna Brit. Ind.* 1 : 111-112.*Material examined* : 1 ex., Matla river, 11.v. 1870.

Diagnostic characters : The head large, broad snout rounded, as long as the orbit and slightly projecting beyond the lower jaw. Skin of the posterior portion of head is divided into large shields. Carapace with three well-defined keels. Plastron nearly as long as carapace, deeply notched at the back. Colour jet-black above, spotted and streaked with yellow.

Distribution : Hugli-Matla Estuary : *as stated in the material.* Elsewhere : The species is restricted to the floodplains of the Indus-Brahmaputra-Ganga river system. Records are available from Sind (Pakistan) to West Bengal.

Remarks : The species is absolutely aquatic and prefers to live in quite shallow and clear water with plenty of aquatic vegetation. Its diet mainly consists of snails. Nothing is known about its breeding habits.

Status : This attractively patterned turtle is poorly known, despite of its fairly wide range, possibly due to anthropogenic pressures on standing water bodies along the major river system where intensive agriculture is practised.

Genus 4. *Batagur* Gray, 1855.4. *Batagur baska* (Gray)
(River Terrapin)1831. *Emys baska* Gray, *Syn. Rept.* : 241879. *Batagur baska* : Anderson, *Zool. Res. W. Yunnan* : 771. pls 66-671931. *Batagur baska* : Smith, *Fauna Brit. Ind.* 1 : 134-135*Material examined* : 1 ex., Hugli river, Oct, 1872., Coll. J. Anderson.

Diagnostic characters : The head comparatively small with an upturned, pointed and strongly projecting snout. Skin of the posterior part of head divided into small shields. Carapace smooth, shining, sub-truncated anteriorly, rounded posteriorly, heavy and moderately depressed.

Distinguished from other terrapins by the presence of only four, instead of five claws on the forelimb.

Distribution : Hugli-Matla Estuary : *as stated in the material. Elsewhere* : Its distribution is restricted to the estuaries of the river Ganga and Brahmaputra, known from the Sunderbans, and also the Bhitarkanika area (Brahminy-Baitarani delta) and the mouth of the Subarnarekha river. Das (1987) recorded some specific localities in the Sunderbans like Kanak, Nagbarachar, Kedo and Mechua where the species nests in India.

Remarks : It occurs in the mouth of rivers that are under tidal influence and mangrove-dominated.

Status : The species is endangered over much of its range, on account of large scale exploitation for its eggs and flesh for food. Species is protected under Schedule I of the Indian Wildlife (Protection) Act, 1972.

Family 4. TRIONYCHIDAE

Key to genera of family TRIONYCHIDAE

1. Plastron with a cutaneous femoral valve LISSEMYS
Plastron without cutaneous femoral valve 2
2. Orbit nearer the temporal than the nasal fossa ASPIDERETES
Orbit nearer the nasal than the temporal fossa.....PELOCHELYS

Genus (5). *Pelochelys* Gray, 1864.

5. *Pelochelys bibroni* (Owen) (Asian Giant Softshell Turtle)

1853. *Trionyx bibroni* Owen, *Cat. Osteol. Ser. R. Coll. Surg.* 1 : 185

1931. *Pelochelys bibroni* : Smith, *Fauna Brit. Ind.* 1 : 160-162.

Material examined : 1 ex., Hugli river, Coll. Dr. N. Annandale.

Diagnostic characters: Anterior of shell poorly defined, grading smoothly into skin of neck; carapace very flat; proboscis, a thin nubbin; head and shell unpatterned or with a scattering of small dots and dashes.

Distribution : Hugli-Matla Estuary : *as stated on the material. Elsewhere* : The species has been reported from both east and west coasts of India. Its distribution in India includes : West

Bengal (Hugli river), Orissa (Udaipur, Chandrabali Chaur, Mahadevi Adiya), Kerala (Trivandrum), Tamil Nadu (Palk Bay of Mandapam).

Status : This species, though rare in many other parts of this subcontinent, appears to be not uncommon in Orissa, where large numbers are killed for consumption in the northern parts of this state along the rivers Subarnarekha and Kharasrota and in the vicinity of Gahirmatha. It is protected under Schedule I of the Indian Wildlife (Protection) Act, 1972.

Genus (6) *Lissemys* Smith, 1931

6. *Lissemys punctata andersoni* (Webb)
(Indian Flapshell turtle)

1789. *Testudo punctata* Bonnaterre, in Daubenton's Tab. Encycl. Meth., Erpet : 30, Pl. 6.

1931. *Lissemys punctata purctata* smith, *Fauna Brit. Ind.* 1 : 157-159

Material examined : 1 ex., Hugli river. 3. vi. 1870, Coll. Anderson.

Diagnostic characters : Distinguished from all other freshwater species of Indian turtles by the presence of skin flaps on the plastron for hiding hindlimbs and tail. Shell low domed, oval in adults, almost circular in the young. Shell bones finely granular, eight pairs of coastal plates, the last pair meeting medially. Head oval terminating in tubular nostrils. Digits fully webbed. Carapace olive-brown. Plastron yellowish or white.

Distribution : Hugli-Matla Estuary : *as stated in the material.* Elsewhere : Tamil Nadu, Orissa, Goa, Bihar, Gujarat, West Bengal, Karnataka, Madhya Pradesh, Andhra Pradesh, Punjab, Rajasthan and Andamans.

Remarks : The subspecies prefers to live in shallow, muddy ditches, lakes and marshes. It is a carnivorous species and feeds mainly on frogs, fishes, shrimps and snails.

Status : The species is, for inexplicable reason, protected under Schedule I of the Indian Wildlife (Protection) Act, 1972.

Genus (7) *Aspideretes* Geoffroy, 1809

Key to species of genus Aspideretes

Alveolar surface of mandible raised at its inner margin *Gangeticus*

Alveolar surface of mandible not raised at its inner margin *Hurum*

7. *Aspideretes gangeticus* (Cuvier)
(Indian Softshell-Turtle)

1824. *Trionyx gangeticus* Cuvier, *Oss. Foss.* 5 : 186..

Material examined : 1 ex., Hugli river

Diagnostic characters: Alveolar surface of mandible raised at its inner margin. Head comparatively large and broad with dorso-laterally situated eyes and quite thick and somewhat elongated proboscis. Snout equal to the diameter of the orbit. Limbs with three claws. Tail short. Dorsal colouration olive green; carapace dull olive or greenish with irregular dark reticulations; plastron ivory white; head greenish, with a black longitudinal streak from between the eyes on to the nape and three oblique black streaks on either side diverging from it; another streak starting from behind the eye.

Distribution : Hugli-Matla Estuary : *as stated in the material. Elsewhere* : Its range includes the drainages of the Indus, Ganga and Mahanadi among the larger river systems, and also includes the Bhogava, Viswa Mitri, Tapi Luni and Purna river systems.

Remarks : As a carnivorous species it is attracted to rotting flesh. It is a very prominent scavenger also. A large numbers are caught and sold for food.

Status : It is covered under Schedule I of the Indian Wildlife (Protection) Act, of 1972.

8. *Aspideretes hurum* (Gray)
(Indian Peacock Softshell Turtle)

1831. *Trionyx hurum* Grey, *Syn. Rept.* : 47.

Material examined : 1 ex., Gangetic delta, vi. 1872, Coll. W.H.Hayes.

Diagnostic characters : Alveolar surface of mandible not raised at its inner margin. Head large with snout strongly downturned; several longitudinal rows of tubercles on the posterior of the carapace. Carapace olive with a yellow rim. Plastron light grey. Head and limbs olive; head with black reticulations and large orange or yellow patches, especially across snout and over the tympanic region, behind the eyes.

Distribution : Hugli-Matla Estuary : *as stated in the material. Elsewhere* : Widespread in the northern part of the Indian subcontinent, inhabiting in the drainages of the Ganga, Brahmaputra and Subarnarekha rivers.

Remarks : The species is markedly aquatic and omnivorous.

Status : The species has become endangered on account of habitat loss and by the predation of man and animals for food. It is protected under Schedule I of the Indian Wildlife (Protection) Act of 1972.

Order : SQUAMATA
Suborder (ii) : SAURIA
Family 5. : VARANIDAE
Genus (8) : *Varanus* Merrem, 1820

Key to species of genus Varanus

1. Nostril an oblique slit nearer to the orbit than to the end of the snout.....*Bengalensis*
 Nostril nearer to the end of the snout than to the orbit 2
2. Nostril an oblique slit; nuchal scales larger than those on crown of head; snout convex
 *Flavescens*
 Nostril round or oval; nuchal scales smaller than those on crown of head; snout depressed
 *Salvator*.

9. *Varanus bengalensis* (Daudin)
 (Indian Monitor)

1758. *Lacerta monitor* Linnaeus, *Syst. Nat. ed.* **10** : 201.

1932. *Varanus bengalensis* Smith, *J. Bombay nat. Hist. Soc.*, **35** : 615.

Material examined : 1 ex., Kakdwip, 12. xi. 1986. Coll. S.K.Talukdar.

Diagnosistic characters : Snout convex at the end, its length from two to two and a half times its height. Nostril an oblique slit nearer to the orbit than to end of snout. Scales on crown of head larger than the nuchal scales. Supraocular scales small, subequal. Digits elongates. Tail strongly compressed, with low double-toothed crest above. Adult olive grey, or brownish above with sparse black spots, yellowish below, uniform or flecked with black.

Distribution : Hugli-Matla Estuary. *as stated in the material.* *Elsewhere* : Distributed throughout the Indian subcontinent.

Remarks : It lives in all biotops, swim well and can remain submerged for a considerable time. Eats any animal it can overcome. Its food items which include small mammals, bird, bird's egg, eggs of crocodiles, small turtles, lizards and snakes, fish, crabs and prawns.

Status : The population of the Indian monitor is suspected to be threatened on account of killing and over-exploitation of the adult for their commercially valuable skin. It is protected under Schedule I of the Indian Wildlife (Protection) Act, of 1972.

10. *Varanus flavescens* (Gray)
 (Yellow Monitor)

1827. *Monitor flavescens* Gray, *Zool. Journ.* **3** : 226

1932. *Varanus flavescens*; Smith, *J. Bombay nat Hist. Soc.*, **35** : 616.

Material examined : 1 ex., Sagar Island, 12. ii. 1972, Coll Dr. A.K.Mukherjee.

Diagnostic characters : Snout short, convex, its length less than twice its height. Canthus rostralis distinct. Nostril an oblique slit, nuchal scales larger than those on crown of head. Median supraoculars slightly enlarged transversely; abdominal scales smooth. Digits short. Tail strongly compressed, with a low double-toothed crest above. Colour yellow or yellowish brown with broad red cross bands being are markedly evident during the rainy season but indistinct at other times of the year.

Distribution : Hugli-Matla Estuary : *as stated in the material.* Elsewhere : It occurs in the Gangetic Plain from Punjab to Bengal and is said to be common in Bihar.

Remarks : It is a very good swimmer and prefers to make burrows on muddy bunds around ponds, lakes and canals. Crabs and small fishes are its main food items.

Status : The population of the yellow monitor has greatly run down, as it has been exploited commercially for its beautiful skin. It is protected under Schedule I of the Indian Wildlife (Protection) Act of 1971.

11. *Varanus salvator* (Laurenti) (Indian Water Monitor)

1768. *Stellio salvator* Laurenti, *Syn. Rept. 2:*, Pl. 88, fig. 2.

1932. *Varanus salvator* : Smith, *J. Bombay nat. Hist. Soc.*, 35 : 616.

Material examined : 1 ex., Bisalakshipur, South 24-Parganas, 19. ix. 1975, Coll. S.K.Talukdar.

Domestic characters : Snout depressed at the end, its length at least three times its height; canthus rostralis obtuse. Nostril round or oval; nuchal scales smaller than those on crown of head. Median supraoculars transversely enlarged; dorsal scales keeled. Digits elongated. Tail strongly compressed with a low double toothed crest above. A fully grown lizard dark olive, indistinctly spotted with yellow; the young blackish, with small yellow and large rounded spots arranged in transverse rows.

Distribution : Hugli-Malta Estuary : *as stated in the material.* Elsewhere : It occurs in Orissa, Bengal, eastern India and Andaman Islands.

Remarks : It is the largest among the Indian monitor lizards. The most aquatic of Indian monitors and found in fresh as well as salt water. Frequents coastal estuaries are searched by these monitors for crustaceans and molluscs when the tide is out.

Status : This species is severely depleted in number and is at risk almost throughout its

range of occurrence. This lizard is protected under Schedule I of the Indian Wildlife (Protection) Act of 1972.

Suborder (iii) : SERPENTES

Family 6 : COLUBRIDAE

Subfamily (A) : COLUBRINAE

Genus (9) : *Xenochrophis* Gunther, 1864

Key to species of genus Xenochrophis

1. Maxillary teeth subequal *Cerasogaster*
 Maxillary teeth not subequal *Piscator*

12. *Xenochrophis piscator* (Schneider)

(Checkered Keelback)

1799. *Hydrus piscator* Schneider, *Hist. Amph.* 1 : 247.

1935. *Natrix piscator* Pope, *Rept. China* : 120.

1965. *Xenochrophis piscator* : Malnate, *Proc. Acad. nat. Sci. Philadelphia.*, 112 : 41-71.

Material examined : 1 ex., Ferryghat, Kakdwip, 16. ix. 1975; 1 ex., Bakkhali, 21. ix. 1975. Coll. S.K.Talukdar; 2 exs., Sagar Islands, Coll. A.K.Mukherjee, 1 ex., Bakkhali, 12. xi. 1974, Coll. Dr. Das.

Diagnostic characters : Head slightly flattened, distinct from neck; snout bluntly pointed; rostral wider than high; nostrils between nasals; single large loreal; eye with round pupil. 9-10 upper labials, fourth and fifth touching the eye; 10 lower labials. 19 scales at midbody; scales of lateral rows smooth, those of median rows feebly keeled. Maxillary teeth gradually enlarged posteriorly. Head olive-brown with two black streaks one below and one behind eye. Belly white or yellowish.

Distribution : Hugli-Matla Estuary : *as stated in the material.* Elsewhere : It is found throughout the Indian subcontinent.

Remarks : It is widely distributed in the Hugli-Matla basin. Its main food comprises small fishes and frogs.

Status : Available in abundance throughout its range.

13. *Xenochrophis cerasogaster* (Cantor)
(Dark bellied Marsh Snake)

1839. *Psamophis cerasogaster* Cantor, *Proc. Zool. Soc.*, : 52.

1864. *Xenochrophis cerasogaster* : Gunther, *Rept. Brit. Ind* : 274.

Material examined : 3 exs., Lower Bengal.

Diagnostic characters : Maxillary teeth subequal. The head long, narrow, distinct from neck, flattened and with a bluntly pointed snout. Rostral square shaped, nostrils in the nasal; 1 pre-ocular, 3 or 4 post-oculars. 8 to 9 upper labials, 4 touching the eye; 9 to 11 lower labials. Coastal in 20 or 21 : 19 : 17 ; all dorsal scales keeled except 2 or 3 lateral rows. Colour olive-brown to green above, with or without more or less distinct darker spots; lower parts reddish.

Distribution : Hugli-Matla Estuary : *as stated in the material. Elsewhere* : It is distributed from lower Sind (Pakistan) to Bengal and Assam in India through the complete Hugli-Matla basin.

Remarks : The species is absolutely aquatic and inhabits the side streams, pools, marshes and ditches where plenty of aquatic vegetation is available. Its main food comprises the small fishes, shrimp and frogs.

Status : Available in abundance throughout its range.

Subfamily (B) HOMALOPSINAE

Key to genera of subfamily HOMALOPSINAE

- 1 Nasal separated by the internasal *Fordonia*
Nasal in contact with one another 2
2. Scales smooth *Enhydryis*
Scales keeled *Cerberus*

Genus (10) *Cerberus* Cuvier, 1829.

14. *Cerberus rhynchops* (Schneider)
(Dog-faced Water snake)

1799. *Hydrus rhynchops* Schneider, *Hist. Amph.* 1 : 246.

1864. *Cerberus rhynchops* Gunther, *Rept. Brit. Ind.* 279.

Material examined : 1 ex., Haldi camp, Sundarbans, South 24-Parganas, 17. ix. 1983, Coll. S.M.Ali.

Diagnostic Characters : Frontals partially and parietals entirely broken. Three or more rows of costals seen in ventral view, 2 internasals, 9 to 10 upper labials and 23 to 27 costals midbody. The head broader than neck and the nostrils and eyes situated high on head. The back grey with numerous black cross-bars being obscure in the forepart, but prominent on the hinder side. The belly pale yellowish, conspicuous black blotches or cross-bars.

Distribution : Hugli-Matla Estuary : *as stated in the material.* Elsewhere : This is an estuarine species extending along coasts of India and tidal rivers from Sind (Pakistan) to Chittagong and eastwards.

Remarks : A fairly common species of brackish waters of tidal river, creeks and estuaries and also the seas littoral. It feeds mainly on fish.

Status : Common.

Genus 11. *Enhydris* Sonnini and Latreille, 1802.

15. *Enhydris enhydris* (Schneider)
(Common Smooth Water Snake)

1799. *Hydrus enhydris* Schneider, *Hist. Amph.* 1 : 245.

1935. *Enhydris enhydris* : Pope, *Rept. China.* : 314.

Material examined : 3 exs., Sundarbans, South 24, Parganas, 3. viii. 1955., Coll. A.K.Mukherjee.

Diagnostic characters: The nasals in contact with the rostral, 21 or 23 costals at midbody; nostrils situated on the upper surface of the snout; eyes small and directed upwards; snout broad and rounded; 8 upper labials, 4th touching the eye and the last one is very small; dorsal colour brown, olivaceous, with a dorso-ventral stripe, which are bounded on either side by a pale stripe; head brown with light variegations with a light stripe on each side of the eye.

Distribution : Hugli-Matla Estuary : *as stated in the materials.* Elsewhere : An aquatic species frequently found in fresh and brackish water of North-east India, from coastal Andhra Pradesh to Uttar Pradesh.

Remarks : Its main food is fish but occasionally it takes frogs, toads and other small vertebrates available by the side of rivers.

Status : Available in abundance throughout its range.

Genus (12) *Fordonia* Gray, 1842.

16. *Fordonia leucobalis* (Schlegel)
(White-bellied Swamp Snake)

1837. *Homalopsis leucobalia* Schlegel, *Phys. Serp.* 2 : 345.

1890. *Fordonia leucobalia* : Boulenger, *Fauna Brit. Ind.* : 378

Material examined : 1 ex., Pirkhali, Sundarbans, 20. iii. 1975, Coll. M.L.Biswas.

Diagnostic characters : Nostril in the nasal; frontal much broader than the supraocular; 1 pre- and 1-2 post-oculars, 5 upper labials, 3rd touching eye, 5th longest; Colour greyish or brownish above, uniform or with small black spots in the young, Whitish or yellowish below.

Distribution : Hugli-Matla Estuary : *as stated in the material.* Elsewhere : Tidal rivers and coasts of Bengal, Burma (Myanmar), the Nicobar Islands.

Remarks : The species is entirely aquatic and are most active swimmers. The food mainly comprises fishes, shrimps, crabs and molluscs.

Status : Common.

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SUMMARY

The authors report here a total of 16 species under 6 families and 12 genera. Keys to the families, genera and species for field identification have been provided and status of all the species has been included.

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ECOLOGY OF THE HUGLI-MATLA ESTUARINE SYSTEM

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INTRODUCTION

The Hugli estuarine System, which is constituted by the first offshoot of river Ganga—the Bhagirathi, flows southwards through the lower Ganga deltaic plane and joins Bay of Bengal in Sunderban. It is one of the most important estuarine system of the country because of (1) its origin from the largest mountain river, (2) heavy monsoonal discharge from a very vast basin and (3) very long tidal Zone. Being a very active tidal estuary, it has physico-chemical and biological characteristics of its own. The main estuary is classified as a positive estuary in the mixohaline range (Pantalu, 1967) where mixing of freshwater and regular tidal influxes have created a steady gradient from marine to freshwater conditions. This gradient is mainly governed by the amount of freshwater discharge during different seasons of the year. The estuary is further characterized by the heavy load of silt and suspensoids which it carries almost throughout the year. This complex and changing nature of the estuary has its bearing on the faunal occurrence and abundance during different seasons of the year and in different gradient Zones.

Not very long ago, the fishery resources of the estuary were quite rich and a number of commercially important species of fishes and prawn, particularly the highly esteemed hilsa and mullets were captured in sufficient numbers. Besides, it also provided suitable spawning ground to a number of migratory species. However, due to increased silt deposition and reduced discharge from feeder rivers, discharge of large amount of industrial effluents and domestic sewage from a number of industries and urban centres and drawl of huge amount of water, both for human consumption and industrial requirements have considerably altered the condition of the estuary, specially in middle Zone.

The studies on the hydrology, general plankton ecology and fisheries of this estuarine system had been carried out by some earlier workers. Ray (1945, 1949) initiated the studies in this direction by investigating the hydrology and phytoplankton ecology in a small stretch of the estuary near Palta in upper Zone. This was followed by an extensive survey of 108 Km stretch of the estuary from Palta to Diamond harbour in lower region by Datta *et al.* (1954). Later on Bose (1960) reported the result of hydrological survey of the river between Tribeni and Kakdwip, covering a distance of 245 Km. Shetty *et al.* (1960) and Saha *et al.* (1975) reported the results of the work carried out on the entire estuary, covering a distance of 295 Km, including river Roopnarayan and upper Zone of River Matla. Gopalakrishnan (1971) made the biological zonation of the estuary and reported the occurrence and abundance of different planktonic groups and fishes. The studies on the industrial and domestic discharges and their impact on the physico-chemical and biological conditions of the estuary have also been made by a number of workers (Basu, 1966;

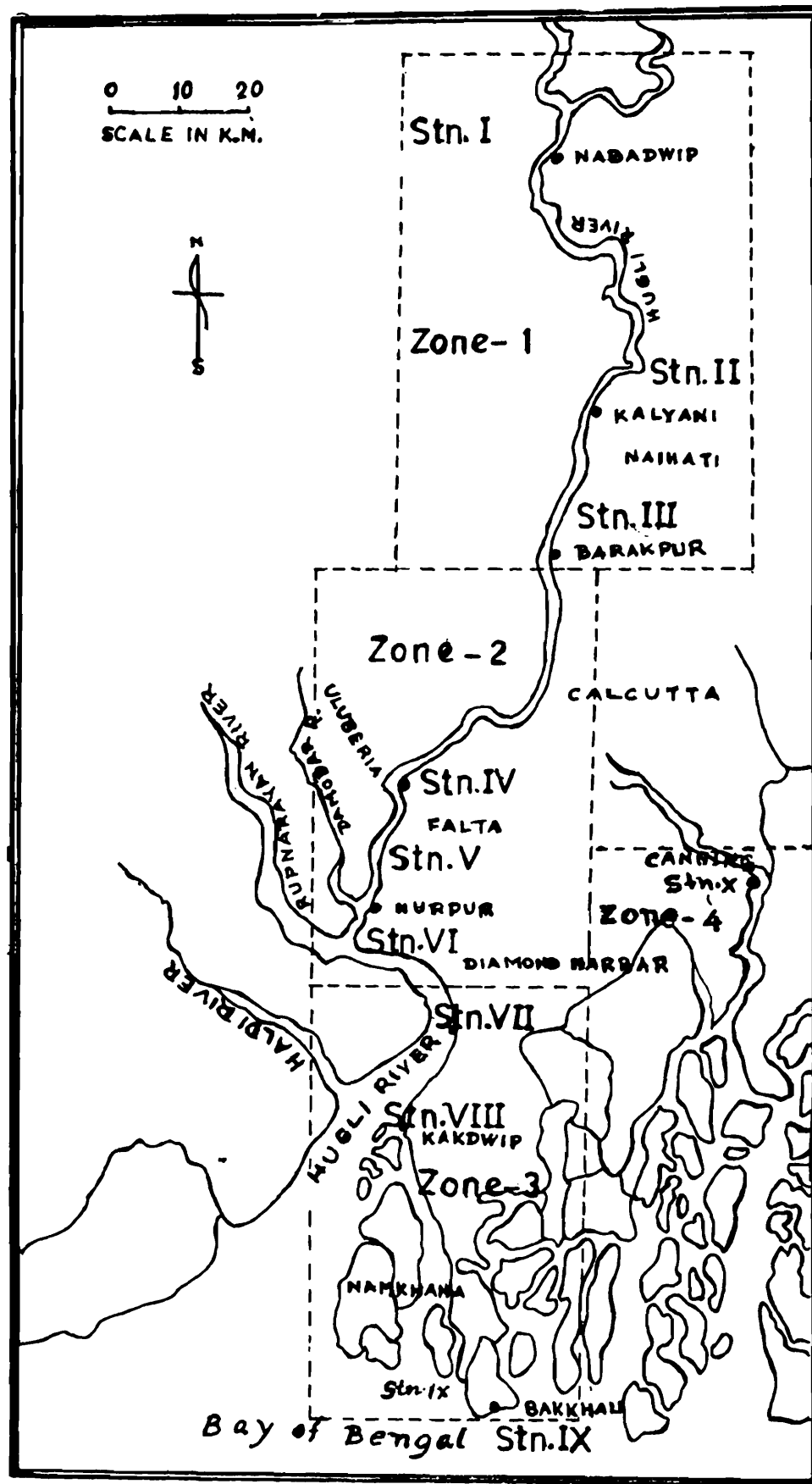


Fig-1 : Map of Hugli-Matla Estuarine region showing different Zones and stations.

Ghosh and Basu, 1968; Basu *et al.*, 1973; Ghosh *et al.*, 1973, 1976, 1979 and 1980; Ray *et al.*, 1979 and Ray, 1986). Bhunia and Choudhury (1981, 1982) and Baidya and Choudhury (1985) reported the detailed observations on the abundance and biomass of various zooplankton groups from a small area around Sagar island in the lower Zone of the estuary.

A close scrutiny of the literature revealed that while earlier studies carried almost 20 years ago, laid emphasis on hydrology and general distribution of different planktonic groups in the estuary without studying in detail the composition, occurrence, abundance and variations of different species and groups, the recent studies, though made an attempt in their direction, are confined to a very small area in the lower Zone. Therefore, the present investigations were undertaken in order to study the hydrological features of the entire estuarine system, its plankton, and benthos and their occurrence, abundance, production and variation with time and space alongwith the impact of important physico-chemical conditions of the estuary on biota. The present paper reports the consolidated results of the work carried out between the period 1986-1991 on different Zones of the estuarine system.

PHYSICAL FEATURES OF HUGLI-MATLA ESTUARINE SYSTEM

River Ganga, after traversing a distance of about 2,000 km, bifurcates near Farakka into a major offshoot Padma, which flows further eastwards to Bangla Desh and a minor offshoot Bhagirathi which flows southwards to Bay of Bengal through lower deltaic region of West Bengal. Almost in the middle of its course, near Nabadwip, it is further joined by two other small offshoots, Jalangi and Churni and enters the tidal zone where it is called as Hugli. The total length of tidal Hugli estuary is about 295 km and it lies between the latitude 21° 31' N and 23° 30' N and longitude 87° 45' E and 88° 45' E and covers the districts of Nadia, Hugli, North and South 24 Parganas, Howrah and Mednipur in West Bengal State (Fig. 1). In lower reaches it is further joined by several tributaries like Ajoy-Damodar, Roopnarayan and Haldi. Before meeting to Bay of Bengal, the estuary bifurcates near Sagar island into main estuary Hugli and river Muriganga which has got connection with river Thakurn and Matla, forming the Sunderban estuarine complex. The river Matla flows almost in the centre of the system. Since the river has lost its main freshwater connection, it becomes practically a backwater for major part of the year.

The catchment area of the estuary includes, besides areas falling along the main course of rivers Ganga and Bhagirathi, Santhal Parganas and Chotanagpur areas from where the freshwater drainage is received directly into the Hugli through the tributaries mentioned earlier. All these tributaries also bring huge amount of silt during monsoon season. The amount of annual freshwater discharge by rivers Ganga, Damodar and Roopnarayan into Hugli has been reported by Bose (1956) as 97,200, 162,00 and 6,21,000 million cubic feet respectively from the catchment area of about 11,900 sq. miles. Recently, Ghosh (1991) quoting Rao (1975) gave figures of annual discharge of different rivers along the Hugli estuary as indicated in Table 1. The discharge of freshwater in the estuary is highly variable and is chiefly governed by the rainfall in the catchment area. Highest discharge was noticed during peak monsoon months (July-August). After monsoon, the freshwater flow decreases considerably. During the drier months of pre-monsoon (March-June) the discharge is extremely low. Mean annual flow during different seasons recorded at Nabadwip is given Table 2.

The width and depth of the estuary are highly variable. Chakraborty and Banerjee (1966) who carried out detailed studies on the depth condition of the estuary with the help of echosounder between Bally Bridge and Tribeni in upper Zone, reported uneven muddy and sandy bottom and that the depth varied between 4.5 to 14.5 m during low tides. Bose (1956) reported that variations in maximum depth at high tides ranged between 91 ft. at Diamond harbour to 30 ft. at Calcutta. The approximate width and depth as reported by earlier workers are given in Table 3.

The tides in the estuary are always strong and variable. The onset and duration of this twice-a-day phenomenon differ considerably from day-to-day and from season to season. The duration of the high tides was always lesser than low tides. At an average these were in the ratio of 4 : 6 hrs, 4 : 5 hrs and 2.5 : 4 hrs during pre-monsoon, post-monsoon and monsoon months respectively. The lunar tidal cycle was distinctly divisible into spring and neap tide phases. The spring tide, which occurs during first half of the month, lasts for 12-13 day and neap tide phase, during the latter half extends for 14 days. The velocity of the spring tides was always considerably higher than neap tides (Table 4) during all seasons. The height of the bore tides, both during the flood and ebb, was always higher than that of the neap tide. The average water level above datum at Garden Reach, Calcutta during last several years are shown in Table 5.

THE CLIMATE

The climate in Hugli estuarine area was generally hot and humid during major part of the the year. Active monsoon covered almost 4 months (June to September) of the year. The climate of the area was chiefly influenced by the monsoon and seasons were classified as pre-monsoon (March-June), monsoon (Jule-October) and post-monsoon (November-February). The post-monsoon period was characterized by lowering of temperature during later part, which comprised the brief but moderate winter season of the area. The premonsoon period included the hot and dry period forming the summer season. The mean temperature and rainfall during different months based on the last 5 years record are given in Fig. 2. The ambient temperature remained moderately high throughout the year fluctuating around 30° C but for a brief spell of two months during December and January when it dropped to the minimum level of 20° C. The mean monthly rainfall figures showed that more than 74% of the annual rainfall occurred during the monsoon months. The mean annual rainfall was around 1700 mm.

HYDROBIOLOGICAL OBSERVATIONS

Description of the Study Stations

For the purpose of present study, the entire tidal stretch of the Hugli estuary and Matla estuary was divided into 4 distinct ecological Zones, following Gopalakrishnan (1971) with some modifications. These are (Fig. 1) :

- Zone— 1 Nearly freshwater Zone extending from Nabadwip to Barakpur.
- Zone— 2. True estuarine Zone from Barakpur to Diamond Harbour.

Zone— 3. Marine Zone from Diamond Harbour to the mouth in Bay of Bengal.

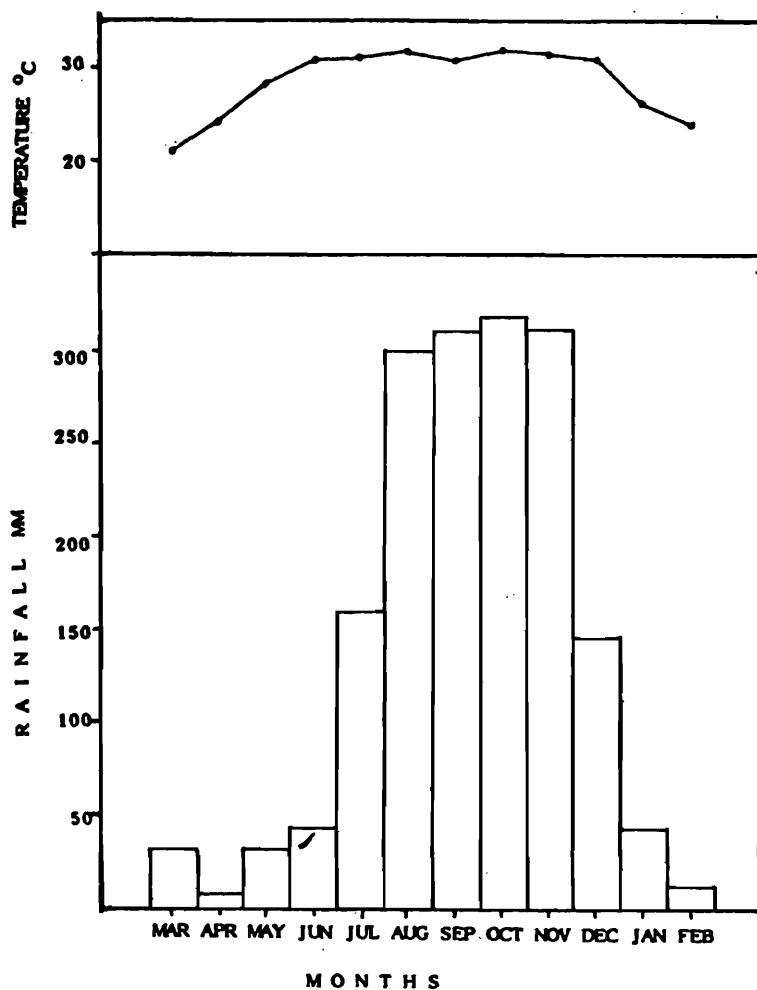


Fig-2 : Variations in monthly average rainfall and temperature.

Zone— 4. River Matla below Canning exhibiting marine conditions.

Ten different stations were selected for the present studies in the entire tidal stretch of the Hugli estuary covering all Zones and Matla estuary (Fig 1):

ZONE 1.

Station I. Nabadwip

Station II. Kalyani

Station III. Barakpur

ZONE 2.

Station IV. Uluberia/Achipur

Station V. Falta

Station VI. Nurpur

ZONE 3.

Station VII. Diamond Harbour

Station VIII. Harwood point

Station IX. Bakkhali (coastal water)

ZONE 4.

Station X. River Matla below Canning

MATERIAL AND METHODS

Investigations were carried out from all stations during different seasons, between the period 1986-91, as part of detailed biological studies of this estuarine system. All collected data were pooled and consolidated results are expressed under three main seasons viz. Pre-monsoon, Post-monsoon and Monsoon. The studies at station X was carried out intensively on monthly basis for detailed studies on the ecology and population dynamics of estuarine animals.

Water samples were collected from different depths with the help of Kremmer type water sampler. Soil samples of intertidal mudflat were collected by scrapping upper 15 cm layer with the help of a core sampler. Phytoplankton samples were collected by filtering 1-2 lit. of water through Whatman Filter paper No. 4 and preserved in Lugol's Iodin. Primary productivity studies were carried out by light and dark bottle method by hanging the bottles from anchored boats. Zoolplankton samples were collected with the help of plankton net made of bolting nylon No. 20 (mesh size 0.075 mm). For relative composition and qualitative studies the samples were collected by placing the net against the curent for about 10 minutes. For quantitative estimation, 100-200 l of water was filtered through the net. The filtered zooplankton were preserved in 4% neutral formalin. The macrobenthos were collected by placing a wooden quadrat frame of 0.25 m² into the substrate to a depth of 15 cm immediately after the water had receded during low tides. The epifauna were hand picked and the sediment so collected was washed through a sieve of 0.5 mm. All animals retained by the sieve were sorted out by putting small samples under low power bincocular or with the help a magnifying glass. The samples were preserved in 10% formalin. Meiofaunal samples were collected with the help of a metal corer of approx. 6.2 cm internal dia. and 20 cm length. This covered approximately an area of 30 cm². The samples thus collected were sieved through 0.500 mm and 0.062 mm brass sieves. The organisms retained on second sieve, representing the meiofauna were preserved in 5% formalin.

Physico-chemical analyses of water carried out as per established techniques. The temperature from different depths was recorded with the help of a reversible thermometer. Water

current was recorded by a current flow meter. The transparency and light penetration were determined using a Sacchi disc. pH and conductivity were determined with the help of electrical meters. The chemical analyses of the water followed the Standard methods (APHA 1975) and Strickland and Parson (1972). Soil samples were analysed for grain size as per the method of Krumbein and Pittijohn (1938). Organic carbon was estimated by the method of EL Wakeel and Riley (1956), Nitrogen by microjhelidal techniques of Barnes (1959) and Phosphate by Murphy and Riley (1962). Substrate temperature was determined by pushing a soil thermometer into the soft mud and dissolved oxygen and salinity were determined from interstitial water.

Phytoplankton samples were studied under a high power binocular microscope by taking 0.5 ml of the sample on a glass slide. Counting was done with the help of a maked glass slide counter. Similarly, zooplankton samples were also analysed and counted with the help of glass slide counter and a low powered binocular. The macrobenthos were sorted out into major groups, counted and expressed as no/m² as described by Hullings and Gray (1971). Meiobenthic samples were also similarly analysed and classified into major groups. They were expressed as number/10 cm². Plankton biomass was determined by estimating the wet weight of the samples after absorbing interstitial fluids with absorbant paper and expressed as mg/m². Determination of benthic biomass was done following methods of wet weight measurement. While collecting the samples all industrial and sawage out falls were avoided. Samples were collected at least .1 km away from any discharge point.

RESULTS

A. PHYSICOCHEMICAL

1. Water :

Water temperature : The mean annual temperature of the surface water varied between 20° C and 31° C revealing a difference of 11 degrees between minimum and maximum.

No significant differences were noticed in the temperature of different stations (Fig. 3). Similarly, the differences between the temperatures of surface, mid surface and bottom were also very little (0.5 to 1.0 degree). The seasonal fluctuation of water temperature followed a bimodal pattern with first peak during May-June and second during September-October. Minimum temperature was recorded during January. Except for this brief spell of low values, it was fairly high during rest of the year and fluctuated around 30°C. The water temperature in all Zones closely followed air temperature (Fig. 4). Water temperatures were slightly lower than air temperature at all stations throughout the year.

Transparency and Turbidity : The turbidity of the estuary was comparatively high throughout the year except during post-monsoon period when a drop was noticed during colder months. The turbidity as detrmind by Sachhi disc transparency at Station X (Fig. 4) showed that the water was compratively clear up to February, after which it started getting turbid steadily reaching to peak level during August. The turbidity was highest during monsoon in all other Zones too (Fig.3).

After the receding of monsoon, it started decreasing gradually. Marked spatial variations in the turbidity were noticed between different Zones. From Fig. 3, it can also be seen that highest

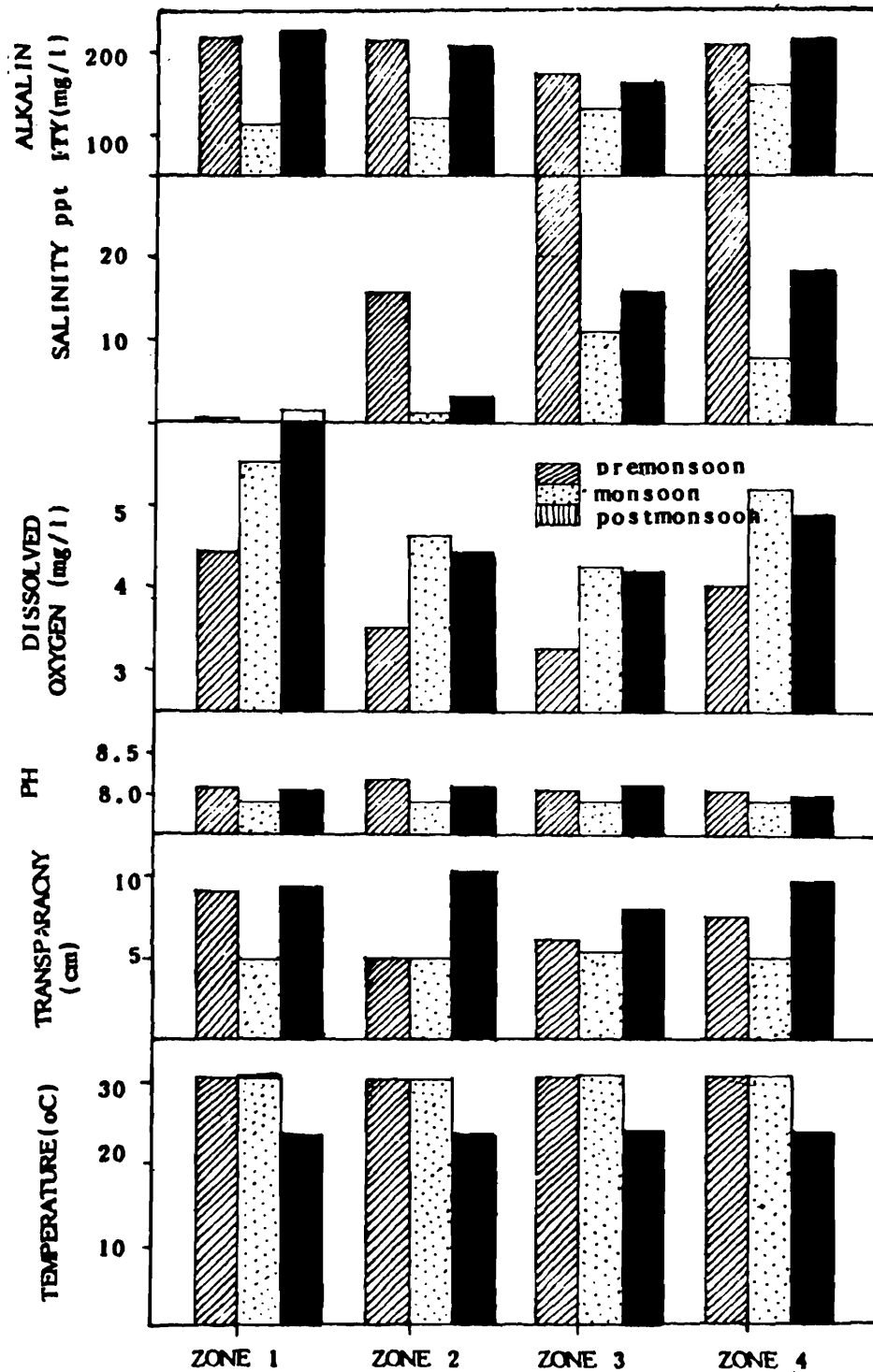


Fig -3 : Seasonal variations in physicochemical parameters of water in different zones.

transparency values were recorded in Zone-1 during pre and post-monsoon periods, followed by Zones 4 and 3. Zone—2 exhibited comparatively lower transparency values almost throughout the year.

pH : The pH values of the estuary remained almost constant and neither seasonal nor longitudinal differences were recorded (Fig. 3 & 4), except during peak monsoon months when a slight but insignificant decrease was noticed. It fluctuated around 8.1 ± 2 .

Dissolved Oxygen : The dissolved oxygen content of the estuary was moderate throughout the year and mean seasonal values varied between 4.20 and 6.20 mg/l in Zone—1, between 3.25 and 4.46 mg/l in Zone—2, between 3.25 and 4.25 in Zone—3 and between 4.0 and 5.1 in Zone—4. It may be seen from Fig. 3 that there was a gradual decrease in dissolved oxygen content from Zone—1 to Zone—3. Highest values were recorded in post-monsoon period. The monthly values at Station X, Zone—4, also fluctuated similarly (Fig.4).

Alkalinity : Except during monsoon months, when a general drop in the alkalinity values were noticed from all stations, it remained almost constant throughout the year in all Zones (Figs. 3 & 4.). No appreciable difference was noticed between Zones. The mean values ranged between 113 and 225 mg/l in Zone—1, 120 and 215 mg/l in Zone—2, 130 and 230 mg/l in Zone—3 and 127 and 228 mg/l in Zone—4. Highest values were recorded during pre-monsoon and lowest during post-monsoon periods.

Salinity : The salinity of the estuarine system varied widely between seasons and Zones (Fig. 3). Lowest salinity values were recorded from Zone—1, where water remained almost fresh throughout the year except during pre-monsoon period when a slight increase was noticed. Maximum variations in salinity was noticed in Zone—2. Lowest values were recorded during monsoon months which started increasing slowly during post-monsoon months. Rapid increase was noticed during pre-monsoon period and the values reached to its peak level of 20.3 ppt. during late pre-monsoon. Again following rains, the values dropped substantially during monsoon. Zones—3 and 4 exhibited comparatively higher salinity values almost throughout the year although a drop during monsoon was clearly evident. It varied between 10.9 ppt. and 29.45 ppt. in Zone—3 and between 9.1 and 31.2 in Zone—4.

When ratio between the mean minimum and mean maximum salinities were calculated, it was noticed that the fluctuation was highest in Zone—2 (14.7 times) as compared to Zone—3 (2.7 times) and Zone—4 (3.4 times). Not such variations were noticed in Zones 3 and 4, both of which exhibited nearly similar conditions.

Phosphate-P : The $\text{PO}_4\text{-P}$ concentration of the estuary was highest during monsoon months at all stations (Fig. 5). Mean seasonal values ranged between $0.8 \mu\text{g at P/m}^3$ to $3.2 \mu\text{g at P/m}^3$, minimum during premonsoon in Zone—1 and maximum in Zone—2 during postmonsoon period. Comparatively higher values were recorded from Zone—2 in all seasons. In Zone-4, the increased values were noticed during the period January-June (Fig-6).

Nitrate-N : The pattern of fluctuation in Nitrate-Nitrogen was almost similar to that of $\text{PO}_4\text{-P}$, being maximum in post-monsoon months and minimum during pre-monsoon months (Fig. 5). A clear upward trend was noticed from Zone—3 to Zone—1 in all seasons. In Zone—4, the variations were of similar magnitude (Fig. 6).

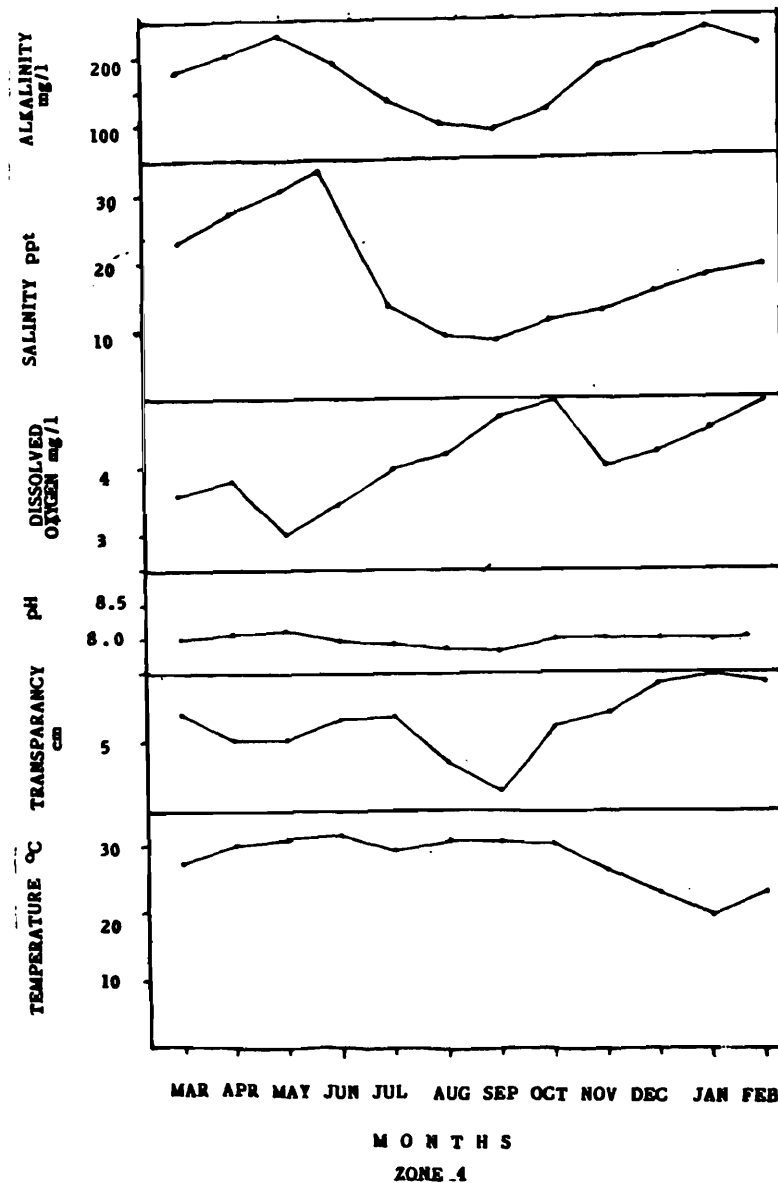


Fig-4 : Monthwise variations in physicochemical variations of water in zone-r.

2. Soil

Bottom Substrate : The bottom sediment of the Hugli-Matla estuarine system was mainly clayay silty with preponderance of silt. The concentration of silt increased gradually from Zone—1 to Zone—4. Table 6 gives the percentage composition of different particles in different Zones. While in upper Zone, the proportion of sand, clay and silt was of the order of 38.5 : 16.2 : 43.3 respectively, in Zone—3 it was 5.2 : 24.4 : 70.6. The condition in Zone—2 was also basically silty. Near the mouth of the estuary (Station IX-Bakkhali), sandy flats were noticed which contained approximately 88% of sand. However, such sandy bottom were not available anywhere in the main estuarine course up to station VIII. The proportion of sand and silt was almost equal in freshwater Zone—1.

Substrate salinity, Dissolved Oxygen and Temperature : The dissolved oxygen

contents and salinity of interstitial water and substrate temperature almost followed the pattern of water quality in all Zones. The temperature was always slightly lesser than water temperature. Wide fluctuations in D.O. content were noticed and the values ranged between 3.05 and 4.8 mg/l

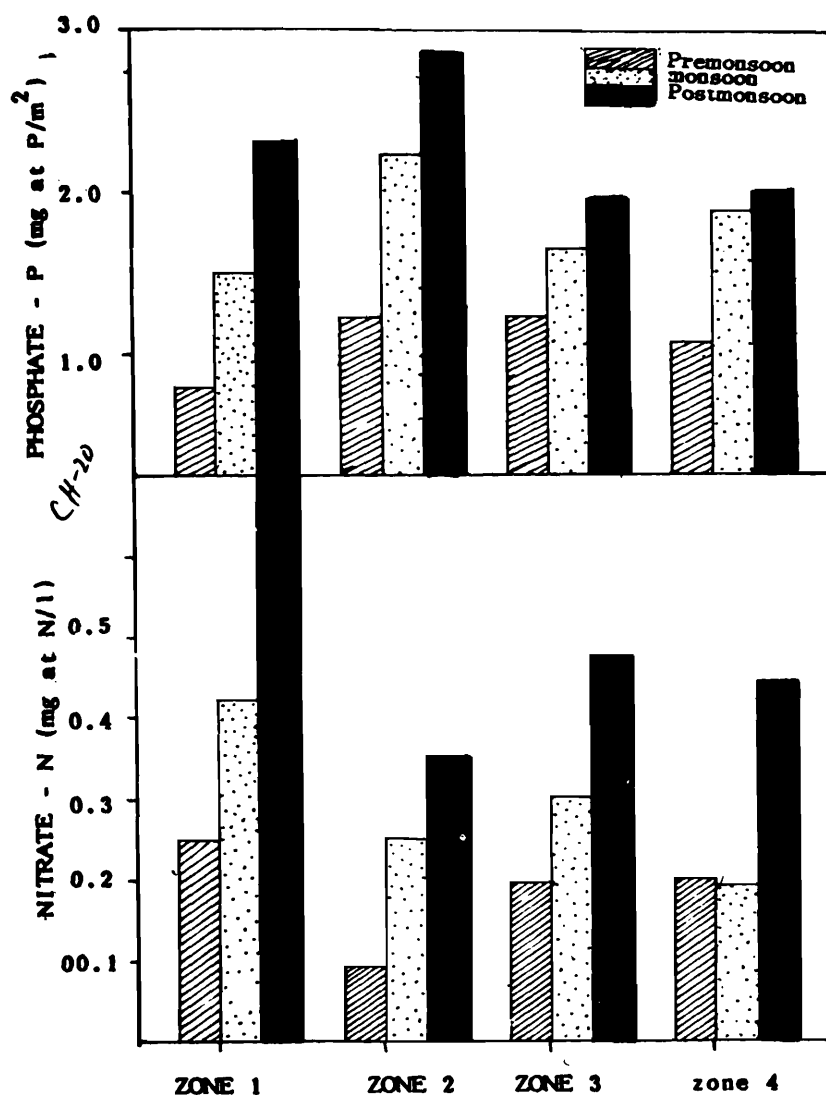


Fig-5 : Seasonal variations in Nitrate-N and Phosphate-P of water in different zones.

Highest values were recorded during post-monsoon. The variations in Zone—4 are shown in Fig. 7. Not much differences were observed in the salinity of the substrate from that of the open water, except that the substrate salinity was slightly higher during high saline period.

Sediment Organic Carbon : Organic carbon values of the sediments ranged between 0.52 and 1.91 mg C/g in Zone—1, 0.36 and 1.2 mg C/g in Zone—2 and 1.2 and 2.9 mg C/g in Zone—3 (Fig. 8). In Zone—4, values ranged from 0.75 (July) to 3.80 (August) (Fig. 9.). Fluctuations were almost similar at all stations with higher values during monsoon and post-monsoon period. The values were always high in Zones 3 and 4.

Sediment phosphahate-p : Seasonal values of sediment phosphorus varied between

0.005 and 0.31 mg P/g in Zone—1, between 0.012 and 0.052 in Zone—2 and between 0.09 and 0.075 mg P/g in Zone—3. Highest values were recorded during monsoon months and lowest

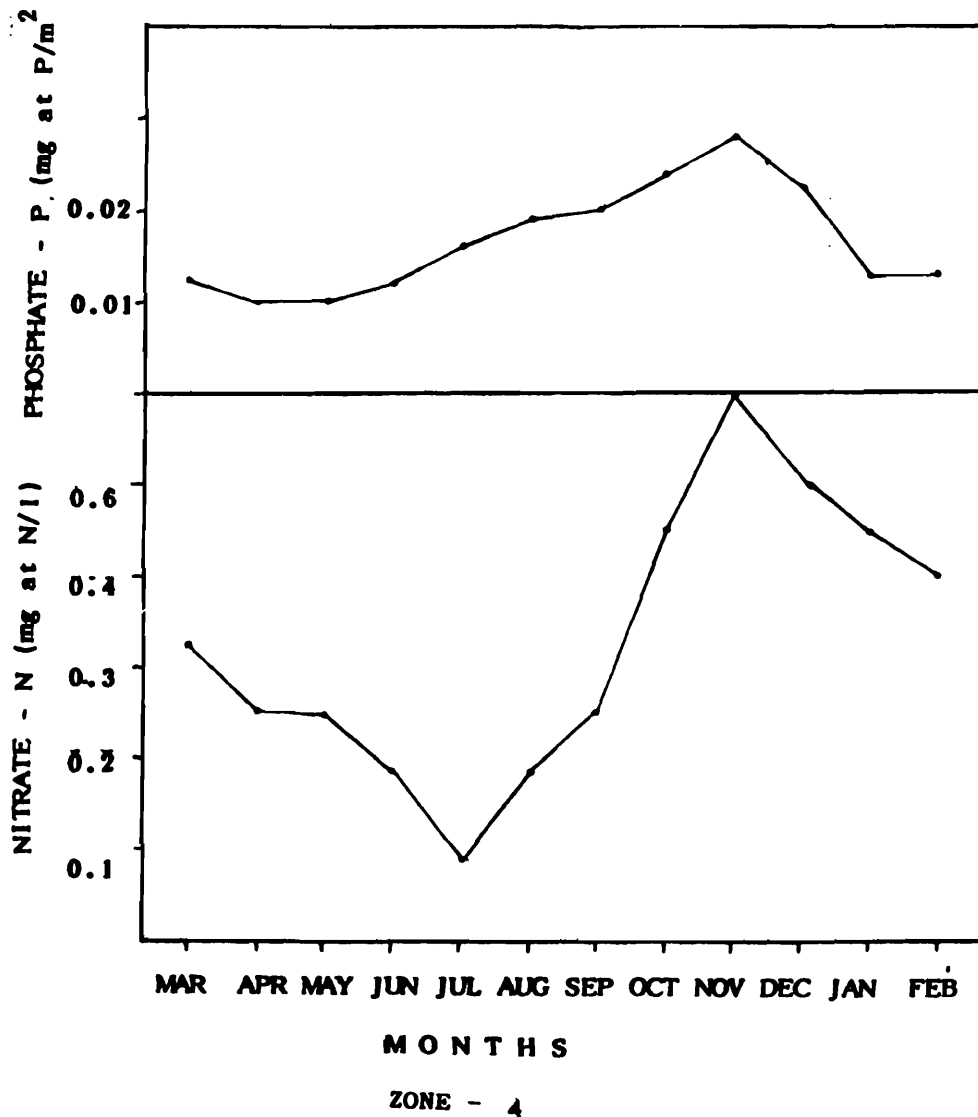


Fig-6 : Monthwise variations in Nitrate-N and Phosphate-P of water in zone-4.

during pre-monsoon from all stations (Fig. 8). The values of phosphorus, like organic carbon, also increased progressively from Zone—1 to 3. In Zone—4, the values shot up in July and remained high up to February.

Sediment Nitrate-nitrogen : Nitrate-N followed a little different pattern in different zones. But in general, values were sufficiently high in monsoon at all stations. However, the peaks were also obtained in both pre-monsoon (Zone—2) and post-monsoon (Zones 3 & 4), but the differences from monsoon were not large. A gradually decreasing trend was noticed from Zone—1 to 3. The values ranged from 0.50-1.18 mg N/g, 0.72-1.00 and from 0.40-0.95 mg N/g in Zones 1, 2, and 3 respectively. In Zone 4, the values increased suddenly during July and remained high upto February (Fig. 9).

B. BIOLOGICAL

1. Phytoplankton :

The phytoplankton of the Hugli estuarine system were constituted mainly by diatoms, followed by green algae, blue-green algae and flagellates. A total of 46 taxa, 22 of diatoms, 13 of

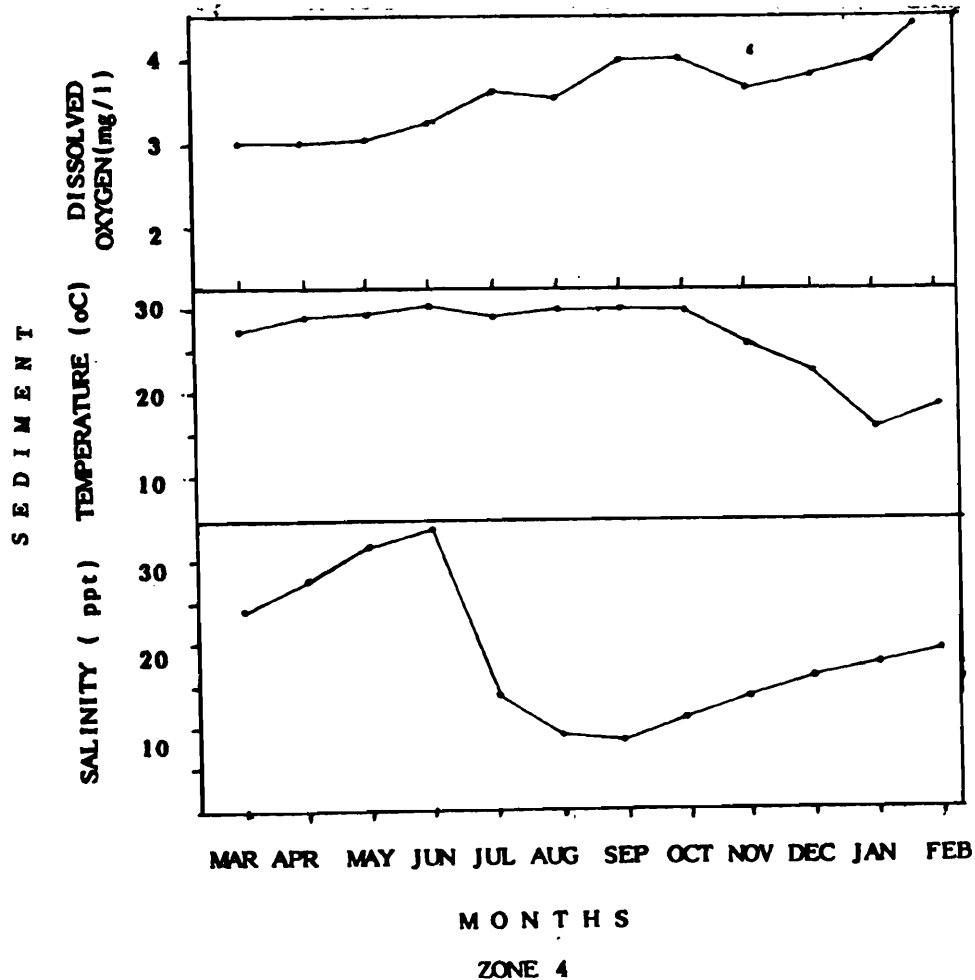


Fig-7 : Sediment salinity, Temperature and Dissolved oxygen in Zone-4.

green algae, five of blue green algae and six of flagellates were recorded during the course of present investigation from different Zones (Table. 7). However, the presence of many of the species was mostly insignificant as bulk of the phytoplankton composition was formed by only few diatom species in all Zones. It may be seen from Table 8 that only three or four species in each Zone contributed 65-82% of the total phytoplankton population during different seasons.

While a number of species were universal, occurring in all Zones, some others were highly specific and occurred only in particular Zone during particular season, which was mainly governed by their salinity preferences (Table. 7 and 8). The distribution of the phytoplankton species in this estuarine system revealed that no species is strictly freshwater or marine. They are either Freshwater-brackishwater, Brackishwater-marine or universal (Table. 9).

Relative composition studies revealed that diatoms were most important constituents in all Zones. While in Zones 3 and 4 their contribution was around 90%, in Zones 1 and 2 they

contributed to 75% and 82% (aprox.) respectively (Fig. 10). Green alage also contributed significantly to phytoplankton composition of Zone—1 (26.75) and Zone—2 (9.4%). They were

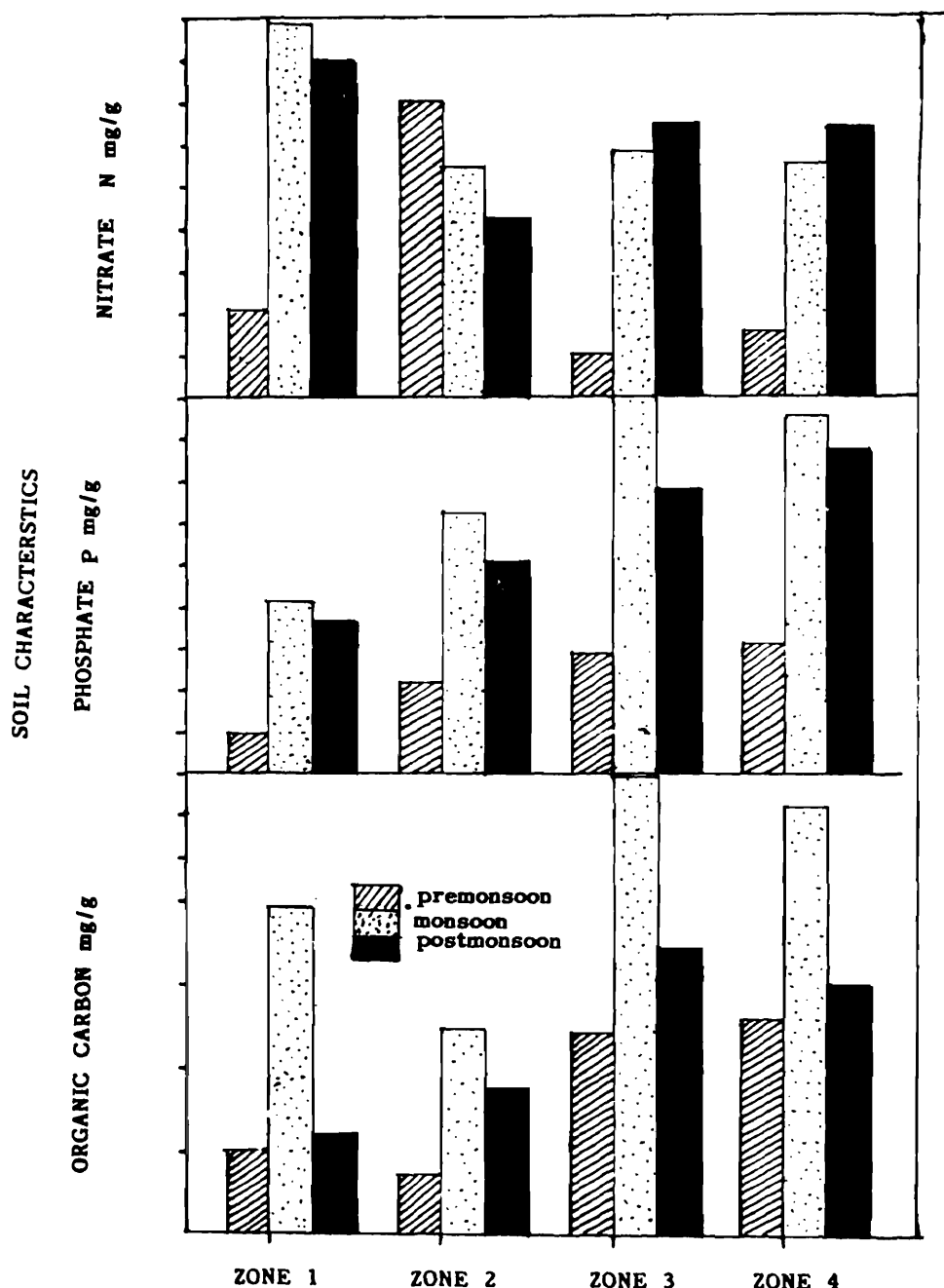


Fig-8 : Seasonal variations in organic carbon, Nitrate-N and Phosphate-P in different zones.

almost absent from lower regions of Zones 3 and 4 with high salinity content. The contribution of blue green alage was almost uniform in all Zones which varied between 6.10% in Zone—1 to 8.3% in Zone—4. The phytoflagellates were recorded in higher numbers from Zone—1 and their contribution varied between 1% and 2.5%. The ratio of different groups in different Zones almost remained constant throughout the year.

The seasonal variation studies revealed a bimodal pattern of abundance in all Zones with peaks in pre and post-monsoon seasons (Fig. 11). In Zone—4 (Fig. 12), the pre-monsoon peak, observed during April was very sharp as compared to post-monsoon peak noticed in December. Zone-wise analysis revealed the highest concentration in Zone 4 followed by Zones 3 and 1 and lowest in Zone 2.

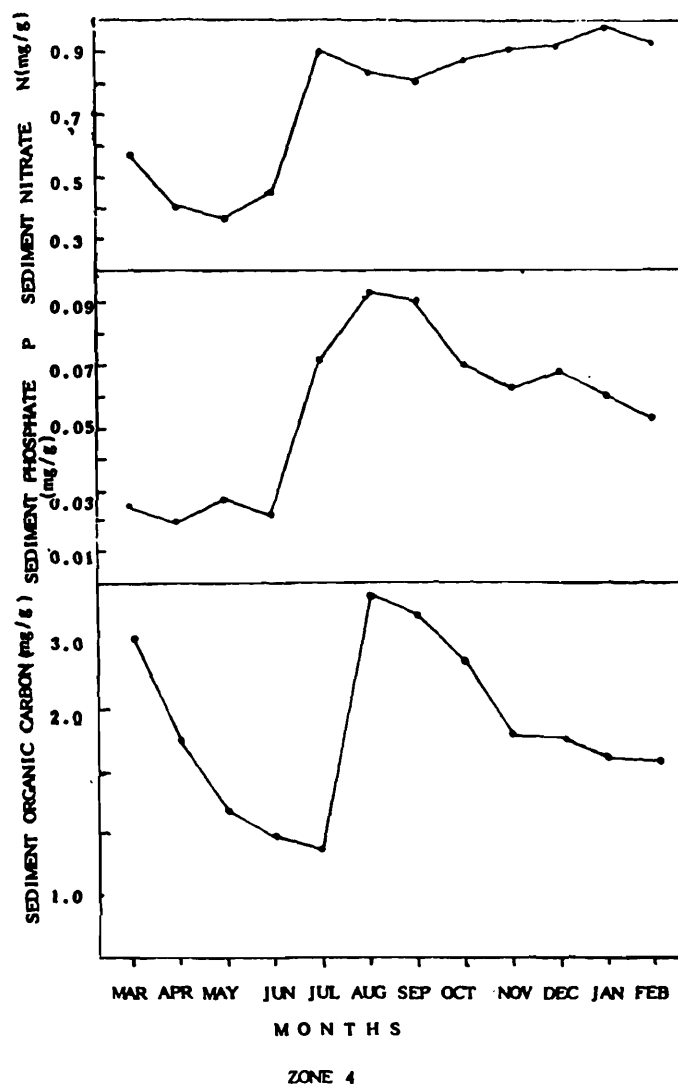


Fig-9 : Monthwise variations in sediment organic carbon, Nitrate-N and Phosphate-P in Zone-4.

2. Primary Productivity

The gross and net primary productivity, during different seasons and in different Zones, is depicted in Fig. 13. The primary productivity rate was considerably high in Zone—4, where gross values varied between—34.0 $\text{mgc/m}^3\text{-hr}$ in monsoon and 87.2 $\text{mgc/m}^3\text{-hr}$ (post-monsoon). The monthly variations at this Zone (Fig. 14) revealed three peaks, first in March, second in June and third in December. The December peak was very large showing the maximum productivity period. The gross productivity was always higher than the net productivity except during monsoon month when net productivity was slightly lower than gross in Zone—1. The productivity was also high

in Zone—3. Lowest rate was recorded from Zone—2.

3. Zooplankton :

The zooplankton of the Hugli estuarine system was both rich and diverse. The entire zooplankton fauna was divided into following groups:—

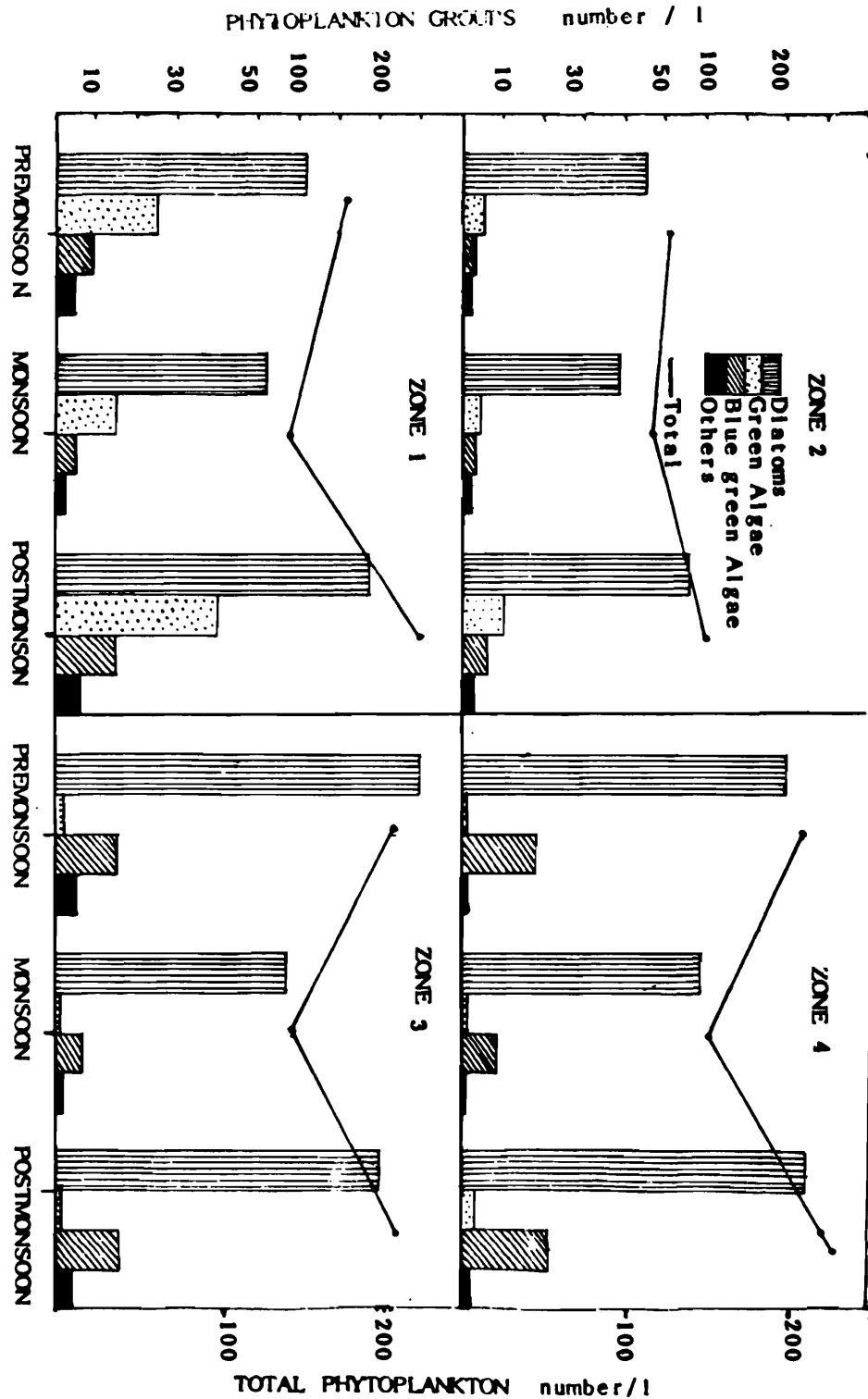


Fig-10 : Seasonal variations in total number of phytoplankton in different zones.

Hydromedusae : These were available only in lower Zones 3 & 4 (Fig. 15)) and their contribution to total zooplankton concentration was very little which varied between 1.22% (monsoon) and 2.0% (post-monsoon) in Zone—3 and between 1.22% and 1.90% in Zone—4 (Table 10).

Copepoda : Copepods were by far the most abundant group of zooplankton dominating in all Zones. The cycle of total zooplankton abundance was exclusively governed by them. Their contribution increased from Zone-1 to Zones 3 & 4. (Fig. 15). The average contribution varied between 52% in Zone—1 to nearly 90% in Zone—3. Their percentage composition was also high in Zone—2 (79%) and Zone—4 (86%). Among copepods, calanoids contributed to the bulk of zooplankton number and biomass.

Cladocera : This group was confined mainly to Zone—1, where at an average they contributed about 16% to the total zooplankton. They also occurred in Zone—2 but with reduced numbers (4.7%), and were totally absent from Zones—3 and 4 (Table 10, Fig. 15).

Rotifera : Like cladoceran, rotifers were also confined to freshwater Zone—1 where it contributed nearly 23%. Highest numbers were recorded during pre-monsoon months. In Zone—2, their annual mean composition was 5.26% (Table 10). They were also completely absent from Zones 3 and 4.

Chaetognatha : The chaetognaths were fairly common in Zone—3 and 4 in all seasons. However, their contribution to total numerical density was very little (1.7% in Zone—3 and 1.5% in Zone—4). They were never recorded from Zones 1 and 2.

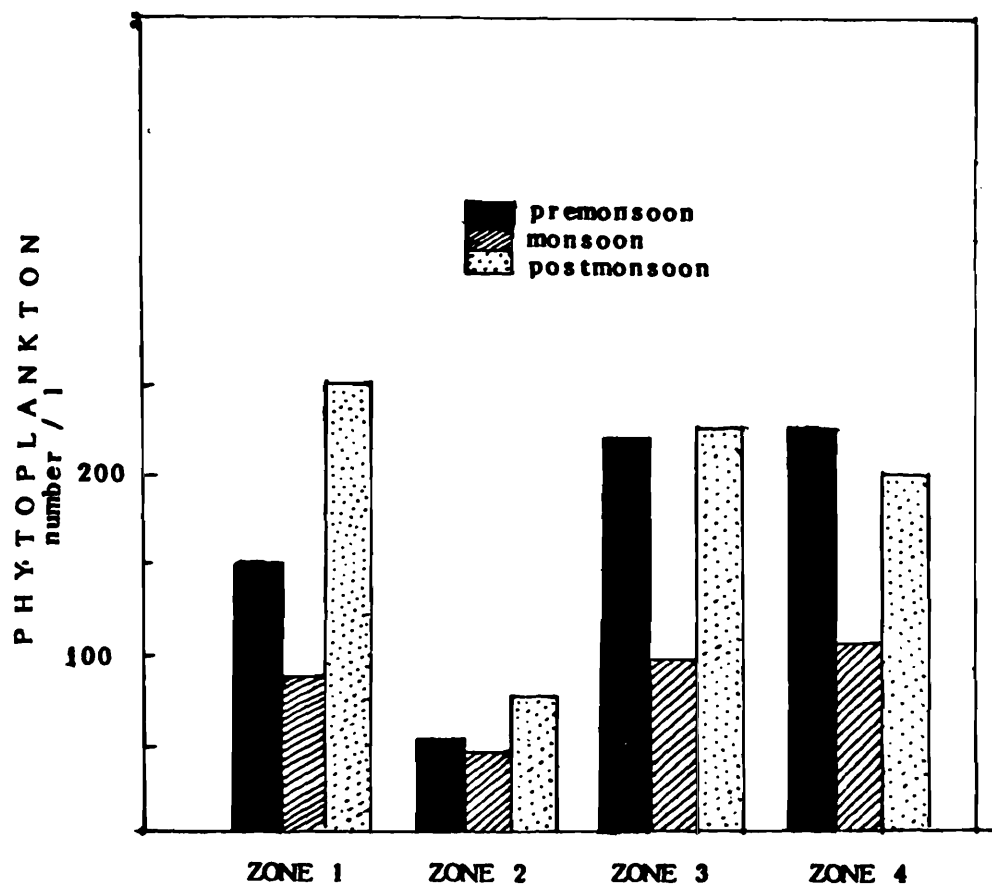


Fig-11 : Mean annual number of phytoplankton in different zones.

Decapod eggs and larvae : Decapod larvae, which mainly included larval and post-larval stages of panaeids and sergestid, were recorded throughout the year from lower Zones and

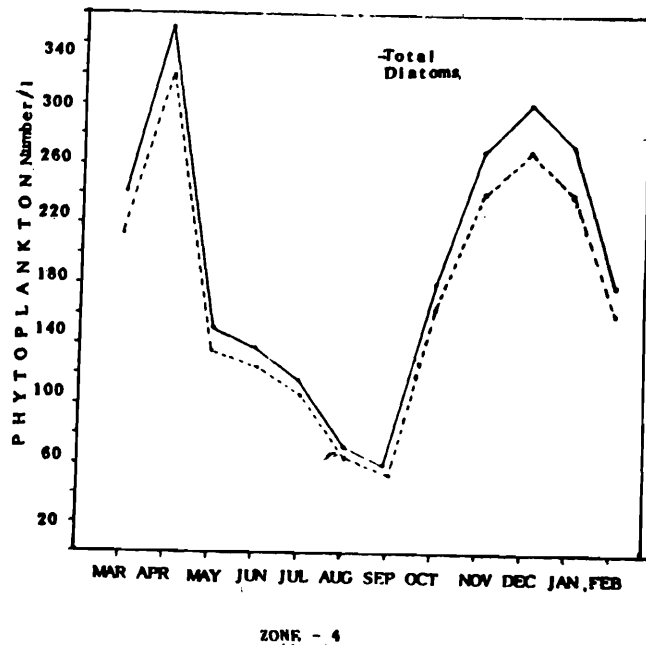


Fig -12 : Monthwise variations in total phytoplankton and diatoms in Zone-4

larvae of *Macrobrachium* sp. from upper Zones. Besides, Brachyuran larvae were also present in sufficient numbers in lower Zones. The contribution of this group was maximum in Zone—2 (4.5%).

Fish eggs and larvae : Like decapod eggs and larvae this group was also present throughout the year in all Zones and contributed nearly 3%.

Other groups : Many other groups such as cirripid larvae, Lucifer, mysids and amphipods etc. were also recorded in fair numbers from lower zones. In upper Zone insect larvae were fairly common.

Ostracods : They were available mainly in Zone 1.

The overall zooplankton density was always high in lower Zones. The mean population density varied between 2275/m² (monsoon) to 5235 (pre monsoon) in Zone—1, between 1130/m² and 3325/m² in Zone—2, between 2375/m² and 9436/m² in Zone—3 and between 2251/m² to 6444/m² in Zone—4 (Fig. 16). The biomass values closely followed the numerical values and ranged between 87.7 mg/m² (Zone—2, monsoon) to 377 mg/m² (Zone—3, pre-monsoon).

Like phytoplankton a bimodal pattern was also evident in zooplankton. In Zone—4, the concentration started to increase from the months of October onwards which culminated in peak concentration in December. This was followed by a drop in January. The number by again started to increase from February onwards till April when second peak was observed. The concentration

thereafter decreased and minimum values were found in August (Fig. 17). Biomass followed the same trend.

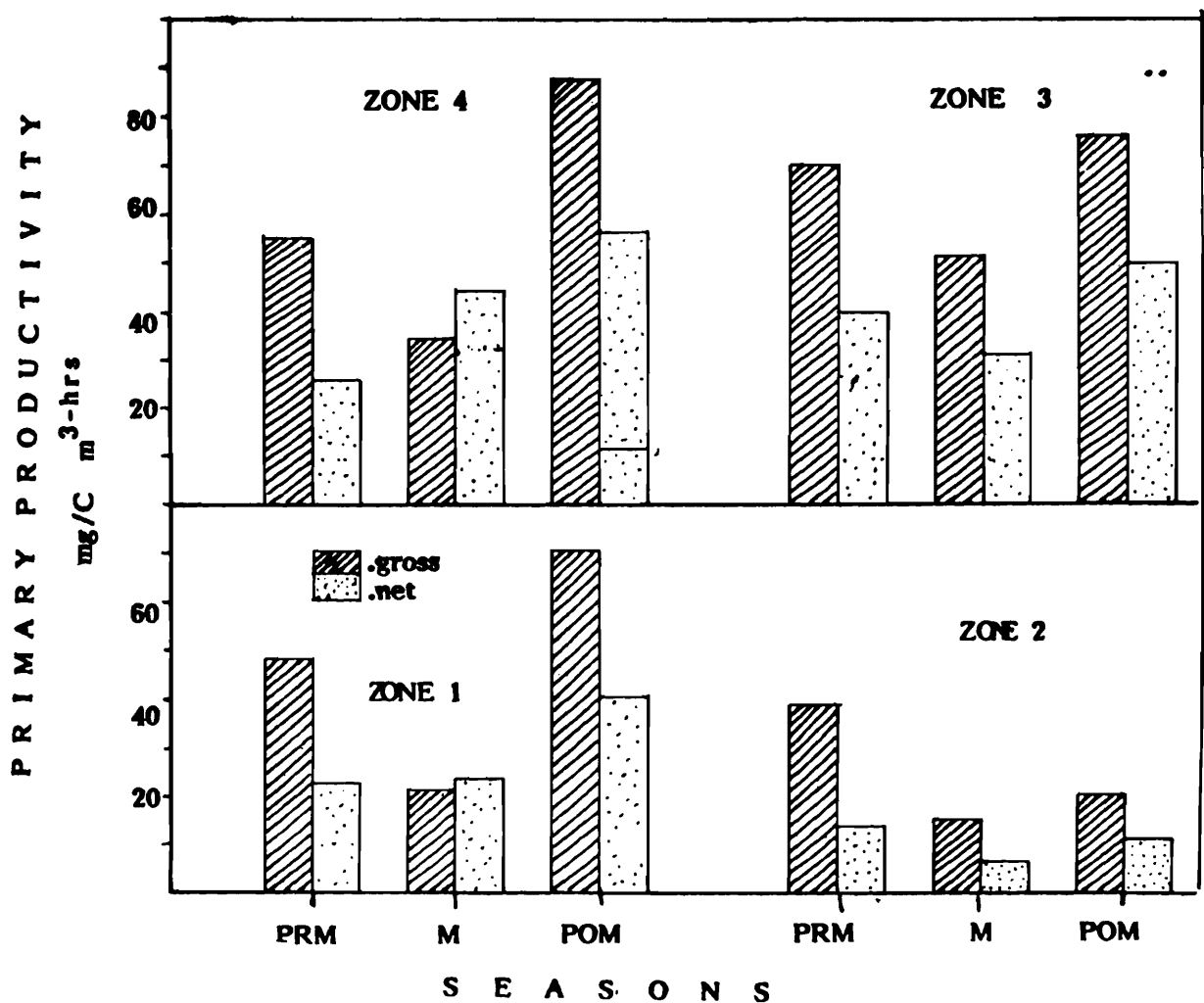


Fig-13 : Seasonal variations in primary productivity in different zones.

4. Meiobenthos :

Meiofauna of the Hugli-Matla Estuarine system was chiefly comprised of Nematodes, polychaetes, herpeticoid copepods, ostracodes and Foraminifera. In addition to these, some other groups like gastropods, oligochaetes and insect larvae were also recorded but their occurrence was very irregular and they never formed any significant component. Nematodes dominated the meiobenthic density in all Zones followed by herpeticoid copepods and polychaetes.

While nematodes contributed about 40% in Zone—1, their share in Zone 2,3, and 4, was 45%, 52% and 50% respectively. The share of Foraminifera was higher in Zone—1 than Zones 2 and 3. Polychaetes were highest in Zone—2 as compared to other Zones. Ostracodes were found

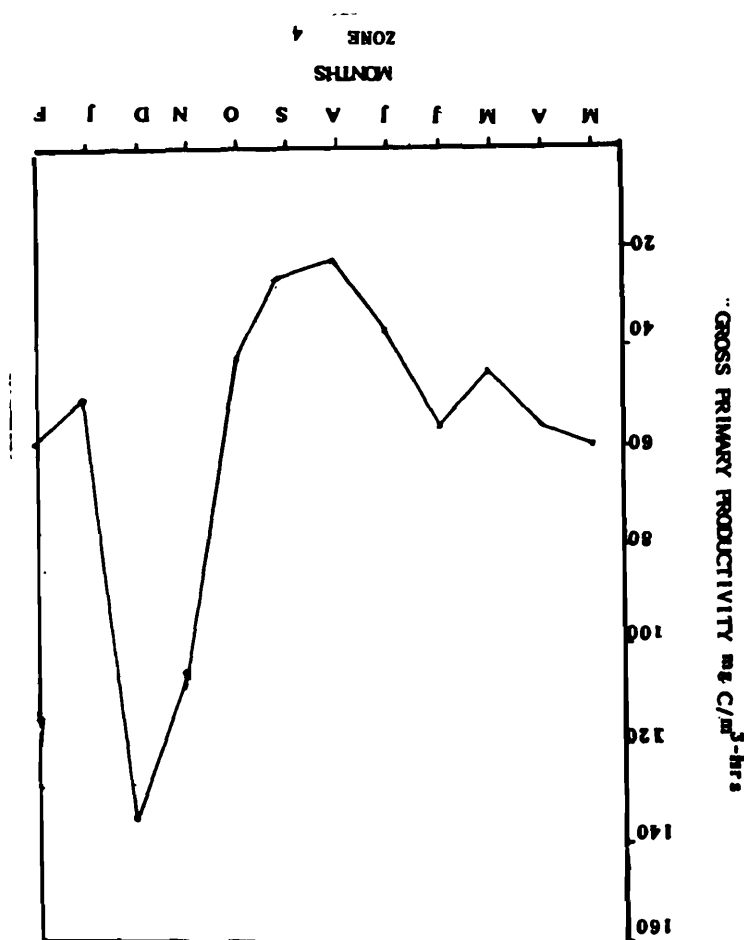


Fig-14 : Monthwise variations in primary productivity in zone-4.

only in Zone—1. Copepods occurred constantly in all Zones. Amphipods were found only in Zones 3 and 4. (Figs. 18 & 19).

Two peaks, first in late post-monsoon and second in early pre-monsoon were recorded. The detailed monthwise studies at station X (Zone—4) showed that density started to increase from October onwards till December and from February till April (Fig. 21). Both number and wet Weight biomass were highest in Zone—3 (935/10 cm² and 52.36 g/10 cm², during pre-monsoon) and lowest in Zone—2 (95/10 cm² and 4.0 g/10 cm², during monsoon) (Fig. 20). Values in Zone—4 were also high.

5. Macrobenthos :

The most abundant macrofaunal group was gastropods which constituted more than 55% of total macrobenthic population (Table 11). The other groups recorded were, Polychaeta (14.5%), Bivalvia (5%), and Brachyura (19.0%), all, except freshwater bivalves, from Zones 2, 3, and 4.

Besides these, other common groups of macrobenthos of lower Zones were, Anomura, Alphiediae, Actinaria, Nemartina and Asteroidea. In the freshwater Zone—1, oligochaetes represented by several species, specially *Tubifex tubifex* (Muller) and *Limnodrilus hoffmeisteris/Claparede* etc., were fairly common almost throughout the year. Among gastropods, while *Littorina melanostoma* Gray was the abundant species of Zones 2 and 1, three species dominated the composition in lower

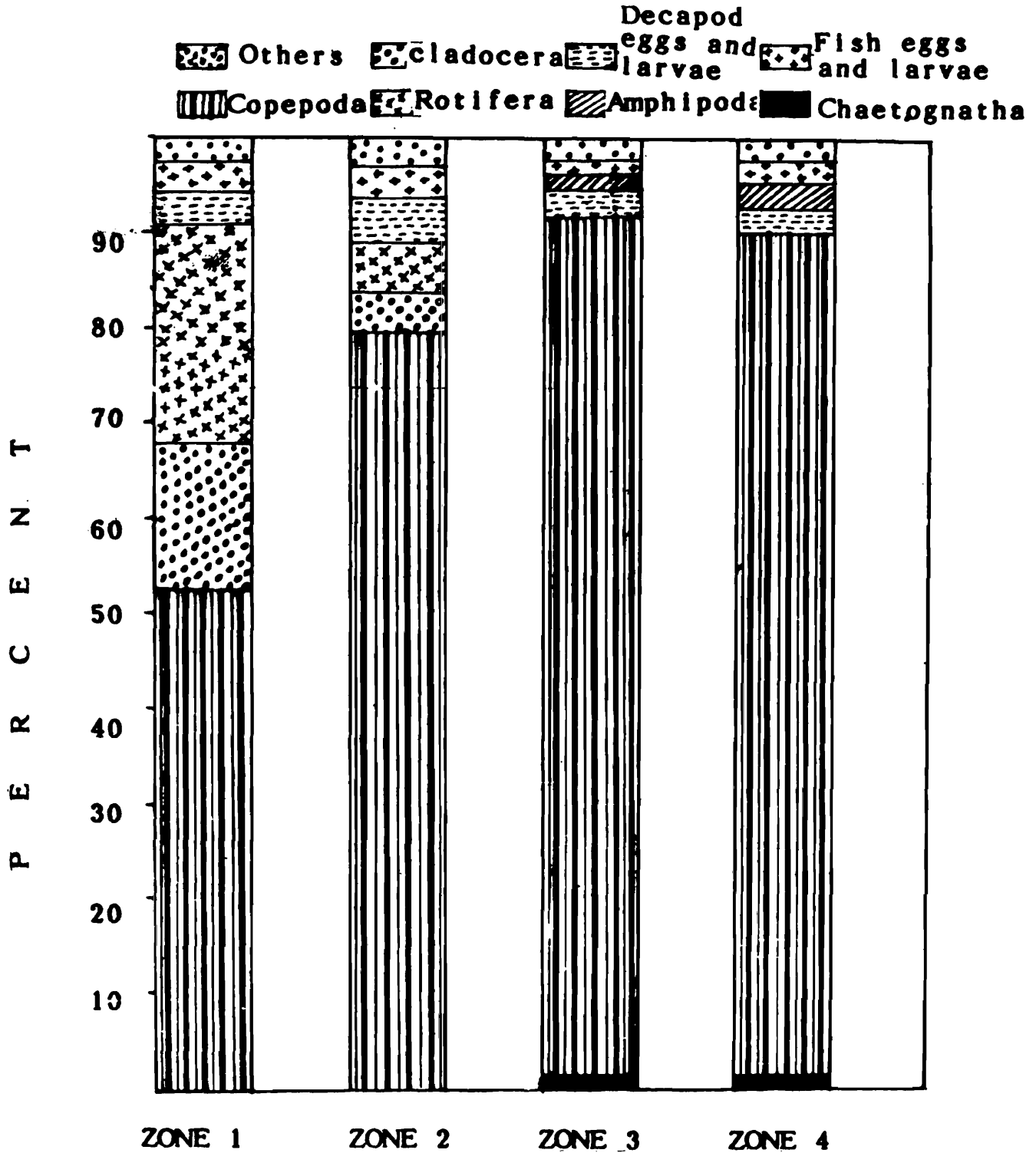


Fig-15 : Mean annual percentage composition of different groups of zooplankton in different zones.

mud flat region which are *Assiminea brevicula* Pfeiffer, *Telescopium telescopium* Linn. and *Cerithidea cingulate* (Gmelin). Among bivalves of lower Zones, *Meritrix meritrix* (Linn.) and

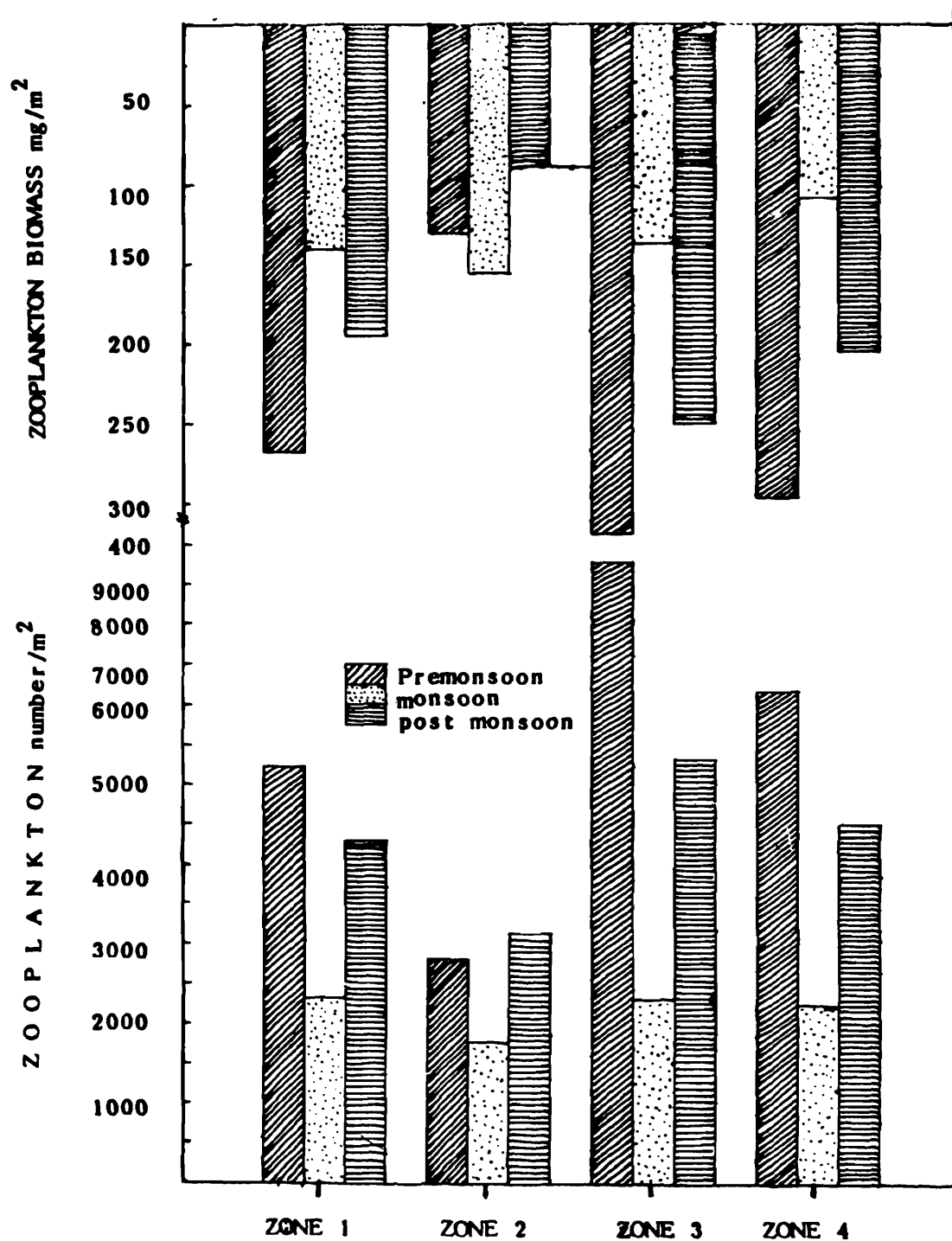


Fig-16 : Seasonal variations in total number and biomass of zooplankton in different zones.

Dossina triguna (Reeve) were abundant. A number of other gastropod and bivalve species were observed but they did not contribute much to benthic biomass. The polychaetes were dominated by *Diopatra cupera cupera* (Bosc.). While anomuran crabs were represented by *Cliobanarius pudvensis* de Man in muddy zone and by *Coenobita cavipes* Stimpson in sandy Zones mainly, the brachyuran

crabs were represented by a large number of species. The sea anemones, mostly comprised of *Pelocoetes exul* Annandale were fairly common especially in Zone—4. Nemertines and starfishes were also noticed in small numbers mostly from Zones 3 & 4. (Table 11). The monthly variations in Zone—4 were of similar nature (Table 12).

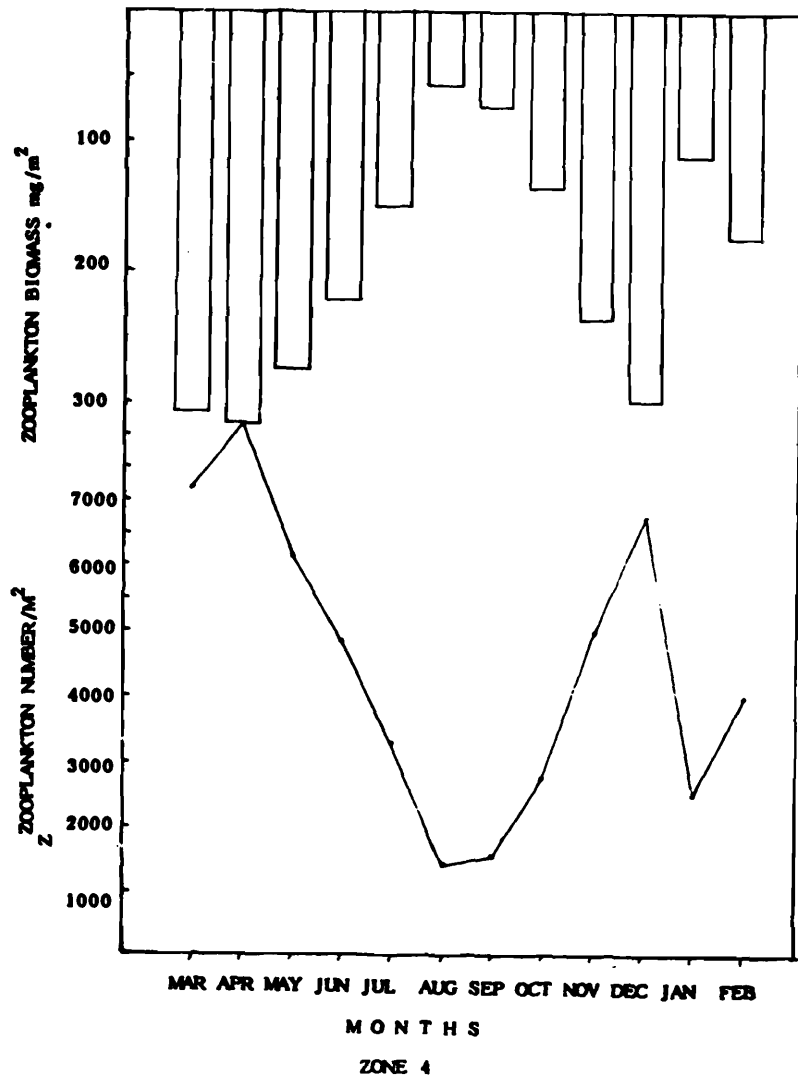


Fig-17 : Monthwise variations in zooplankton number and biomass in zone-4.

The seasonal variation studies revealed an extended period of abundance from late post-monsoon to entire pre-monsoon period (Fig. 22). In Zone—4 (Fig. 23), the values increased from November onwards and remained almost steady except during March and June when peaks were observed. The mean macrobenthic number varied between 12/m² to 105/m². Higher numbers were recorded from Zones 3 and 4. Biomass values were also considerably high in these Zones (Fig. 21a,b). The percentage composition of the abundant groups viz, gastropods, polychaetes, decapods and bivalves more or less remained constant.

C. RELATIONSHIP BETWEEN ZOOPLANKTON AND BENTHOS WITH HYDROLOGICAL FACTORS

The relationships of zooplankton, meiobenthos and macrobenthos with some physicochemical factors were worked out statistically by analysing Correlation Coefficients, which have been shown in Table 13.

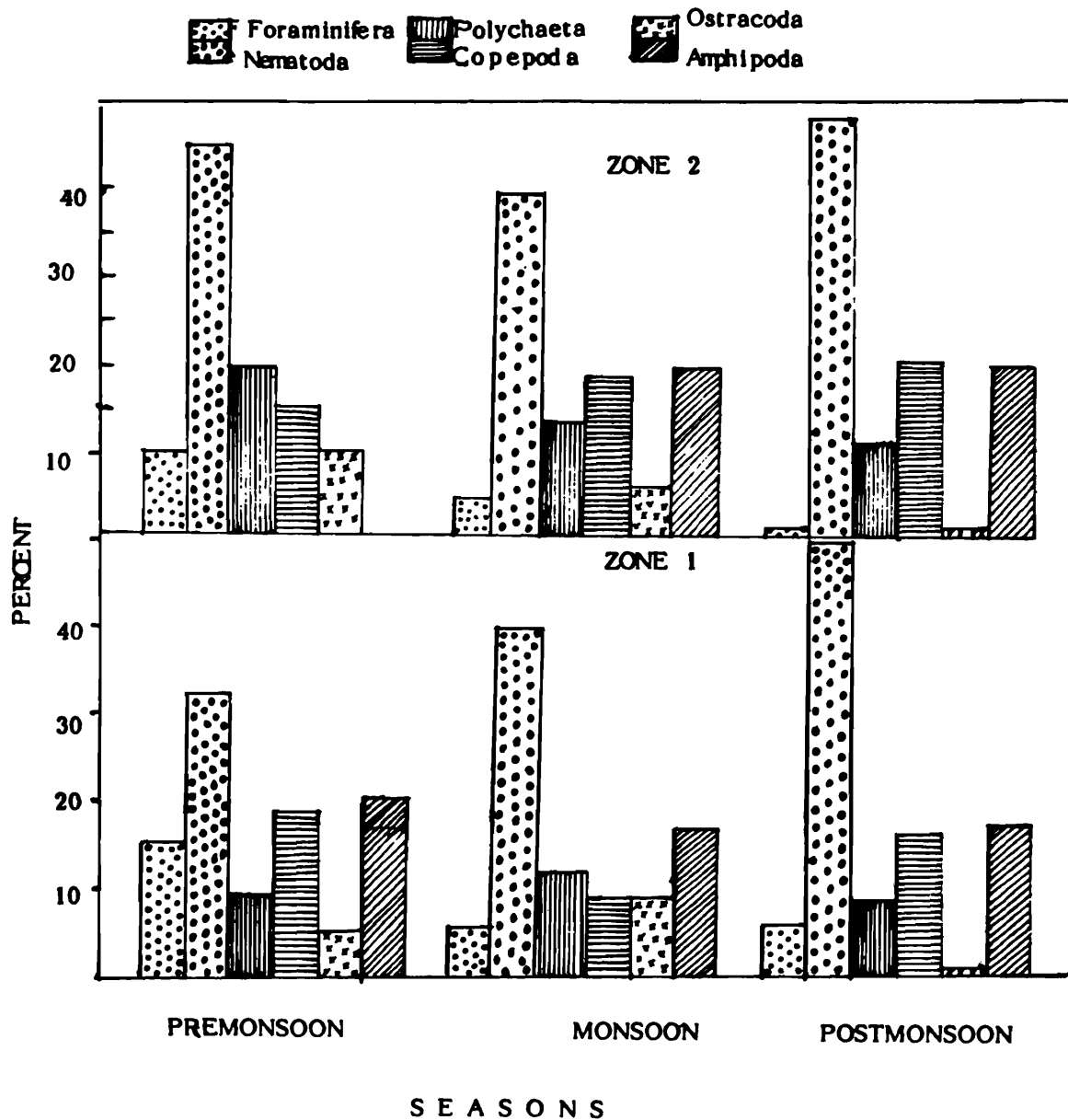


Fig-18 : Seasonal variations in percentage composition of various meiobenthic groups in different zones (zones 1 and 2)

It may be seen that while zooplankton were significantly and positively related to water transparency, salinity, phytoplankton density and primary productivity, no significant relationships were observed with temperature, Nitrate-N and Phosphate-P.

Meiobenthos were found to have direct significant relationship with sediment salinity, sediment organic carbon and percentage of silt in the sediment but no significant relationship was observed with sediment nutrients (Nitrate-N and Phosphate-P) and temperature.

Macrobenthos were also found to be significantly related to salinity, sediment organic carbon and percentage of silt. The temperature and nutrients again failed to establish their statistically significant relationship with the macrobenthic community of the estuarine system.

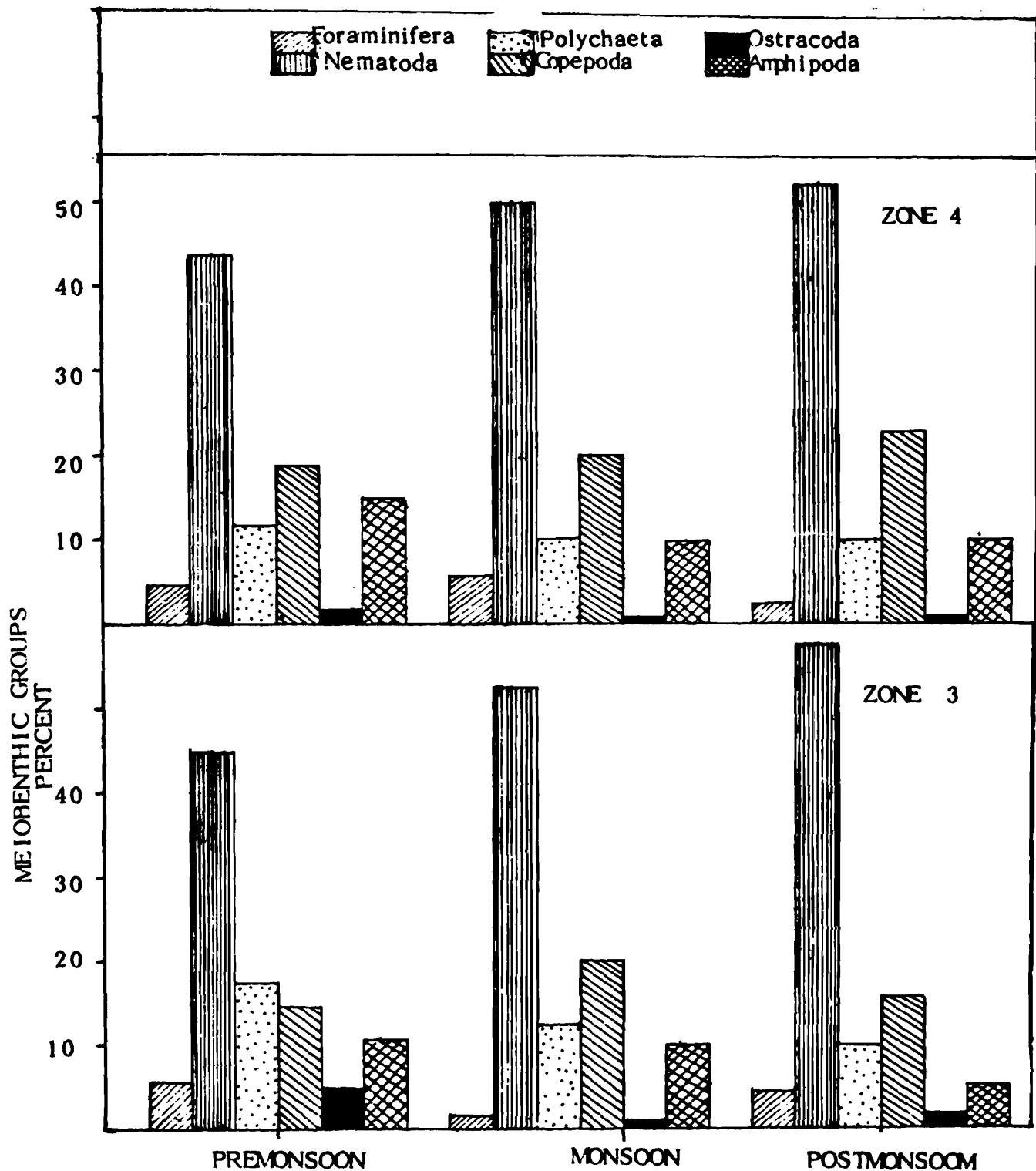


Fig-19 : Seasonal variations in percentage composition of various meiobenthic groups in different zones (zones 3 and 4)

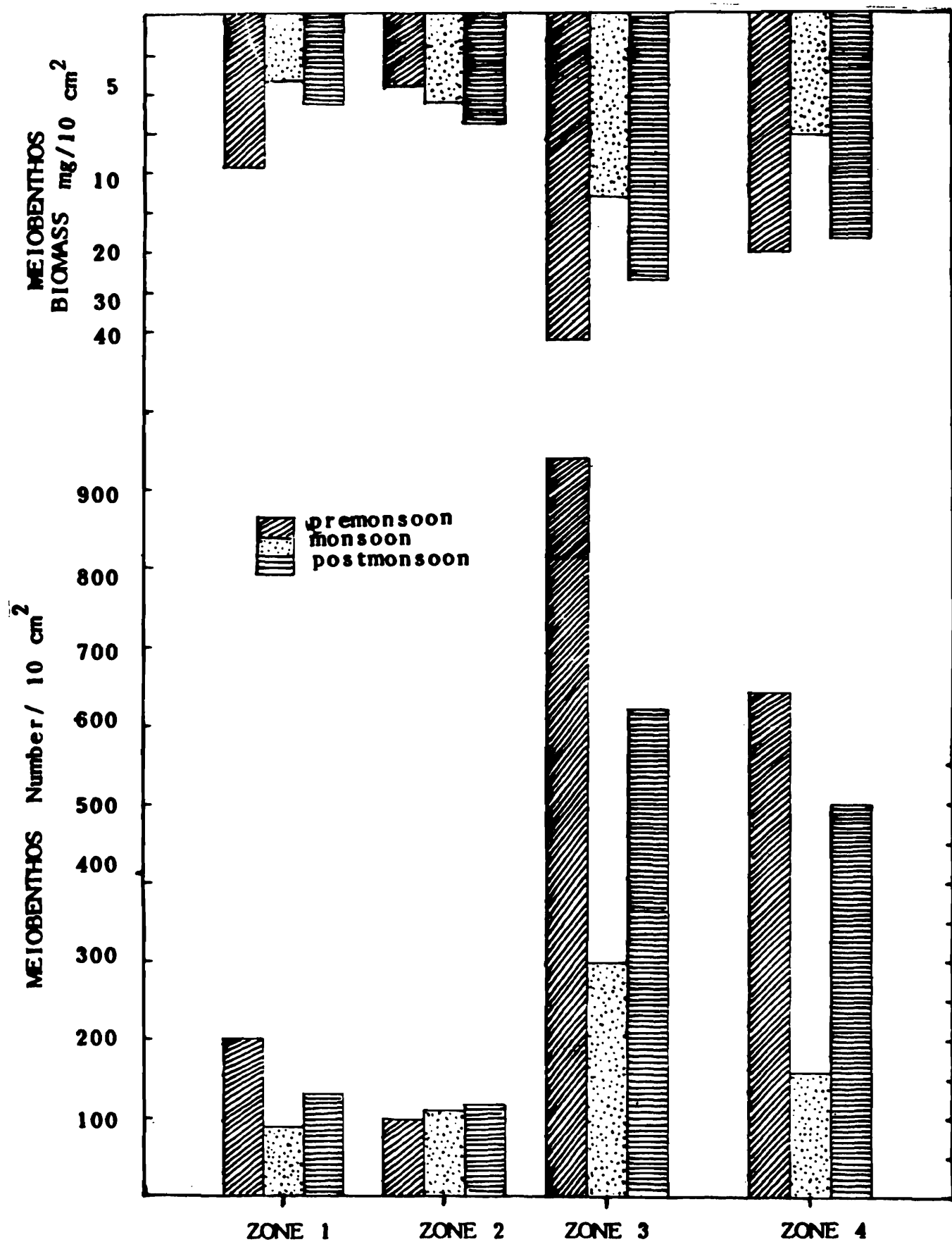


Fig-20 : Seasonal variations in meiobenthos number and biomass in indifferent zones.

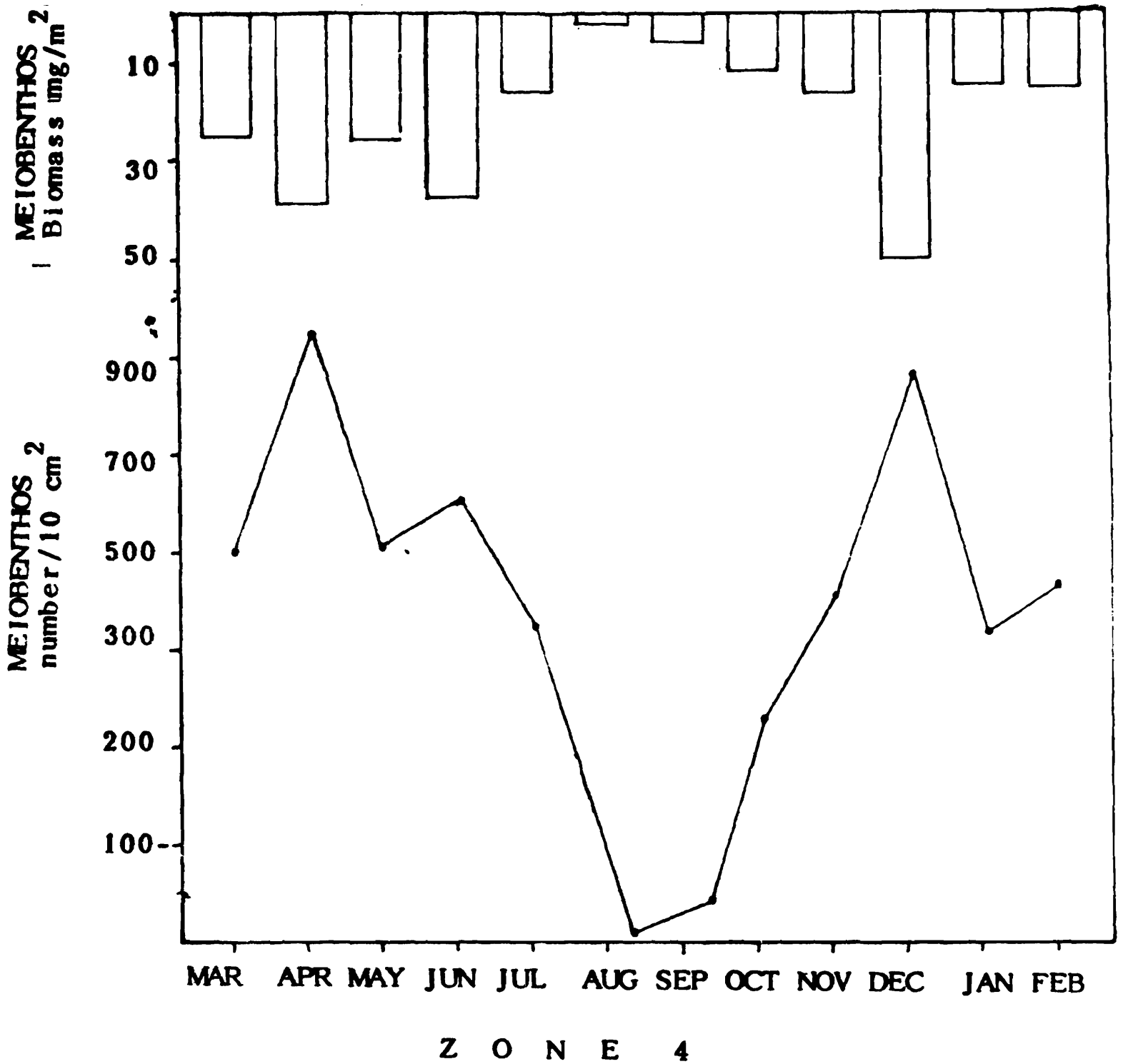


Fig-21 : Monthwise variations in number and biomass of meiobenthos in zone-4..

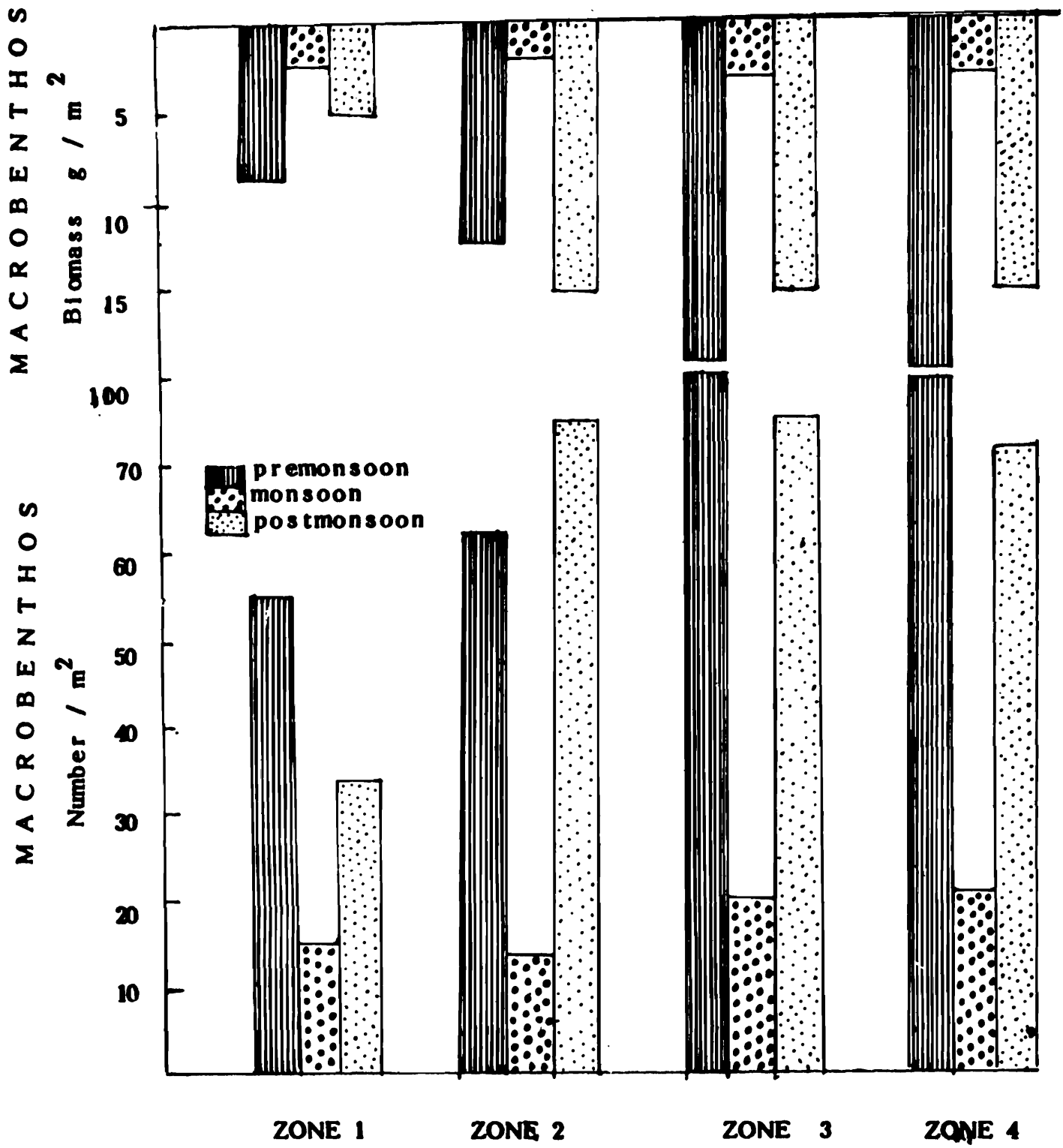


Fig-22 : Seasonal variations in macrobenthos number and biomass in different zones.

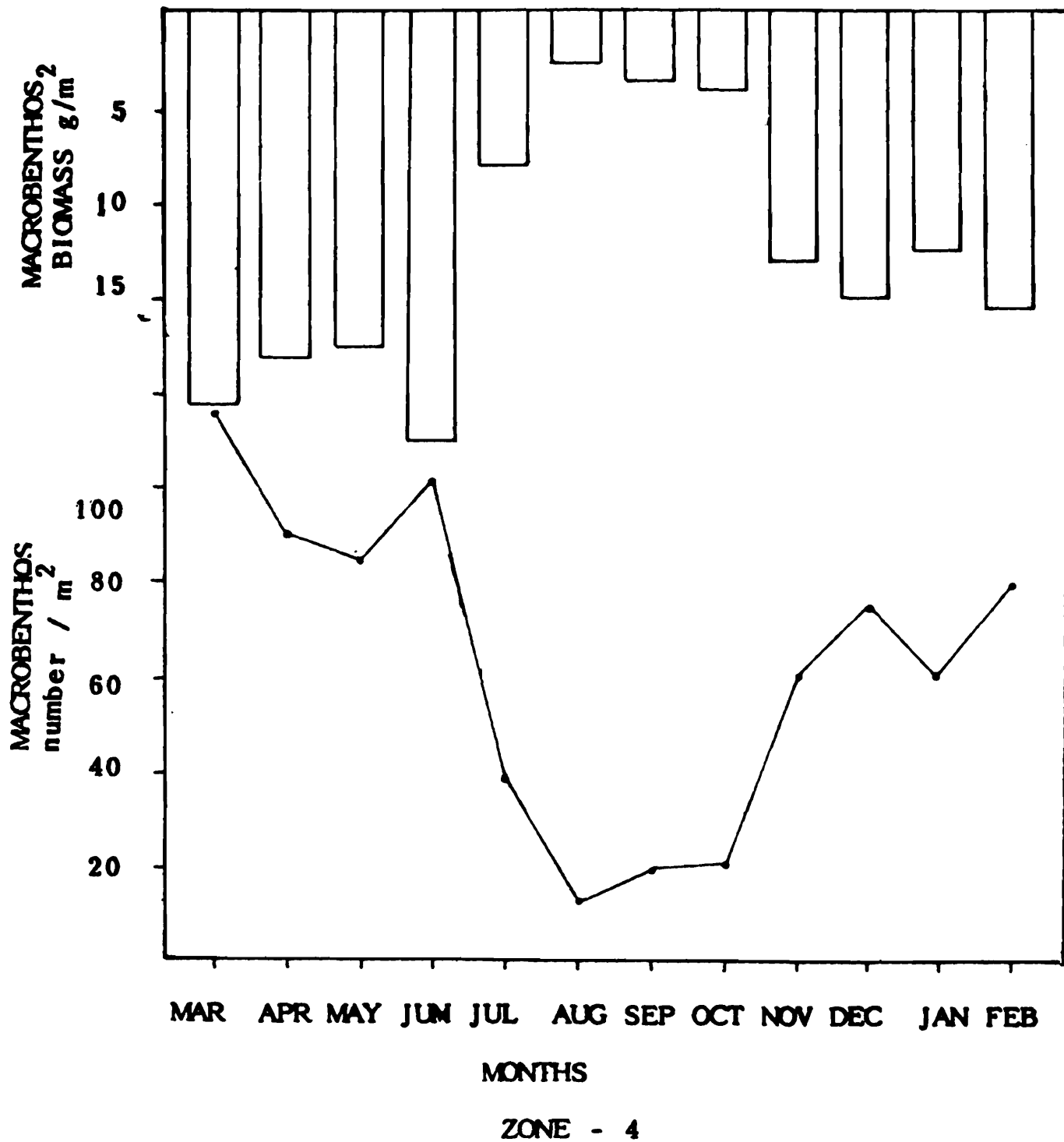


Fig-23 : Monthwise variations in macrobenthos number and biomass in zone-4..

TABLE—1
MEAN ANNUAL DISCHARGE OF VARIOUS RIVERS ALONG HUGLI.

Streams	area of basin (km ²)	Total annual yield million m ²
Damodar	25,820	12,210
Haldi	10,210	5,300
Roopnarayan	8,530	4,400
Ajoy	6,050	32.7
Ganga*	8,61,404	4,68,700

* denotes the total flow of river Ganga in Indian Region
After Rao (1975), Ghosh (1991)

TABLE—2
MEAN FLOW OF THE RIVER GANGA AT NABADWIP DURING
DIFFRENT SEASONS

Seasons	Mean seasonal flow (cm/m ²)	Mean annual rate of flow (m ³ /sec)
Pre-monsoon	7,107	
Monsoon	18.666	1,314
Post-monsoon	15,673	

After Rao (1975) as cited by Ghosh (1991)

TABLE—3
THE WIDTH AND DEPTH OF HUGLI ESTUARY
AT DIFFERENT CENTRES

Centres	max. width at high tides (km)	max. depth at high tides (m)	min. depth at low tides (m)
Barakpur	0.54	18.0	12.0
Calcutta	0.75	15.3	8.0
Uluberia	0.75	21.0	12.0
Falta	1.2	20.0	13.8
Daimond Harbour	4.65	37.0	9.6
Kulpi	4.59	16.8	10.2

Based on Bose (1956) Ray (1989)

TABLE—4
AVERAGE TIDAL VELOCITIES DURING DIFFERENT SEASONS

Tidal phase	Average velocity in km/h					
	high tides			low tides		
	pre-monsoon	monsoon	post-monsoon	pre-monsoon	monsoon	post-monsoon
Spring	28.3	27.9	27.7	12.1	10.9	10.16
Neap	18.5	20.3	18.2	12.6	12.5	10.5

TABLE—5
WATER LEVEL IN METERS DURING HIGH AND LOW TIDES
Meters

Tides	pre-monsoon	monsoon	post-monsoon
Bore tide high	5.25	6.0	5.17
Bore tide low	1.30	2.47	2.13
Neap tide high	4.80	5.50	5.13
Neap tide low	1.25	2.36	1.80

TABLE—6
PERCENTAGE COMPOSITION OF SAND, SILT AND CLAY IN SEDIMENTS

Zone	Seasons	Percent			Sand Silt Ratio
		Sand	Silt	Clay	
1	Pre-monsoon	40.5	16.5	43.0	0.94
	Monsoon	36.8	19.3	59.9	0.63
	Post-monsoon	28.2	17.6	56.2	0.52
2	Pre-monsoon	20.7	22.3	57.9	0.36
	Monsoon	16.6	20.9	62.5	0.26
	Post-monsoon	18.2	20.3	61.5	0.29
3	Pre-monsoon	5.0	21.5	73.5	3.07
	Monsoon	4.0	26.0	70.0	0.06
	Post-monsoon	5.5	22.2	72.3	0.07
4	Pre-monsoon	4.3	22.2	73.5	0.06
	Monsoon	6.2	25.5	68.3	0.09
	Post-monsoon	5.1	24.9	70.0	0.07
Sand Flats	Pre-monsoon	92.0	4.2	3.8	24.20
	Monsoon	84.3	8.5	7.2	11.70
	Post-monsoon	88.5	6.8	4.7	18.92

TABLE—7

DISTRIBUTION OF IMPORTANT PHYTOPLANKTON SPECIES OF HUGLI ESTUARINE SYSTEM

Species	Zone	Pre-monsoon				Monsoon				Post-monsoon			
		1	2	3	4	1	2	3	4	1	2	3	4
DIATOMS :													
<i>Synedra ulna</i>		++	-	-	-	+	+	-	+	++	+	+	-
<i>Coscinodiscus granll</i>		++	++	+	+	+	+	+	+	++	+	+	+
<i>Coscinodiscus spp.</i>		+	+	-	+	+	+	+	+	-	-	-	+
<i>Surirella sp.</i>		+	+	-	-	+	-	-	-	+	-	-	-
<i>Melosira spp.</i>		-	-	+	+	-	-	+	+	++	+	-	+
<i>Nitzschia spp.</i>		++	++	-	+	+	+	+	-	+	-	+	+
<i>Naviculla spp.</i>		++	+	-	-	+	+	-	-	+	+	-	-
<i>Pleurosigma spp.</i>		+	+	-	+	-	+	+	+	-	-	-	+
<i>Stephanodiscus spp.</i>		+	+	-	-	+	+	-	-	+	+	-	-
<i>Cyclotella spp.</i>		++	+	-	-	+	+	+	-	+	+	-	-
<i>Chaetoceros spp.</i>		-	-	++	++	-	-	+	+	-	+	++	++
<i>Biddulphia spp.</i>		-	-	++	++	-	+	-	+	-	+	++	++
<i>Lithodesmus spp.</i>		-	+	+	+	+	+	+	+	-	+	+	+
<i>Fragilaria spp.</i>		-	+	+	+	+	+	+	+	-	+	-	+
<i>Hemidiscus spp.</i>		-	+	-	+	+	-	-	-	-	+	+	+
<i>Rhizosolenia spp.</i>		-	-	-	-	-	-	+	+	-	+	+	++
<i>Skelitonema spp.</i>		-	+	+	+	-	-	-	-	-	+	+	+
<i>Triceratium spp.</i>		+	+	-	+	+	+	+	+	+	+	+	+
<i>Coscosira spp.</i>		+	+	++	+	+	+	+	+	+	+	+	-
<i>Ditylum spp.</i>		-	-	+	+	+	+	+	-	-	+	++	++
<i>Thalanothrix spp.</i>		-	+	+	+	-	+	+	+	-	+	+	+
<i>Pleurosigma spp.</i>		-	-	+	+	-	-	-	+	-	+	+	+
BLUE GREEN ALGAE :													
<i>Oscillatoria spp.</i>		+	+	+	+	+	+	+	+	+	+	+	+
<i>Nostoc spp.</i>		+	+	+	+	+	+	+	-	+	+	+	+
<i>Anabaena spp.</i>		+	+	+	+	+	+	+	+	+	+	+	+
<i>Phormidium spp.</i>		+	+	+	+	+	+	+	+	+	+	+	+

TABLE-7 (Contd.)

Species	Zone	1	2	3	4	1	2	3	4	1	2	3	4
<i>Microcystis spp.</i>		+	+	-	+	+	++	+	+	+	+	-	+
GREEN ALGAE :													
<i>Pediastrum spp.</i>		+	+	-	-	+	+	-	-	+	-	-	-
<i>Spirogyra spp.</i>		+	+	+	+	+	+	+	+	+	+	-	-
<i>Mongeotia spp.</i>		+	+	-	-	+	++	+	+	+	+	+	-
<i>Eudorina spp.</i>		+	-	-	-	+	+	-	-	+	+	+	+
<i>Tribonema spp.</i>		+	-	-	-	+	+	-	-	+	-	-	-
<i>Closterium spp.</i>		+	+	+	+	+	+	-	+	+	-	+	+
<i>Cosmarium spp.</i>		+	+	+	+	+	+	-	+	+	-	-	-
<i>Zygnema spp.</i>		+	-	-	-	+	+	-	-	+	-	-	-
<i>Chlorella spp.</i>		+	+	-	-	+	+	-	-	+	+	-	-
<i>Scenedesmus spp.</i>		+	-	-	-	+	+	-	-	+	+	-	-
<i>Ankistrodesmus spp.</i>		+	+	-	-	+	-	-	-	+	-	-	-
<i>Volvox spp.</i>		+	-	-	-	+	-	-	-	+	-	-	-
<i>Bogia spp.</i>		+	-	-	-	-	-	-	-	+	-	-	-
FLAGELLATES :													
<i>Euglena spp.</i>		+	+	+	-	+	+	+	+	+	+	+	-
<i>Ceratium spp.</i>		+	+	+	+	+	+	+	+	-	-	+	-
<i>Phacus spp.</i>		+	+	+	+	+	+	+	+	-	-	+	+
<i>Peridinium spp.</i>		+	+	-	-	+	+	+	-	-	-	+	+
<i>Trachelomonas spp.</i>		+	+	+	+	-	+	+	-	+	+	+	+
<i>Notiluca spp.</i>		-	+	+	+	-	-	+	+	-	-	+	+

TABLE—8
DOMINANT PHYTOPLANKTON SPECIES IN DIFFERENT ZONES

Seasons	Zone-1	Zone-2	Zone-3	Zone-4
Premonsoon	<i>Synedra spp.</i>	<i>Coscinodiscus spp.</i>	<i>Coscinodiscus spp.</i>	<i>Chaetoceros spp.</i>
	<i>Coscinodiscus spp.</i>	<i>Melosira spp.</i>	<i>Chaetoceros spp.</i>	<i>Biddulphia spp.</i>
	<i>Melosira spp.</i>	<i>Hemidiscus spp.</i>	<i>Biddulphia spp.</i>	<i>Lithodesmus sp.</i>
	<i>Nitzsilia spp.</i>			<i>Ditylum spp.</i>
	65%	72%	80%	82%
Monsoon	<i>Synedra spp.</i>	<i>Synedra spp.</i>	<i>Coscinodiscus spp.</i>	<i>Pleurosigma spp.</i>
	<i>Melosira spp.</i>	<i>Coscinodiscus spp.</i>	<i>Chaetoceros spp.</i>	<i>Ditylum spp.</i>
	<i>Naviculla spp.</i>	<i>Naviculla spp.</i>	<i>Thalainiothrix spp.</i>	<i>Chaetoceros spp.</i>
	67%	70%	82%	83%
Postmonsoon	<i>Synedra spp.</i>	<i>Synedra spp.</i>	<i>Coscinodiscus spp.</i>	<i>Coscinodiscus sp.</i>
	<i>Coscinodiscus spp.</i>	<i>Naviculla spp.</i>	<i>Chaetoceros spp.</i>	<i>Chaetoceros spp.</i>
	<i>Melosira spp.</i>	<i>Coscinodiscus spp.</i>	<i>Biddulphia sp.</i>	<i>Ditylum spp.</i>
	69%	73%	80%	81%

TABLE—9
PHYTOPLANKTON SPECIES IN DIFFERENT SALINITY ZONES

Purely freshwater	Freshwater-Brackish	Brackish-marine	universal	Purely marine
	<i>Suirella spp.</i>	<i>Chaetoceros spp.</i>	<i>Synedra spp.</i>	
	<i>Naviculla spp.</i>	<i>Biddulphia spp.</i>	<i>Coscinodiscus spp.</i>	
	<i>Cyclotella spp.</i>	<i>Lithodismus spp.</i>	<i>Melosira spp.</i>	
	<i>Stephanodiscus spp.</i>	<i>Thalainiothrix spp.</i>	<i>Nitzschia spp.</i>	
		<i>Ditylum spp.</i>		
		<i>Pleurosigma spp.</i>		
		<i>Hemidiscus spp.</i>		
		<i>Skelitonema spp.</i>		
		<i>Rhizosolenia spp.</i>		

TABLE—10
SEASONAL VARIATIONS IN TOTAL ZOOPLANKTON NUMBER AND PERCENTAGE
COMPOSITION OF DIFFERENT GROUPS

Zones	Season		Hydromed- usae	Copepoda	Cladocera	Rotifera	Decapoda eggs & larvae	Chaetog- natha	Fish eggs & larvae	Others	Total zoo- plankton
1	Premonsoon	...	—	55.50	17.20	24.01	1.49	—	0.30	4.80	5235
	Monsoon	...	—	48.50	13.00	18.50	0.50	—	11.00	4.00	2275
	Postmonsoon	...	—	52.00	18.18	25.00	1.81	—	1.20	1.81	4360
2	Premonsoon	...	—	80.00	4.00	4.50	6.50	—	3.00	2.08	2725
	Monsoon	...	—	71.27	4.60	6.10	8.67	—	5.57	3.27	1130
	Postmonsoon	...	—	82.07	5.41	5.62	0.93	—	3.27	2.70	3325
3	Premonsoon	...	1.49	91.50	—	—	2.00	2.00	1.60	1.40	9436
	Monsoon	...	1.22	88.00	—	—	4.80	7.70	1.68	1.60	2375
	Postmonsoon	...	2.00	90.01	—	—	4.20	0.40	2.00	1.40	5399
4	Premonsoon	...	1.50	91.88	—	—	2.49	1.20	1.50	1.42	6444
	Monsoon	...	1.22	88.60	—	—	3.78	2.40	2.00	2.00	2251
	Postmonsoon	...	1.90	90.90	—	—	3.78	1.48	1.28	1.20	4555

TABLE—11
SEASONAL VARIATIONS IN PERCENTAGE COMPOSITION OF DIFFERENT GROUPS
OF MACROBENTHOS IN DIFFERENT ZONES

season	Total population No. m ²	Biomass mg/g	Gastro- poda	Bivalvia	Oligo- chaeta	Poly- chaeta	Brachy- ura	Anomura	Alphe- idae	Actin- aria	Nemer- tina	Aste- roidea	Others
Premonsoon	55.0	8.80	60.20	11.20	12.40	14.20	—	—	—	—	—	—	2.00
Monsoon	15.0	2.61	70.00	5.00	10.50	12.20	—	—	—	—	—	—	2.30
Postmonsoon	38.0	5.53	65.50	7.70	9.60	13.60	—	—	—	—	—	—	3.60
Premonsoon	65.0	12.40	60.00	7.00	8.00	14.00	7.50	—	—	—	—	—	3.50
Monsoon	12.0	2.14	67.30	5.00	13.20	12.50	—	—	—	—	—	—	2.00
Postmonsoon	85.0	15.32	67.00	5.00	5.10	13.20	6.20	—	—	—	—	—	3.5
Premonsoon	105.0	22.05	59.50	5.20	—	12.90	8.50	2.80	0.20	4.70	1.50	1.20	3.50
Monsoon	20.0	3.60	45.00	5.00	—	18.30	15.50	13.70	—	—	—	—	2.50
Postmonsoon	80.0	15.23	56.60	5.20	—	12.50	9.50	6.50	0.20	2.00	1.00	1.00	5.50
Premonsoon	98.0	19.60	55.20	5.59	—	13.20	9.00	5.70	0.30	4.50	1.00	2.10	3.40
Monsoon	22.0	3.96	40.50	5.11	—	20.50	15.20	12.80	8.20	—	—	—	5.30
Postmonsoon	70.00	12.57	52.20	5.00	—	14.80	11.50	8.20	0.30	0.80	1.20	2.50	3.50

TABLE—12
SEASONAL VARIATIONS IN PERCENTAGE COMPOSITION OF DIFFERENT GROUPS
OF MACROBENTHOS IN ZONE—4

Months	Total population No. m ²	Gastropoda	Bivalvia	Polychaeta	Brachyura	Anomura	Alpheidea	Actinaria	Nimer-tina	Astro-idea	Others
March	115.0	51.50	5.40	13.40	9.70	6.70	0.30	5.00	1.50	3.50	3.00
April	90.0	57.00	5.80	12.20	9.00	5.10	0.40	4.00	1.00	2.00	3.50
May	85.0	55.40	6.20	13.50	8.80	5.50	0.20	5.50	1.50	—	3.40
June	102.0	56.30	5.00	14.20	8.50	5.90	0.30	4.00	1.00	1.20	3.50
July	38.0	53.20	5.20	18.50	10.00	9.80	0.40	—	—	—	1.1
August	12.0	33.80	5.50	22.80	17.00	12.70	0.20	—	—	—	8.5
September	18.0	56.20	5.00	26.20	19.00	13.00	0.20	—	—	—	4.4
October	20.0	42.00	7.00	16.50	15.80	15.00	0.80	—	—	—	4.3
November	65.0	49.80	5.00	15.50	12.80	10.50	0.40	0.50	1.50	2.00	2.00
December	75.0	52.2	5.30	15.00	11.10	8.50	0.30	0.50	—	3.5	3.9
January	60.0	53.60	5.50	13.70	10.80	6.30	0.10	1.00	1.80	2.00	3.70
February	80.0	52.40	5.00	15.50	10.80	7.50	0.10	1.20	1.20	2.50	3.80

TABLE—13

RELATIONSHIP OF ZOOPLANKTON AND BENTHOS WITH SOME IMPORTANT PHYSICOCHEMICAL AND BIOLOGICAL FACTORS

Factors	Degree of freedom	Correlation coefficient	Level of significance
Zooplankton and Temperature	22	0.325	N. S.
Zooplankton and Transparency	22	0.452	5%
Zooplankton and Salinity	22	0.782	1%
Zooplankton and Nitrate-N	22	0.385	N. S.
Zooplankton and Phosphate-P	22	0.312	N. S.
Zooplankton and Phytoplankton	22	0.589	1%
Zooplankton and Primary Productivity	10	0.610	5%
Meiobenthos and water Temperature	22	0.305	N. S.
Meiobenthos and Salinity	22	0.479	5%
Meiobenthos and organic carbon	10	0.621	5%
Meiobenthos and sediment Phosphate-P	10	0.585	5%
Meiobenthos and sediment Nitrate-N	10	0.630	5%
Meiobenthos and percentage of silt in sediment	22	0.512	5%
Macrobenthos and water temperature	22	0.400	N. S.
Macrobenthos and Salinity	22	0.510	5%
Macrobenthos and organic carbon	10	0.060	5%
Macrobenthos and sediment Phosphate-P	10	0.312	N. S.
Macrobenthos and sediment Nitrate-N	10	0.320	N. S.
Macrobenthos and percentage of silt in sediment	22	0.0280	N. S.

DISCUSSION

The most distinct feature of Hugli-Matla estuarine system was the influence of monsoon which is brought about by south-west currents. The monsoonal rainfall drastically altered physico-chemical and biological conditions of the entire estuarine system. In fact, it was the single most important factor governing occurrence, abundance and dynamics of the entire biota. Since nearly 74% of total rainfall in the catchment area occurred during monsoon months of June-September, the discharge from feeder rivers into estuary was also huge during this period. This resulted in the flooding of the estuary and consequent considerable dilution. Further, huge amount of silt and detritus were also brought to the estuary by feeder rivers, which increased the turbidity.

The mean temperature of surface water in different zones of the estuarine system did not fluctuate much which revealed the absence of any longitudinal temperature gradient. Further, very little differences between surface, mid-surface and bottom temperatures, also ruled out the possibilities of any vertical temperature gradient. The lack of either horizontal or vertical temperature gradient in the estuarine system could be related to the high agility and continuous mixing of the water due to strong tidal currents (Bose, 1956; Shetty, *et al.*, 1961). Bose (1956) also related this homothermy to high turbidity of the water which helped in transmission of heat preventing any marked stratification. Similar situations have also been reported from other Indian estuaries (Ansell *et al.* 1972; Fernando, 1987; McLachlan, 1977). The considerably high temperature during most part of the year with brief colder period during late post-monsoon months resulted in a bimodal pattern of seasonal fluctuation of temperature. The first peak occurred in late post-monsoon (September-October) and second in late pre-monsoon (May-June). Although the differences between mean annual maximum and minimum were large (11 degrees), this was for a very brief period and was not found to have much significant impact on general ecology of the estuary.

The enormous amount of the silt brought to the estuary during monsoon months and its continuous upheaval from coastal areas through flood tides, kept the entire estuary very turbid almost throughout the year except during late post-monsoon period when the tidal flow was comparatively slow and the rainfall was minimal. As compared to other Indian estuaries like Ashtamundi (Nair and Abdul Azis., 1987), Cochin backwaters (Qasim, *et al.* , 1978) and Mandovi (Qasim, 1979) etc., the Hugli estuarine system was highly turbid.

The little differences between pH values either between seasons or between stations revealed the buffering capacity of the entire estuarine system, as also observed by Bose (1956). The dissolved oxygen content was fairly moderate throughout the year in all zones. The increased values during monsoon months may be attributed to increased flow of freshwater carrying high levels of dissolved oxygen and intense mixing of the surface water. Similar increase in dissolved oxygen contents during monsoon have also been reported by several other workers from different Indian estuaries (Krishnamurthy, 1964; Achuthankutty, 1976; Nair, 1978 and Fernando, 1987). The dissolved oxygen content was found to decrease significantly from upper zone to lower zone. The lower dissolved oxygen contents of the highly saline waters may be due to its control by

salinity. Values considerably lower than the present investigations were found by Baidya and Choudhury (1985) who conducted the studies in highly saline zone of the estuary near Sagar Island.

The salinity was the most important chemical factor which affected directly diversity and abundance of biota in the estuarine system. Because of the varied physiological adaptability of different species of animals and plants to salinity ranges, specific biotic communities colonized different areas of the estuary depending upon the prevailing level of salinity and the tolerance limits of individuals of the community. The distributional pattern of both salinity and biota clearly demarcated different zones of the estuary. Zone—1 with almost negligible level of salinity was classified as freshwater zone. The wide fluctuation in salinity levels of the middle zone (Zone-2) as indicated by a very high maximum : minimum ratio exhibited the considerably altering nature of this zone, which is typical to a true estuarine gradient zone. The constantly high salinity values and lesser level of fluctuation in Zones 3 and 4 confirmed their stable, almost marine nature. Similar views have been expressed by other workers (Saha *et al.*, 1971). However, contrary to these observations, Bose (1956) opined that Hugli estuary is free from salinity zones as very clear demarcation of different saline zones was difficult. The seasonal salinity cycle of the estuary was exclusively governed by the monsoon. During heavy freshwater discharge, the flood tides from highly saline marine water were completely nullified by the freshlets. The subsequent increase was mainly due to reduced discharge and increased surface evaporation during hot premonsoon months, a condition common to other tropical estuaries (Dwivedi *et al.*, 1975; Nair, 1978; and Fernando, 1987).

The availability of the nutrients in the estuarine system varied seasonally. The phosphate-P was high during post-monsoon months, which is contrary to the findings of Bose (1956) who recorded highest values during pre-monsoon months and related to its regeneration from the bottom during summer months. Generally sediments in the estuaries trap most of the phosphates and release the same in overlying waters afterwards (Rittenberg, *et al.*, 1975). During monsoon months freshwater discharges brought huge amount of phosphate laden sediments in the estuary which were released during post-monsoon months leading to the increase in level. Nitrate-N was also high during the same period. Its distributional pattern clearly indicated an upward trend from marine to freshwater zone. Similar observations have been reported by Nair and Abdul Azis (1987) from Ashtamundi estuary.

The bottom sediment of the entire Hugli-Matla estuarine system was comprised mostly of fine silt and clay. This estuarine system is the part of the Gangetic delta. The main river and its tributaries carry huge amount of sediments from the alluvial plains of northern India and also from Himalaya during monsoon which get deposited throughout their course. While coarser sand particles got deposited quickly in upper reaches of the riverine courses, the finer silt particles in the form of suspensions, along with highly enriched detritus reached to deltaic region and settled gradually in the lower parts. This has resulted in the formation of huge deltaic mud flats of Sunderban. The finer particles of the sediment like silt and clay are well known to retain high levels of organic carbon and nutrients (Fernando, 1987). In Hugli-Matla estuarine system higher organic carbon values were recorded during monsoon and post-monsoon months when deposition

of fresh silt particles took place. Obviously as compared to zone—1, the values were high in lower zones which had comparatively higher percentage of silt in the sediment.

Like many of the estuarine and marine environments, diatoms also dominated the phytoplankton composition of Hugli-Matla estuarine system. Their contribution steadily increased from freshwater to marine zone. The green algae, basically freshwater inhabitants, were completely absent from Zone—3, while they were recorded in small numbers from Zone—2. Blue green algae were present in almost constant numbers in all zones and were not found to be affected either by salinity or any other factor. The high resistance and adaptability of blue green algae to changing environmental condition is well known. While a large number of phytoplankton taxa were recorded during different seasons from all zones it was the combination of only few species of diatoms which formed the bulk of phytoplankton abundance and biomass in any given time and space. The presence of most of other species was of nominal value having little bearing on the total productivity and food chain of the environment. Different taxa of the diatoms were responsible for the abundance in different zones. While *Synedra* sp., *Melosira* sp., *Nitzschia* sp., *Cyclotella* sp. were the main component of Zone—1, *Chaetoceros* sp., *Biddulphia* sp., *Lithodesmus* sp., *Ditylum* sp. and *Pleurosigma* sp. were main saline species occurring abundantly in Zones 3 and 4. *Scenedesmus* sp. was highly tolerant to changing levels of salinity as it occurred uniformly in all zones. Such differential salinity preferences of many diatom species have also been reported by Shetty *et al.*, (1961).

The phytoplankton production of the estuary followed a bimodal pattern, with two peaks, one during early pre-monsoon and other during late post-monsoon. Low values during monsoon months were obviously due to high turbidity of the water which probably restricted the growth of phytoplankton, in general. Although the nutrients were sufficiently available during this period, these were not found to be utilized. Unstable flood conditions might have also been responsible for poor growth. Similar variations have been reported by Datta *et al.* (1954) and Roy (1955). Contrary to this, Shetty *et al.* (1961) found major peak of abundance during peak monsoon month of August, when the water was warm and turbid. He related this partly to the abundance of those species which thrive on higher temperature and partly to enhanced nutrient supply. He also related this to some physiological state of several species where a drop in salinity induced the sexual reproduction and consequent rapid increase in the population.

The seasonal pattern of zooplankton abundance and biomasses closely followed the bimodal pattern of phytoplankton with two peaks, first in March and second in December. Low values were recorded during high flood period. Generally in most of the Indian estuaries a bimodal pattern of zooplankton abundance, influenced by monsoon, is a common feature (Subbaraju and Krishnamurthy, 1972; Raghunathan and Srinivasan, 1983). Bhunia and Choudhury (1981) and Baidya and Choudhury (1985) also recorded similar pattern from lower region of Hugli around Sagar Island. Again, like phytoplankton, Shetty *et al.* (1961) reported the occurrence of major peak of abundance of zooplankton during monsoon months.

Generally in Indian estuaries (Subbaraju and Krishnamurthy, 1972; Madhupratap, 1976, Goswami, 1982), copepods dominate the zooplankton composition. In Hugli-Matla estuarine

system too, they contributed to nearly 90% of the total zooplankton in lower marine zones 3 and 4. However, In upper freshwater zone, two other groups like cladocera and Rotifera also shared the contribution significantly.

Both species diversity and density of copepods were found to increase from freshwater to marine zone and different set of species occurred and flourished in different zones, which were directly controlled by salinity. Details are given elsewhere (Khan. 1993). The freshwater zone was characterized by the abundance of limnetic species, the middle zone by mixohaline and limnetic species and lower zone by mixohaline and Euhaline species.

Five species of Calanoid, all belonging to family Diaptomidae *Haliodiaptomus contortus* Gurney, *H. viduus* (Gurney), *H. cinctus* (Gurney), *Phylloidiaptomus blancii* (diGuerne) and *Neodiaptomus strigilipes* (Gurney) and three species of cyclopoid (*Mesocyclops Leuckarti* (Clause), *Thermocyclops hyalinus* (Rehberg) and *Cyclops viridis* Jurine) formed the bulk of freshwater copepod zooplankton in zone—1. Zone—2 was characterized by the abundance of several species of *Acartia*, *Acartiella*, *Pseudodiaptomus* and *Oithona* etc. Zones 3 and 4 were basically characterized by several marine species of Family Centropagidae, Pontellidae, Acartidae, Pseudodiaptomidae, Calanidae and Paracalanidae etc. During monsoon months a number of freshwater species were recorded from Zone-2. In Zones 3 and 4, species with low salinity tolerances were recorded during monsoon months.

In addition to copepods, cladocerans and rotifers were also occurred abundantly in Zone—1 only. Rotifers were represented by a number of species of *Keratella*, *Brachionus*, *Filinia* and *Asplanchna* and cladoceran by the species of the genera *Diaphanosoma*, *Daphnia*, *Ceriodaphnia*, *Moina*, *Bosmina* and *Alona*. In lower zones, hydromedusae of the genus *Obelia* and chaetognaths of genus *Sagitta* were fairly common. Beside these groups, all zones were characterized by constant occurrence of large number of eggs, larvae and post larvae of Decapods, obviously consisted of different species in different zones. This is probably due to the fact that large number of species of prawns and crabs use the estuary as their breeding ground and different species breed during different seasons. Other groups were mysids, stomatopod larvae, cirriped larvae and amphipod, etc., in lower zones and insect larvae in upper zone. Foraminifera were common to almost all zones. Baidya and Choudhury (1985) also found similar composition in lower zone of Hugli around Sagar island.

The meiobenthic fauna of the Hugli–Matla estuarine system was dominated by nematods followed by polychaetes and herpeticoid copepods. Generally in most Indian estuaries, nematodes are found to dominate the meiobenthic fauna (Vellar, Fernando, .1987, Gauatami-Godavari, Ramanamurthy and Kundala Rao, 1987), while in some other estuaries groups like Foraminefera (south Gujrat estuaries-Govindan *et al.*, 1983) and polychaetes (Ashtmundi—Nair and Abdul Azis, 1987) have also been reported to dominate. The predominately muddy–silty bottom of Hugli estuarine system was probably more favourable to nematodes.

The seasonal pattern of abundance and biomass of meiofauna closely followed the pattern of other biota, with lower values during monsoon months and high values during post and premonsoon months. Meiofaunal abundance was found to increase from upper to lower zones and

stations located in lower zones supported greater abundance, as also observed by Ramanamurthy and Kundala Rao (1987). The meiofaunal abundance was again directly dependent on salinity like zooplankton. Similarly macrobenthos were also characterized by lower abundance during monsoon and higher during pre-and post monsoon periods.

One of the most important features of the macrobenthic community of the Hugli estuarine system was the dominance of gastropods in all zones over other groups, which is generally not the case with other estuaries where polychaetes are most dominant group followed by bivalves (Parulekar *et al.* 1975, Fernando *et al.* , 1983) or polychaetes followed by crustaceans (Untawale and Parulekar, 1976). This may again be related to very specific muddy bottom of the estuary, which when exposed during low tides, provided very congenial conditions for gastropods. The other groups like polychaetes, brachyuran crabs, hermit crabs, and actinarians, etc., in lower zones, had also formed a typical faunal assemblage specific to this particular estuary. Choudhury *et. al.* (1984), who worked out the fauna of mud flats around Sagar island, also reported similar composition. The highly significant relationships of macrobenthos with salinity and sediment characteristics further asserted the role of these factors in the dynamics of Hugli-Matla estuarine system.

SUMMARY

1. Detailed hydrological and biological studies were carried out on Hugli–Matla estuarine system covering the entire 295 km tidal stretch of main estuary Hugli from upper most point at Nabadwip to its mouth in Bay of Bengal and from Matla estuary below Canning, from ten different stations covered under four biological zones. While studies on Hugli estuary was carried on seasonal basis, Matla was subjected to detailed investigations on monthly basis.
2. The Hugli estuary, characterised by huge monsoonal discharge and great tidal fluctuations, was clearly divisible into upper-freshwater (Zone-1), middle, Brackish (Zone-2) and lower, marine (Zone-3) parts. Matla (Zone-4) was simply a backwater where conditions resembled to lower zone of Hugli.
3. Monsoonal rainfall was most important physical factor governing both, physicochemical and biological conditions of the estuary.
4. Water temperature was moderately high throughout the year except for a brief period during late post monsoon. Neither horizontal, nor vertical temperature gradient occurred in the estuary. The water of the estuary was turbid almost throughout the year with a sudden increase during monsoon. The pH values did not differ much either at Stations or during seasons. Dissolved oxygen concentrations were sufficiently moderate with gradually

decreasing levels from upper to lower zones. Marked spatio-temporal variations in salinity values occurred. It dropped considerably during monsoon and started to increase gradually during post-and pre-monsoon periods reaching to highest level just before the next monsoon. Salinity values increased gradually from zone-1 to zones 3 and 4. Maximum fluctuations occurred in middle zone. Nutrients were high during monsoon and post-monsoon months.

5. The bottom sediment was mainly composed of silt. The sediments with higher silt contents were also richer in organic carbon and nutrients.
6. Phytoplankton were represented by a large number of species of which only few species of diatoms contributed to the bulk of total phytoplankton number and biomass. Different set of species dominated different zones and seasons depending upon the salinity regime. Phytoplankton number, biomass and primary productivity exhibited a bimodal pattern of seasonal fluctuations.
7. Zooplankton were also comprised of a large number of groups but copepods were almost solely responsible for zooplankton density and biomass in middle and lower zones. In upper zone cladocerans and rotifers also shared the abundance and biomass. Seasonal pattern of abundance closely followed the phytoplankton cycle. High salinity zones were more productive than freshwater or brackish water zones.
8. Meiobenthic Fauna were dominated by nematodes, followed by polychaetes and herpeticoid copepods. Lower marine zones harboured more number of meobenthic species.
9. Macrofauna were dominated by gastropods. Like meiobenthos they were always recorded in higher numbers from lower zones.
10. Zooplankton were significantly related to transparency, salinity, phytoplankton density and primary productivity. Meiobenthos were significantly related to sediment salinity, organic carbon and silt content of the sediment. Macrobenthos were also found to have significant relationship with same factors.

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ECOLOGY OF KULTI ESTUARY WITH REFERENCE TO DISCHARGE OF CALCUTTA METROPOLITAN SEWAGE

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INTRODUCTION

The huge quantity of Calcutta metropolitan wastes, arising both from industrial and domestic sources, is currently being discharged into Kulti estuary, situated 35 km south east of the eastern fringe of city through a long canal. Before early forties, metropolitan wastes were discharged into Bidyadhari river but due to deterioration, rather death of the river and its creeks/khals, resulting from drastic reduction in upland freshwater supply and silting, Kulti was found to be the most suitable alternative for the disposal of rapidly increasing volumes of metropolitan wastes (Majumdar, 1952 ; David, 1959). Kulti is a part of an offshoot of Raimangal estuary. Raimangal flows on the eastern boundry of Indian Sundarban and is the deepest amongst estuaries of Hugli -Matla- Raimangal complex.

Although the hydrology-physical features and drainage, of Kulty estuary were studied extensively by several workers (Mitra, 1954; Majumdar, 1942; 1952; Maitra, 1958 etc.) , systematic informations partaining to the biology of the estuary and impact of sewage on ecosystem are meagre as very few workers have attempted to study this aspect. Bose (1944) and Nair (1944) were probably earliest workers who reported the effects of Calcutta sewage on the estuary. Later on David (1959) studied in considerable details the physico-chemical and biological conditions of the estuary on either side of outfall for a distance of about 28 km. Saha *et al* the nature of sewage and its use in pisciculture Thakur (1975) made studies on fish seed resources of the estuary, Recently Ray *et. al* (1981) and Ray and Bandhopadyaya (1984) reported their findings on physico-chemical,biological and bacteriological conditions of the estuary including its contamination by heavy metals and aquaculture in sweage fed fish ponds. Apart from these ecological studies, the surveys conducted by River Research Institute (1970) and NEERI (1978) on the physico-chemical nature of the estuary in relation to disposal of sewage are also worthmentioning.

Keeping in view the importance of estuary as a source of disposal of meteropoliton wastes and scaricity of information on various aspects of ecology, the present work was undertaken to study the physico-chemical and biological nature of the estuary in relation to sewage disposal.

MATERIAL AND METHODS

The wastewaters from the city is carried to Kulti estuary through a very long Dry whether-storm water flow combined canal. For the study of nature and characteristics of the wastewater and changes taking place during its flow in the sewage canal, from eastern fringe of the city to outfall, three study stations were fixed. Station M-1 was fixed before the settling tank (now defunct) at Bantala, Station M-2 was fixed at Ghatakpukur, nearly at a distance of 27 km and Station M-3 was fixed at Ghusighata before outfall at a distance of 35 km. For study of the impact of wastewater on

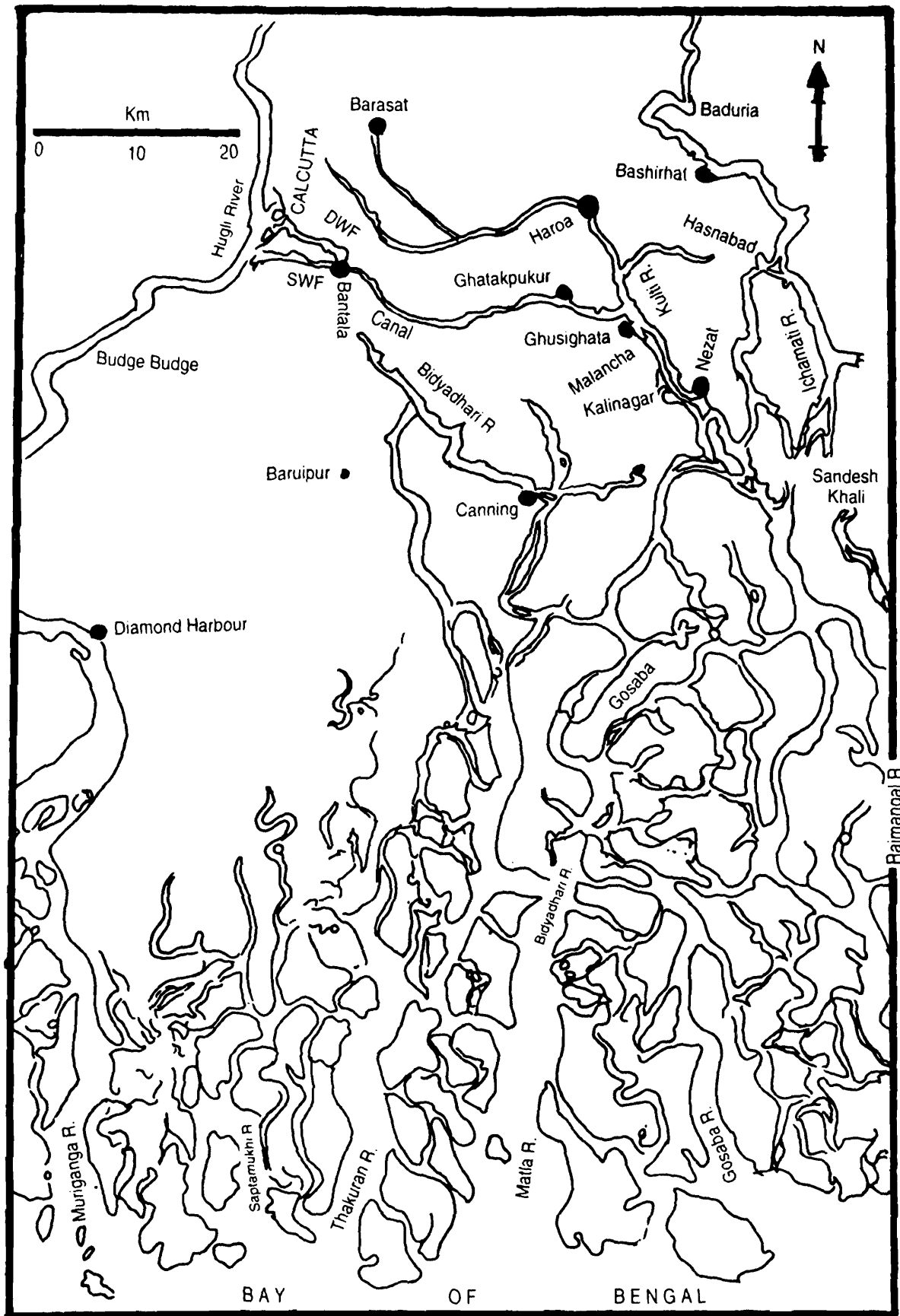


Fig. 1 : Kulti Estuary, Sewage Canals and Study Stations.

ecology of the estuary, further three stations were fixed, Station K-1, near Haroahat, about 8 km above outfall, Station K-2, near Ghusighata at outfall, Station K-3, near Malancha, about 5 km below outfall and Station K-4, near Najat, about 25 km below outfall. The last station represented the unpolluted zone of the Kulti estuary which was interconnected with several khals of Raimangal estuary (Fig.1). Water and soil samples were collected and physico-chemical analysis was done as per standard method (APHA 1975). The collection and analysis of plankton and benthos were done as per the methods described earlier (Khan, 1994a). The record of fish and prawn fauna were made from the actual collections as well as from the collections of fisherman operating in and around Najat.

RESULTS

A. PHYSICAL FEATURES OF THE ESTUARY

1. Physiography :

Kulti estuary is a part of an offshoot of Raimangal estuary and is variously known as Barkalgachi, Kalagachi, Hatgachigong, Kultigong and Haroagong. In upland it terminates into three narrow arterial channels, the Nonagong, the Sunthi and the Nowee (Fig. 2), which are tidal rivulets spilling into brackishwater fish culture ponds and swamps of North 24 parganas (David, 1959). The storm water flow canal carrying sewage runs for about 27km from Bantala to join the estuary near Ghusighata. In spite of a large catchment area, the estuary lacks any perennial source of fresh water above the point of sewage outfall. However, it receives some amount of tidal water brought by sealdahgong from Icchamati river through Hinsee Khal and also freshwater during monsoon months from same river. River Icchamati receives abundant spill water from flooded river Padma. Besides, runoff water from its catchment area of about 659 km² and 400 km² of Calcutta and adjacent areas, bring sufficient amount of water to keep the estuary fresh for two months, August and September (David, 1959).

During earlier period, when Bidyadhari used to receive abundant water supply through Jamuna, then an important tributary of Bhagirathi, the physiography of Kulti estuary was different as it had its outfall in River Matla through Kumerjalong. The physiography of the entire gangetic delta and its rivers/ estuaries had been subjected to vigorous changes during the course of its recent history. This delta is the resultant effect of the deposition of enormous amount of silt brought down through Bhagirathi and its important tributaries like Jamuna and Bidyadhari. River Bidyadhari used to receive major discharges from Ganga, prior to 12th century when it also carried huge amount of silt to Bay of Bengal through Jamuna and its offshoots. During this period Damodar had its outfall into Hugli (Bhagirathi) near Kalna and Niassarai above the offtake of Jamuna (near Tribeni). With the result, Bidyadhari used to receive abundant water supply both from upland through Jamuna-Hugli and also backwaters from the tidal regions. This made Bidyadhari an important river which used to inundate about 250 km² area lying in North 24 parganas including North and South Salt Lakes and areas east of Calcutta.

During last few years of eighteenth century and early nineteenth century, a peculiar phenomenon occurred. Due to sudden geographical annihilation in Rajmahal and neighbouring

areas, river Ganga changed its course of flow, shifting major flow from Jamuna to Padma, reducing the water supply of Jamuna-Bidyadhari drastically. During this period river Damodar which had its outfall in Hugli near Kalna and Niassarai, above the offtake of Jamuna and used to provide moderate quantities of water to Jamuna-Bidyadhari, shifted its main course to present day position at Uluberia. This diversion had disastrous effects on the water supply of Jamuna-Bidyadhari system. In the absence of upland water supply, Bidyadhari became dependent solely on local rains in its drainage basin for its survival. Misfortune further struck the river when it started silting rapidly, due to large amount of silt brought by tidal rivers and absence of proper upland discharge to flush it down. This finally sealed the fate of Bidyadhari. Kulti estuary, which runs parallel to Bidyadhari, also faced changes and started developing perhaps at the cost of Bidyadhari. (Majumdar, 1942). In upland, the Nonagang, the Sinthee and the Nowee, which originally fed Bidyadhari, were gradually absorbed by Kultigong. In lower reaches also it changed its original course from Matla to present day of Raimangal. The dried bed of Bidyadhari river and its spill areas were converted into numerous swamps/marshes of varying sizes, which in later years were converted in fishery farms. The present day wetlands lying east of Calcutta, including North and South Salt lakes are parts of this conversion.

2. Drainage:

The deltic area has been divided into four main categories, viz. (1) Blocks draining into Hugli river, (2) Blocks draining into rivers of Kulti series, (3) Blocks draining into Matla-Piali-Bidyadhari series and (4) Blocks draining into the Icchamati series of rivers (Mitra, 1954). Kulti drainage comprised of following areas :—

- i. A part of the drainage from Birtee beel via Nowee river.
- ii. Drainage from a large block served mainly by Sinthee river.
- iii. Drainage from Nonagong.
- iv. Drainage from various blocks (Blocks V & VI) into Kultigong.
- v. Drainage through Bhangar Canal from south west channel.
- vi. Drainage from salt lake.
- vii Drainage from the blocks covering Kasba and adjacent areas.
- viii. Drainage from areas south of Storm water canal of Calcutta metropoliton.

The total catchment area of Kulti is about 650 km excluding 400km² of catchment of Calcutta. However, due to absence of proper drainage channals, Kulti is deprived of the major volumes of water.

3. Water flow :

Monthly averages of water levels for 27 years from 1931 to 1957, at three points, viz. Haroahat (about 8 km above the sewage outfall), Ghusighata (outfall) and Malancha (about 5 km

below the outfall), were reported by Maitra (1958) at highest of high and lowest of low tides. The figures were :

Haroahat— HHW—10.0-10.9 ft, LLW—2.1-3.4 ft,

Ghusighata— HHW—10.3-10.9 ft, LLW—4.1-5.5 ft

Malancha— HHW 9.2—11.9 ft. LLW 4.1-6.8 ft.

Monthly discharge figures of Ghusighata during 1966 indicated the higher discharges during the months of March, and September—October.

David (1955) reported the condition of the estuary around 1940, prior to discharge of metropolitan sewage as :

Max. depth (High tide) : up to 42 ft.

Average high water level : 14.50 ft above datum,

Average low water level : 3.33 ft above datum,

Max, flood discharge : 27,000 Cusecs,

Max. ebb discharge : 24,000 cusecs.

Max. discharge at low tides : 8,000 to 9,000 cusecs,

Difference between LLT and MMT : 17.8 ft,

Difference during neap tide : 8.11 ft,

Average discharge : 17,000 cusecs.

The velocity of water was recorded to vary between 1.35-2.44 m/scc at flow and ebb currents respectively, near the outfall.

The rate of siltation of estuary was determined by cross sectional area and slope factor data obtained from five centres Viz. Nowee-Sinthee junction, Haroahat, Ghusighata (outfall), Malancha and Barmajore between 1952-1956 (Pramanik and Roy, 1972). They observed that at Nowee-Sinthee junction the average sectional area decreased progressively during 1952-58 while the average values of shape factor showed rising trend during this period. On the basis of cross sectional data, and the shape factor, it was concluded that during 1959-1960 the deterioration was checked, during 1961-65, there was a slight improvement but in 1966 high siltation was again noticed. At Ghusighata (below outfall), the average values of sectional cross area fluctuated widely between 1952-1958. During 1959-1961 the slight deterioration was observed, However, the period between 1962-66 was characterised by improved conditions as indicated by data on shape factor and cross sectional area. at Malancha, during 1952-1959 while the values of sectional cross area decreased, progressively, the values of shape factor increased which indicated deterioration. During 1960-1963, the conditions indicated gradual improvement but in 1964-66 further deterioration was noticed.

B. MODE OF WASTEWATER DISPOSAL

To dispose the enormous amount of wastewaters generated both by domestic and industrial sources, the city has about 1412 km length of drainage system of interconnected network of drains. The sewage is carried from the eastern fringe of the city by an open dry weather flow canal up to sedimentation tank near Bantala, about 8 km away. After the sedimentation tanks, which are defunct for quite sometimes, the DWF is joined by Storm water flow Canal(SWF), which brings rainwater from the city during monsoon, and the combined canal runs down to a distance of 27km before meeting the Kulti estuary. The outfall canal is provided with 16 vents with a total capacity of 220 cusecs but only few vents are kept open except during monsoon months. The discharge of wastewater is so regulated as to provide sufficient sewage to sewage fed fishery farms, locally known as Bheries, scattered all along Bidyadhari, Bantala, Dhapa and Hanakhali areas. Therefore, the period of discharge varies from month to month. The sedimentation tank, which was constructed during 1942 for settling the silt, remained operational for a very short time. During the period of its operation nearly 9 tones of sludge used to be removed daily from seven lagoons and disposed as manure. After settling, the supernatant sewage with 20-30% silt, was being used in the bheries and rest drained into storm water flow canal. The capacity of SWF canal is about 3,000 cft/sec while that of DWF canal it is only about 280 cft/sec. After the sedimentation tank became defunct, the raw effluent, during its course in open canal of 8 km before Bantala, get most of its suspensoids settled or absorbed by thick rooted water hycanths, growing in abundance in the canal before the regulation gate. In the process, the raw sewage is partially settled and converted into light black colour wastes. The large amount of this sewage is also used for agro-pisciculture purposes. The flow in DWF canal is very much slow and restricted during pre and postmonsoon periods, which can be attributed to the stopage of the discharge of some 0.41 mm³/ day of unfiltered water of Hugli used by the city for street washing and fire fighting etc. and drawl of raw sewage from DWF canal for irrigation and fisheries purposes. With the result, this portion of DWF canal has been covered by black residual matter. The flow in SWF canal after Bantala, where the DWF canal joins, is also slow and the entire stretch is almost like an open sedimentation tank during major part of a year.

C. NATURE AND CHARACTERISTICS OF WASTEWATER DISCHARGED

The metropolitan waste compared of both, domestic sewage and industrial effluents. It has been reported that some 20% of the total discharge is contributed by industrial sector. A large number of industries which include chemicals, fertilizers and pharmaceuticals; ferrus and non-ferrus metallurgical, galvanizing, and electroplating; pulp and paper, textiles and safety matches; soaps and detergents; mineral oil and numerous tanneries, discharge their crude waste into DWF canal through city's drainage system alongwith domestic sewage. The industrial effluents have somewhat changed the primarily organic nature of wastewater into a complex one by adding metals and various other industrial chemicals. It has been reported (Ray *et al*, 1981) that both sewage sludge

and water contained higher quantity of heavy metals like, lead, zinc, copper, manganese, chromium, cobalt and nickel etc. However, the nature of the wastewater was still predominately organic.

The physicochemical characteristics of wastewaters at 3 centres, M-1, M-2 and M-3, spread over the entire 35 km of canal length during different seasons are given in Table 1. Salient features are discussed below :

1. Wastewater flow :

The rate of wastewater flow varied considerably between seasons. Highest flow was recorded during monsoon months at all stations (3.196, 2.557 and 2.144m³/sec respectively for Stations M-1, M-2 and M-3) followed by post monsoon. The lowest flow was noticed during premonsoon months. The values obtained are comparable with those of NEERI (1978), which reported the range of values as 4.59 and 0.14 m³/sec at different stations. However, no definite seasonal pattern of wastewater flow was noticed by them.

TABLE -1. PHYSICO-CHEMICAL CHARACTERISTICS OF METROPOLITAN WASTEWATERS

Parameters	STATION-M-1 Topsia-Bantala			STATION M-2 Ghatakpukur			STATION M-3 Ghusighata		
	PRM	M	POM	PRM	M	POM	PRM	M	POM
Flow M ³ /Sec	1.946	3.1991	2.166	1.746	2.560	1.966	1.213	2.146	1.459
pH	7.5	7.2	7.5	7.6	7.4	7.7	7.8	7.5	7.8
Total Solids mg/l	3200.5	1120.4	1530.2	2210.6	1180.5	1760.0	2150.2	820.4	1250.0
Suspended solids mg/l	384.2	202.4	229.5	250.6	80.2	88.5	205.2	36.3	160.4
Dissolved Oxygen mg/l	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Free Carbon dioxide mg/l	45.2	28.5	95.3	29.4	18.2	20.4	28.8	15.3	26.4
Alkalinity (as CaCO ₃) mg/l	260.0	180.5	245.5	280.0	170.7	280.1	255.0	219.2	265.5
Chloride mg/l	233.7	120.0	160.0	290.0	150.0	175.0	295.0	105.6	210.5
B.O.D. 5 day mg/l	335.2	212.4	275.2	180.5	185.6	140.2	65.5	20.3	25.2
Oxygen consumed 30 min 100C	55.2	28.3	35.4	35.5	26.3	28.2	30.5	10.3	18.4
Ammonia-N mg/l	3.0	9.2	9.8	11.3	6.2	9.2	14.2	4.3	10.5
Nitrate -N mg/l	5.2	3.5	3.9	4.4	2.5	4.0	4.5	2.1	3.5
PO ₄ -p mg/l	3.5	1.8	12.5	6.0	2.0	14.2	4.8	3.0	12.5

TABLE -2. WASTEWATER CHARACTERISTICS OBSERVED DURING DIFFERENT PERIOD

Factors	NEERI,1978	Ray & Pakrasi 1979	Ray & Ban- dhopadhyay 1984	Ray <i>et al</i> 1981	Ghosh 1983
Turbidity mg/l	—	780-972	100	—	—
Total solid mg/l	792-2260	380-972	—	—	—
Suspended solid	64-198	—	—	—	—
pH	7.2-8.6	7.0-7.4	7.1-7.5	—	—
D.O.mg/l	NIL	NIL	NIL	—	—
Dissolved CO ₂ mg/l	—	24-45	—	—	—
Alkalinity (CaCO ₃) mg/l	206-440	78-292	136-316	—	—
Chloride mg/l	88-895	120-130	—	—	—
B.O.D. 5 day mg/l	55-95	400-530	60-80	—	200-650
O.C. 30 min. 100°C mg/l	2-10.5	30-75	—	—	—
POLLUTION LOAD (8 hrs discharge)					
Total volume : mld mean	51.839				
B.O.D. ton/day	3.3123 x	—	—	200.8	200-650
Total solids t/day	71.260				
Suspended solid t/day	6.316				
O.C	" 9.080				

2. Colour and odour :

The colour of the wastewater was light black with undesirable odour. Stinging odour was noticed from a distance before Bantala during premonsoon months.

3. pH:

The pH of the waste water varied between 7.2 and 7.8 with highest values at station M-3. While David(1959) , Ray and Pakrasi (1979) and Ray and Bandhopadhyay (1984) reported the values ranging between 7.0-7.5, NEERI (1978) reported extremely high values at Ghatakpukur (Station M-2 of present investigations) where it varied between 8.0 (winter) to 8.6 (monsoon).

4. Solids:

The solids (suspended plus dissolved) load of the effluents was considerably high throughout the course of flow. It varied between 820.4 (Station M-3, monsoon) to 3200.5 mg/l (Station M-3

pre monsoon). There was a gradual decrease in the values from Station M-1 to Station M-3 as silt and other suspended solids got deposited gradually in the canal during its course of 27km. The total solids values recorded by earlier workers varied widely. NEERI (1978) observed that the total solid values ranged between 792-2260 mg/l and Ray and Pakrasi (1979) found the variations in value as 380-792 mg/l (Table-2) The values obtained during present investigations were comparatively higher than recorded earlier.

The contribution of suspended solids was always small and varied between 384.2 and 36.3 mg/l, highest during premonsoon and lowest during post monsoon. The values recorded by earlier workers differ widely and no definite comparison can be made, regarding the variations in the values during different periods.

5. Dissolved Oxygen:

There was a total absence of any dissolved oxygen in the entire sewage throughout the year. The highly organic effluents perhaps consumed all the oxygen. The availability of oxygen in the sewage was never noticed by any earlier worker except that NEERI (1978) noticed small quantities during monsoon.

6. Free carbon-di-oxide:

It was abundantly recorded from all stations, highest being at station M-1 which decreased gradually at Stations M-2 and M-3. Seasonwise the values varied between 15.3 and 45.2, mg/l, highest during premonsoon and lowest in post monsoon. The values estimated during 1958 by David (1959) and Ray and Pakrasi (1979) were also high and ranged between 20-96 and 24-45 mg/l respectively.

7. Alkalinity:

The alkalinity was always moderately high in the entire canal but the values decreased gradually from upper to lower regions. The range of variation was 170.7-280.1 mg/l. Moderately high values ranging between 178-440 mg/l were also observed by earlier workers during different period of time (David, 1959; NEERI, 1978 and Ray and Bandhopadhyay, 1984).

8. Chloride:

Chloride values varied between 295 and 150 mg/l, highest during premonsoon and lowest during monsoon. Extremely high values were recorded by NEERI (1978), which varied between 88-895 mg/l. On the other hand, Ray and Pakrasi (1979) reported its variations between 120 and 130 mg/l.

9. Biochemical Oxygen demand:

Very high B.O.D. values were recorded from the entire stretch ranging between 335.2 and 20.3mg/l. A gradual decrease from station M-1 to M-3 was noticed, during all seasons. Widely

varying B.O.D. values have been reported by different workers. Ray and Bandhopadhyay (1984) reported very low values ranging between 60-80 mg/l, NEERI (1978) found it to vary between 55-96, Ray and Pakrasi (1979) reported its as 400-530 mg/l and Ghosh (1983) reported its range of variation as 200-650 mg/l. The values obtained during the present investigations were moderate as compared to both extremes.

10. Oxygen Consumed:

The O.C., 30 min -100°C values, representing the organic matter varied between 10.3 and 5.5 mg/l and followed almost the same pattern as B.O.D. Comparatively higher values were recorded during earlier surveys (David, 1959—24-88 mg/l, Ray and Pakrasi, 1979—30-75 mg/l).

11 Nutrients:

Ammonia-N and Nitrate-N values were quite high in the wastewater. The values of NH₃-N varied between 14.2 and 4.3 mg/l. Highest values were recorded during premonsoon months. Almost similar observations were made by earlier workers. Similarly, Nitrate-N values fluctuated between 2.1-5.2 mg/l. The values higher than the present one have been recorded by Ray and Bandhopadhyay (1984). However, David (1959) recorded a very low Nitrate-N contents. It appears that nutrient loads has increased considerably. Inorganic phosphate contents of wastewater was also very high and ranged between 1.8 and 4.2 mg/l. The highest value of phosphate-P were recorded during post monsoon months.

D. POLLUTION LOAD OF THE WASTEWATER

The total volume of wastewater discharged was estimated on the basis of rate of flow at three stations. the values were highest during monsoon months and lowest during premonsoon period (Table 3). Mean calculated values for premonsoon, monsoon and postmonsoon seasons were 47.099, 75.896 and 54.074 million litres per day respectively, with an annual mean of 59.025 mld. The pollution load was calculated in terms of total solids, suspended solids and B.O.D. The values for total solid were 121.90, 80.325 and 83.058 tons per day for premonsoon, monsoon and postmonsoon respectively, with an annual average of 95.097 tons per day. The corresponding seasonal values for suspended solids were 13.772, 8.73 and 7.302 tons per day respectively, with an annual average of 9.934 tons/day. The load generated by B.O.D. was of the order of 10.052, 9.016 and 8.731 respectively with an annual mean of 9.26 ton/ day. The total amount of wastewater discharged into the estuary has increased considerably during recent years. NEERI (1978) recorded the discharge for 1974-75 (average 8 hrs discharge as 51.839, which is 7.186 mld lesser than that observed during present investigations for the year 1988-91. However, the NEERI's values of total solids (mean 71.26 t/day), suspended solids (mean 6.316 t/day) and B.O.D. (mean 3.312 t/day) were considerably lesser than those obtained during the present study. On the other hand values recorded by other workers (Ray and Pakrasi, 1979) were significantly higher than those recorded during present investigations.

TABLE-3. POLLUTION LOAD GENERATED BY METROPOLITAN WASTEWATER

Parameters	STATION M-1			STATION M-2			STATION M-3			MEAN SEASONAL VALUES			ANNUAL MEAN
	PRM	M	POM	PRM	M	POM	PRM	M	POM	PRM	M	POM	
Total volume (mld)	56.06	92.15	62.45	50.29	73.72	56.63	34.94	61.82	43.19	47.10	75.89	54.07	59.02
Total solids tons/day	179.33	103.24	95.46	111.19	87.03	99.71	75.12	50.71	54.01	121.91	80.32	83.06	95.08
Suspended Solids tons/day	21.48	18.65	14.28	12.60	5.91	5.01	7.17	1.76	2.60	13.77	8.73	7.30	9.93
5 day Biochemical Oxygen Demand tons/day	18.78	16.91	17.17	9.08	8.89	7.94	2.29	1.25	1.08	10.05	9.01	8.73	9.26

PRM—Premonsoon, M—Monsoon POM—Post-monsoon mld—million liters per day.

E. HYDROBIOLOGICAL FEATURES OF THE ESTUARY

Hydrobiology of the estuary was studied at four stations spread over 33km stretch of the estuary from above the outfall to 25 km below the outfall. Out of these three stations, K-1, K-2 and K-3 were polluted stations and Station K-4, situated at Nejat, 25 km below the outfall, represented the unpolluted zone of the estuary. Therefore, the polluted and unpolluted zones are discussed separately.

The variations in different physico-chemical parameters of the polluted zone of the estuary during different seasons are given in Table 4. Salient features are described below :

1) PHYSICOCHEMICAL FEATURES

a. Water temperature :

The seasonal fluctuations in temperature, was not very appreciable and ranged between 30.6° C and 23.0°C, lowest during postmonsoon and highest in premonsoon. Further, longitudinal gradient was also not visible.

TABLE -4. PHYSICO-CHEMICAL CONDITIONS OF THE ESTUARY AROUND OUTFALL

Parameters	STATION-K-1 Haroahat (above outfall)			STATION K-2 Ghusighata (Outfall)			STATION K-3 Malancha (below outfall)		
	PRM	M	POM	PRM	M	POM	PRM	M	POM
Temperature ° C	30.6	27.9	23.0	30.4	28.2	23.5	30.2	28.5	23.0
Turbidity mg/l	110.0	460.0	65.0	90.0	420.0	230.0	85.0	190.0	55.0
pH	7.6	7.5	7.7	7.2	7.3	7.5	7.7	7.5	7.9
Total solids mg/l	610.0	2250.0	680.0	2420.0	4510.0	1820.0	1210.0	2150.0	640.0
Suspended solids mg/l	65.0	295.0	85.0	321.5	445.2	122.7	100.0	310.0	95.0
Dissolved Oxygen mg/l	1.0	3.0	2.0	-0.0	0.6	0.8	1.2	3.2	2.5
Alkalinity mg/l	215.0	180.0	245.0	220.0	180.0	295.0	140.0	160.0	190.0
Salinity ppt	12.2	1.2	5.2	16.0	2.5	12.0	32.5	5.5	14.2
B.O.D. mg/l	20.2	11.5	16.4	50.2	16.5	28.0	22.0	10.6	16.8
O.C. mg/l 30 min 100°c	23.5	15.8	19.5	42.5	18.0	28.4	30.0	20.0	25.0
Ammonia -N mg/l	0.35	0.22	0.65	3.5	1.0	7.5	3.2	0.80	1.6
Nitrate-N mg/l	1.22	0.50	1.20	2.80	0.65	1.15	1.5	0.21	0.90
Inorganic P mg/l	0.38	0.26	0.40	1.60	0.52	3.2	1.90	0.80	2.3

PRM—Premonsoon, M—Monsoon and POM—post monsoon

h. Turbidity :

The turbidity of the estuary was contributed by washings of catchment area during monsoon season and scrotching effects, besides wastewaters. Highest values were recorded at station K-1, (460 mg/l) closely followed by Station K-2 (420 mg/l) and lowest at Station K-3. Seasonwise it was lowest during premonsoon. Values considerably higher than present ones were recorded by David (1959) and Ray *et. al.* (1981).

c. pH :

The pH of the estuary at Stations K-1 , 2 and 3 were always very low and varied between 7.2 and 7.7 at different stations, comparatively higher values were observed at Station K-3, 5 km below the outfall. There was almost sudden decrease in pH at the outfall, where the values dropped to 7.2 during premonsoon, showing the stressful condition of the zone. Similar value of pH were also recorded by other workers.

d. Solids :

Because of constant discharge of sewage, the solid load of the estuary was always high. The highest values were recorded during premonsoon months and values ranged between 4510 mg/l (Station K-2 monsoon) to 610 mg/l (Station K-1, premonsoon). The contribution of suspended solids was considerably lesser than dissolved solids, and the values ranged between 95 and 445 mg/l, lowest at station-1 during premonsoon and highest at station K-2 during monsoon. The enormously high load of dissolved solids were due to organically enriched sewage from the metropoliton.

Similar observations were made by NEERI (1978) where contribution of suspended solids ranged only between 52-74 mg/l as compared to total solid load of 664-12996 mg/l. The values recorded by NEERI for total solids were abnormally high.

e. Dissolved oxygen :

The dissolved oxygen concentration was probably the most important factor affected drastically by the discharge of metropoliton waste. The values were not found to improve much at Station K-3, 5 km below the outfall, which revealed the gravity of the situation. The station above the outfall was also found almost devoid of oxygen at certain occassions. The values varied between 0.53 to 3.5 mg/l between stations K-1 and K-3. The most important aspect was that even the high tides at stations K-1, 2 and 3 could not improve much oxygen contents. Similar observations were made by Ray *et. al.* (1981).

f. Alkalinity:

Moderately high values of alkalinity was recorded from all stations. There appeared to be no impact of sewage upon alkalinity of the estuary as the changes at station K-2 (outfall) an K-3 (bellow outfall) were not appreciable. The values ranged between 180-295 mg/l. Highest values were generally recorded during postmonsoon period. Slightly higher values of alkalinity were

observed by NEERI (1978), During postmonsoon period (340-368 mg/l), whereas values lesser than the present one were recorded by Ray *et al.* (1981).

g. Salinity:

The salinity of the entire estuary was considerably high during premonsoon period and lowest during monsoon. The variation in salinity of the estuary was quite wide and great differences occurred between wet and dry seasons. During premonsoon months, the values varied between 9.2 ppt and 22.6 ppt, lowest at Station K-1 and highest at Station K-3. During monsoon salinity of all three stations dropped considerably. Salinity was always comparatively higher at Station K-3. No apparent impact of sewage on the salinity of the estuary was visible and it followed its own cycle.

The values of salinity recorded by different workers differ widely and no correlation could be established. David (1959) reported its range of variations as traces to 30.69 ppt. River Research Institute (1970) study revealed its fluctuations around outfall area as 1.03 to 30.3 ppt and above outfall at Haroa as 0.756 to 21.6 ppt. As per NEERI'S (1978) report values ranged from 3.99 to 11.25 ppt, 0.148 to 0.271 ppt and 0.5 -1.21 ppt during premonsoon, monsoon and post monsoon respectively. Ray *et al.* (1981) observed the range of variations between 1.43 and 40.6 ppt. The last value seems to be extremely high.

h. Biochemical Oxygen Demand :

Extremely high values of B.O.D. were observed during premonsoon at Station K-2 (50.2 mg/l). Station K-1 and K-3 also exhibited moderately high values during this period. Because of freshwater influx and dilution, B.O.D. values decreased during monsoon months. Contrary to this, NEERI (1978) observed lowest values during premonsoon and highest during postmonsoon. The range of B.O.D. values were also considerably lesser as compared to present one. However, the values obtained by Ray *et al.* (1981) were much higher in premonsoon around outfall.

i. Oxygen consumed :

The fluctuations in oxygen consumed almost followed same pattern as that of B.O.D. The values ranged between 42.5 mg/l and 23.5 mg/l during premonsoon, lowest at Station K-1 followed by Station K-3 and highest at Station K-2. Higher values of O.C. in the estuary were also recorded by NEERI which varied between 56-92 mg/l during post monsoon and between 60-103 mg/l during premonsoon. Ray *et al.* (1981) found the fluctuations in O.C. values varying between 150-250 mg/l during premonsoon.

j. Nutrients :

The nitrogen contents of the estuarine water compared of Ammonia-N, albuminoid-N, Nitrite-N and Nitrate-N. Highest values of NH₃-N were observed during postmonsoon at Station K-2 (7.5 mg/l) and lowest during monsoon at Station K-1 (0.22 mg/l). NO₃-N values were also highest at Station K-2 (2.80mg/l) but during premonsoon months. The higher values of nitrogen in the estuary was definitely contributed by the sewage. High values were also recorded by previous workers but the values obtained differed widely. As per NEERI's (1978) observations, ammonia-N

at outfall varied from 8.5 -11.6 mg/l during premonsoon and 1.12-1.68 mg/l during postmonsoon. The Nitrate-N was in higher concentrations during premonsoon (0.45-3.35 mg/l). Ray *et. al.* (1981) reported the variations between 0.40-2.5 mg/l during premonsoon for the entire estuary. Similarly PO₄-P values were also high at stations around outfall and immediately below outfall. Highest values were obtained during post monsoon period at all stations, as compared to other stations. Comparatively higher values were reported by NEERI (1978).

2) BIOLOGICAL FEATURES

Extremely severe impact of wastewater discharge on the total ecology of the estuary was evident at all stations, except Station K-4, situated some 25 km below the outfall at Nazat. Stations close to outfall, K-1, K-2 and K-3 were affected considerably throughout the year, particularly during premonsoon months. No animal or plant species was collected from outfall area, near Ghushighata during any season. One of the most important features of the estuary was that deterioration of conditions not only took place below outfall but impact travelled upward and entire stretch between Ghushighata and Haroa was affected. During premonsoon period, conditions in the arterial channels, Sinthee and Nowee were also affected. The pollutants discharged during low tide remained in the estuary for quite sometimes and during high tide these were pushed above. Since Station K-4 did not show any sign of pollution, it has been discussed separately considering it as a normal zone of unpolluted Kulti. The biological conditions at all other stations (K-1, K-2 and K-3) are discussed below (Table 5 & 6).

TABLE -5. NUMERICAL ABUNDANCE OF VARIOUS GROUPS OF PHYTOPLANKTON ZOOPLANKTON AND BENTHOS AT STATIONS K-1 TO K-3 AROUND OUTFALL

Stations Groups	Premonsoon			Monsoon			Postmonsoon		
	K-1	K-2	K-3	K-1	K-2	K-3	K-1	K-2	K-3
PHYTOPLANKTON NO/1									
Diatoms	1	—	2	2	—	8	3	—	8
Green algae	—	—	—	2	—	—	1	—	—
Blue green algae	4	—	5	6	—	5	6	—	10
Phytoplankton	1	—	1	2	—	3	—	—	—
ZOOPLANKTON NO/1									
Protozoa-Rhizopoda	4	—	1	1	—	—	1	—	—
Rotifera	—	—	—	2	—	—	1	—	—
Hydromedusae	—	—	—	—	—	—	—	—	4
Copepoda	—	—	2	4	—	4	3	—	6
Crustacean									
larvae	1	—	2	1	—	1	2	—	2
others	—	—	1	—	—	2	1	—	—

TABLE -5. *contd.*

	K-1	K-2	K-3	K-1	K-2	K-3	K-1	K-2	K-3
BENTHOS NO/m²									
Oligochaeta	—	—	—	2	—	—	—	—	—
Polychateta	—	—	2	—	—	5	—	—	4
Nematoda	2	—	3	4	—	4	3	—	3
Gastropoda									
Bivalvia	—	—	—	—	—	—	—	—	—
Brachyura	—	—	—	—	—	8	—	—	6
Anomura	—	—	—	—	—	—	—	—	4
Alpheidae	—	—	—	—	—	4	2	—	3

TABLE -6. OCCURRENCE OF DIFFERENT BIOTIC SPECIES AROUND OUTFALL

	Premonsoon			Monsoon			Postmonsoon		
	K-1	K-2	K-3	K-1	K-2	K-3	K-1	K-2	K-3
PHYTOPLANKTON									
Diatoms									
<i>Coscinodiscus sp</i>	+	-	+	+	-	+	+	-	+
<i>Cylotella sp</i>	-	-	-	-	-	+	-	-	-
<i>Naviculla sp</i>	-	-	-	-	-	-	+	-	+
<i>Nitzschia sp</i>	-	-	-	-	-	-	+	-	+
Green Algae									
<i>Pediastrum sp</i>	-	-	-	+	-	-	-	-	-
<i>Scenedesmus sp</i>	-	-	-	+	-	-	-	-	-
<i>Spirogyra sp</i>	-	-	-	+	-	-	+	-	-
Blue green Algae									
<i>Oscillatoria sp</i>	+	-	+	+	-	+	+	-	+
<i>Anabaena sp</i>	-	-	+	+	-	+	+	-	+
<i>Nostoc sp</i>	-	-	-	+	-	+	-	-	+
<i>Microcystis sp</i>	-	-	+	-	-	+	-	-	+
Phytoplankton									
<i>Euglena sp</i>	+	-	+	-	-	+	+	-	+

TABLE -6. contd.

	K-1	K-2	K-3	K-1	K-2	K-3	K-1	K-2	K-3
ZOOPLANKTON									
Protozoa									
<i>Diffugia sp</i>	+	-	+	+	-	+	+	-	+
Rotifera									
<i>Brachionus caliciflorus</i>	-	-	-	+	-	-	+	-	-
<i>Keratella tropica</i>	-	-	-	+	-	-	+	-	-
<i>Asplanchna</i>									
<i>Brightwelli</i>	-	-	-	+	-	-	-	-	-
Cladocera									
<i>Daphnia similis</i>	-	-	-	+	-	-	+	-	-
Copepoda									
<i>Haliodyptomus</i>									
<i>contortus</i>	-	-	-	+	-	-	+	-	-
<i>Pseudodyptomus</i>									
<i>anandalaiei</i>	-	-	-	+	-	-	+	-	++
<i>P.binghami</i>	-	-	-	-	-	-	-	-	+
<i>P.tollingerae</i>	-	-	+	+	-	+	-	-	+
<i>Othiona bravicornis</i>	-	-	-	-	-	+	-	-	+
<i>Mesocyclops</i>									
<i>leuckarti</i>	-	-	-	+	-	-	+	-	-
Crustacean larvae	-	-	+	+	-	+	+	-	+
BENTHOS									
Oligochaeta	+	-	-	+	-	-	-	-	-
polychaeta	+	-	+	+	-	+	+	-	+
Nematoda	+	-	+	+	-	+	-	-	+
Mollusca	-	-	-	-	-	-	-	-	-
Crustacea : Brachyura									
<i>Sesarma bidens</i>	-	-	+	-	-	+	-	-	+
<i>Metaplax intermedia</i>	-	-	-	-	-	+	-	-	+
<i>Varuna litterata</i>	-	-	+	-	-	+	-	-	+
Crustacea : Macrura	-	-	-	+	-	+	-	-	+
FISHES									
<i>Mystus gulio</i>	-	-	+	+	-	+	+	-	+
<i>Pangasius pangasius</i>	-	-	+	-	-	+	-	-	+
Others	+	-	+	+	-	+	+	-	+

i. **Phytoplankton:**

The phytoplankton were considerably affected at all the stations (Table 5). No live specimen was collected from the outfall area during any season. At Station K-1, during premonsoon, only few stray individuals of blue green algae, diatoms and euglenoids were recorded. Similarly, Station K-3 was also almost devoid of phytoplankton excepting few cells. *Coscinodiscus sp.* was the only species of diatom which occurred with blue green algae, *Oscillatoria sp.*, both above and below the outfall. During monsoon months conditions appeared to be somewhat improved due to availability of freshwater and consequent dilution of sewage. Both diversity and density of phytoplankton increased as compared to premonsoon. The phytoplankton species observed at K-1 were *Oscillatoria sp.*, *Microcystis sp.*, *Coscinodiscus sp.*, *Naviculla sp.*, *Pediastrum sp.* and *Spirogyra sp.* Station K-3 also showed considerably improved conditions. Six species of phytoplankton, comprising all the three groups were available (Table 6). During post monsoon period, conditions started changing gradually with time as both density and diversity of flora started reducing. Though species composition did not change much, the density was affected.

David (1959) gave a long list of phytoplankton species occurring in polluted regions, of which nine species occurred during premonsoon, 12 during monsoon and 14 species during post monsoon. Compared to present observations, more number of species occurred during the period of his study in forties and fifties. However, Ray *et al* (1981) recorded higher density of phytoplankton (52-149 and 11-30 units/l during monsoon and post monsoon respectively) than those observed during present studies. They also found almost similar set of species occurring in the polluted zone as those recorded presently.

ii. **Zooplankton:**

Zooplankton fauna of the estuary at polluted stations (K-1, 2 and 3) were also very poor (Table 5). No living organism was ever recorded from Station K-2 (outfall). The conditions were also extremely bad at station K-1 and K-3 during premonsoon season, At Station K-1, zooplankton were comprised of few protozoan, *Diffugia* species and few stray diaptomid, *Pseudodiaptomus tollingerae*. At station K-3, another species, *P. annandalei* and cyclopoid, *Othiona brevicornis*, were also seen along with *P. tollingerae*. Besides this some crustacean larvae and occasional chaetognath, *Sagitta* species were also seen. However, their numerical density was so poor that it is doubtful whether they played any role in the trophic dynamics of the estuary or they were simply drifted in the zone. (Table 6).

The conditions improved moderately during monsoon period. At station K-1, rotifers *Brachionus calyciflorus* and *Keratella tropica* along with stray cladoceran *Daphnia similis* were observed specially during August-September. Among copepods, cyclopoid *Mesocyclops leuckarti* and diaptomid, *Haliodyptomus contortus* were seen. At station K-3, copepods, *Pseudodiaptomus annandalei* and *p. tollingerae*, were noticed at one time or other. The other important group was crustacean larvae. Neither cladoceran nor rotifers were seen, though at times salinity was very low.

Similarly no freshwater copepod species descended into this zone. During post monsoon period almost similar species formed the composition at both stations but their numerical abundance was decreased substantially. Number of zooplankton also improved at both stations but with lower densities (Table 5). Zooplankton concentrations varied between 5/l and 8/l at station K-1 and 8/l and 12/l at station K-3.

David (1959) gave a very general list of zooplankton of the estuary which included mainly protozoan, crustacean larvae and copepod. Ray *et. al.* (1981) found the total zooplankton concentration varied between 13-10 units/l during monsoon and 2-16 units/l during post monsoon. There is no other account of zooplankton or other fauna of the estuary in quantitative terms and therefore no comparison can be made. If the results are compared with that of Sewell (1934), who recorded a large number of copepod species from Bidyadhari spill areas and channels (arterial), during the period when salt lakes used to receive abundant water supply and most of the creeks/khals of Bidyadhari were connected, it is disappointing to note that barring few, all the other species were not found in Kulti estuary in the polluted zone.

iii. **Benthos :**

Benthos were also found to be affected considerably both, qualitatively and quantitatively. No benthic species was recorded from Station K-2 (outfall) during any season. During premonsoon season, Station K-1 contained few polychaetes and nematodes only. Insect larvae and molluscan were conspicuously absent. Station K-3 also exhibited no better conditions. Here also few polychaetes and nematodes formed the benthic composition. During monsoon months conditions improved considerably at station K-3, where the density of polychaetes increased considerably. Besides, a number of crab of different species (Table 6) were seen. However, no molluscan species was noted during this season too. At station K-1, the faunal composition was not much changed and no other group except those found in premonsoon were available but the number was found to increase (Table 5) During post monsoon months the numbers reduced from those of monsoon and no other group of benthos appeared (Table 6). David (1959) also found similar specific composition at polluted stations. He reported a large number of burrows of fiddler crabs of the genera, *Sesarma*, *Dotilopsis*, *Metaplex*, *Tympanomerus* and *Pachygrapsus* from below Minakhan (below outfall and above station K-3). He also could not get any snails.

iv. **Necton-prawn:**

No prawn seed or juvenile were recorded at stations K-1 and 2 during premonsoon period. Few postlarvae of prawns were seen at station K-3 but their number was extremely meagre. During monsoon at station K-4, juveniles of *Macrobrachium* species were seen. At station 3, few individuals of *Metapenaeus*, *Macrobrachium* and *Acetes* were seen. During post monsoon also these species were available. However their numerical density was always poor at all stations. No prawns were collected from Station K-2, near outfall.

v. **Fishes:**

The fish fauna of the polluted zone of estuary between Stations K-1 and K-3 were also poor and these were only seen occasionally during monsoon and early post monsoon period. No fishes

were seen at Station K-2. At station K-1 economically unimportant fishes like *Glossogobius giuris*, *Mastacembelus armatus*, and *Puntius titco* etc were seen in few numbers. At station K-3 during the same period species recorded were *Mystus gulio*, *Pangasius pangasius*, *Glossogobius giuris*, *Esomus danricus* and some other unimportant fishes.

F. ECOLOGY OF THE ESTUARY AT UNPOLLUTED STATION

Station 4 near Nazat represented almost unpolluted conditions as evident both from physico-chemical and biological conditions.

The pH did not differ much between the seasons and varied around 8.1 and 8.3. The turbidity values were always low and ranged between 120-20 mg/l. Similarly total solids and dissolved solid loads were also low. values for total solids varied from 190-380 mg/l, highest during monsoon and lowest during post monsoon. The suspended solid contents were proportionally high as compared to polluted station but dissolved solids consisting of mainly nutrients were considerably low. Dissolved oxygen values were always above 7.0 mg/l showing very good condition of the estuary at this station in respect of availability of oxygen. Alkalinity varied between 125-160 mg/l, salinity was always higher as compared to other stations and varied between 5.8 (monsoon) to 28.5 (premonsoon) ppt. The B.O.D. values were extremely low (2.5-1.5 mg/l). Similarly, O.C. values were also very low. Nutrients were in minute quantities as compared to very high concentrations at other polluted stations. Nitrate-N values varied between 0.04-0.20 and phosphate varied from 0.09 to 0.38 mg/l (Table 7).

TABLE -7. PHYSICO-CHEMICAL CONDITIONS OF THE ESTUARY AT STATION K-4 (NAZAT)

Parameters	Premonsoon	Monsoon	Postmonsoon
Temperature °C	30.2	28.5	23.0
Turbidity mg/l	35.0	110.0	20.0
pH	8.3	8.1	8.2
Total solids mg/l	210.0	285.0	190.0
Suspended solids mg/l	65.0	90.0	75.5
Dissolved Oxygen mg/l	9.0	7.8	8.5
Alkalinity mg/l	140.0	125.0	166.0
Salinity ppt	28.5	7.6	18.5
B.O.D. 5 days mg/l	2.5	2.0	1.5
Oxygen consumed 30 min. 100 C mg/l	6.2	4.0	3.6.
Ammonia-N mg/l	0.075	0.400	0.12
Nitrate-N mg/l	0.055	0.030	0.860
PO ₄ -P mg/l	1.00	0.90	1.80

Among biological factors, the total, phytoplankton concentration varied between 85 and 12 units per litre, predominately composed of Diatoms. The important diatom species were *Coscinodiscus* sp., *Naviculla* sp, *Cyclotella* sp, *Melosira* sp., *Hemidiscus* sp., *plurosigma* sp, and *Nitzschia* sp etc. There was little seasonal variation in species composition but quantitative variations were visible. The next dominant algal group was blue green algae which was compared of four species and all four occurred during all seasons. The contribution of green algae was lowest because of high salinity (Table 8, 9).

TABLE -8. NUMERICAL ABUNDANCE OF VARIOUS GROUPS OF PHYTOPLANKTON ?
ZOOPLANKTON AND BENTHOS AT STATION K-4
(NAZAT)

Parameters	Premonsoon	Monsoon	Postmonsoon
PHYTOPLANKTON No/l	112	64	87
Diatoms	88	50	69
Green Algae	—	2	2
Blue green Algae	12	6	10
Phytoflagillates	12	6	6
ZOOPLANKTON NO/L	18	14	19
Protozoa	2	2	3
Hydromedusae	3	—	—
Copepoda	10	8	12
Chaetognatha	2	—	1
Crustacean larvae	1	2	2
Others	—	2	1
BENTHOS	59	50	51
Polychaeta	14	20	11
Nematoda	20	12	15
Gastropoda	19	8	10
Bivalvia	2	2	2
Brachyura	8	5	8
Anomura	4	2	2
Alpheidae	2	2	2

TABLE -9.DISTRIBUTION OF IMPORTANT PLANKTON, BENTHOS AND NECTON AT STATION K-4

(Nazat)

Species/group	Premonsoon	Monsoon	Postmonsoon
PHYTOPLANKTON			
Diatoms			
<i>Synedra sp.</i>	+	-	-
<i>Coscinodiscus sp</i>	+	+	+
<i>Malosira sp</i>	+	+	+
<i>Nitzschia sp</i>	-	+	+
<i>Naviculla sp.</i>	+	+	+
<i>Cylotella sp</i>	+	+	+
<i>Fragillaria sp</i>	-	+	-
<i>Hemidiscus sp</i>	+	+	+
<i>Pleurosigma sp</i>	+	+	+
Green Algae			
<i>Pediastrum sp</i>	-	+	+
<i>Ankistrodesmus sp</i>	-	+	+
<i>Scenedesmus sp</i>	-	+	-
<i>Spirogyra sp.</i>	-	+	+
Blue green Algae			
<i>Spirulina sp.</i>	+	-	+
<i>Oscillatoria sp</i>	+	+	+
<i>Nostoc sp</i>	+	+	+
<i>Anabaena sp</i>	+	+	+
<i>Microcystis sp</i>	+	+	+
Phytoflagellate			
<i>Euglena sp.</i>	+	+	+
ZOOPLANKTON			
Copepoda			
<i>Acartiella sewelli</i>	+	+	+
<i>Peudodiaptomus binghami</i>	+	+	+
<i>Pseudodiaptomus annandalei</i>	-	+	+
<i>Pseudodiaptomus tollingerae</i>	+	+	+
<i>Acartia spinicauda</i>	+	-	+
<i>Paracalanus dubia</i>	+	-	-
<i>Pontonella andersoni</i>	+	-	-
<i>Temora turbinata</i>	+	-	+
<i>Microsetella arosea</i>	+	-	+
<i>Othiona brevicornis</i>	+	+	+

TABLE -9.contd.

1	2	3	4
<i>Corycaeus danae</i>	+	-	+
Hydromeduseae	+	+	+
Chaetognatha	+	-	-
Crustacean larvae	+	+	+
BENTHOS			
Polychaeta			
<i>Dendronereides aestuarina</i>	+	+	+
<i>Namalycastis indica</i>	+	+	+
<i>Neanthes chingrighattensis</i>	+	+	+
<i>Diopetra neopolitana</i>	-	+	+
<i>Talehsapia annandalei</i>	+	-	+
Decapoda-Brachyiura			
<i>Sesarma bidenes</i>	+	+	+
<i>Metapograpsus messor</i>	+	-	-
<i>Metaplax intermedia</i>	+	-	+
<i>Varnua littornia</i>	+	+	+
<i>Uca acuta</i>	+	-	+
<i>Uca dussumieri</i>	+	-	+
<i>Dotilopsis bravitorsis</i>	+	-	+
<i>Scylla serrata</i>	+	+	+
Decapoda-Alpheidae			
<i>Alpheus paludicola</i>	+	+	+
Decapoda-Anomura			
<i>Clibanarius padavensis</i>	+	+	+
Mollusca-Gastropoda			
<i>Neritina articulata</i>	+	+	+
<i>Littornia (Littorartia)</i>			
<i>Melanostoma</i>	+	+	+
<i>Assiminea brevicula</i>	+	+	+
<i>Telescopium (Telescopium)</i>			
<i>telescopium</i>	+	+	+
<i>Cerithidea (Cerithidopsis)</i>			
<i>cingulata</i>	+	-	+
<i>Onchidium tigrinum</i>	+	+	+
Mollusca-Bivalvia			
<i>Modiolus undulatus</i>	+	-	-
<i>Anadora granosa</i>	+	+	+
<i>Macoma birmanica</i>	+	-	+

Zooplankton fauna of the station was quite rich and dominated by copepods which contributed about 60% of the total zooplankton. As many as 11 species of copepods were commonly recorded during different seasons. These species were mainly of brackishwater or brackish-marine origin (Khan, 1994b). Three species of Pseudodiaptomus, *P. annadalei*, *P. binghami* and *P. tollengeriae*, *Acartia erythraea*, *Pontella andersoni*, *Temora turbinata*, *Paracalanus dubia*, *Othiona brevicornis*, *Corycaeus danae* and *Microsetella rosea* etc. were main contributors during different seasons. Besides copepods, other groups of zooplankton were chaetognaths, hydromedusae, and crustacean and fish egg and larvae (Table 8 & 9).

The benthic fauna of mud flats were comprised of 23 species during premonsoon, 15 during monsoon and 22 during postmonsoon. The numerically important groups were polychaetes, nematodes, gastropods and crabs (Table 8). The polychaetes were mainly represented by *Dendronereis aestuarina*, *Namalycastis indica*, *Neanthes chingrighattensis* and *Diopatra neopolitana*. The crab were represented by *Sesarma bidens*, *Metaplex intermedia*, *Metapogras-pus messor*, *Varuna litterata*, *Uca acuta*, *Dotillopsis brevitarsis* and *Scylla serrata* etc. Alpheid prawn was represented by *Alpheus paludicola*. The gastropods were comprised of *Nerita articulata*, *Littorina (Littoratia) melanostoma*, *Assimineia brevicula*, *Telescopium (Telescopium) telescopium*, *Cerithidea (Cerithidiopsis) cingulata* and *Onchidium tigrinum* etc. Bivalves were represented by *Macoma birmanica*, *Modiolus undulatus* and *Anadara granosa* etc.

The density of macrobenthos was highest during premonsoon followed by postmonsoon (Table 8).

The most important group of the estuary from commercial viewpoints was penaeids and palaemonids prawn. The prawn fauna of the station comprised of a number of penaeids viz. *Penaeus semisulcatus*, *P. indicus*, *P. mondon*, *Metapenaeus monoceros*, *M. bravicornis*, *Parapenaeopsis sculptilis*, *Palaemon stylifera* and *Macrobrachium rude* etc. These prawns were recorded almost throughout the year mostly in post larval and juvenile forms, but the main period of occurrence was postmonsoon and early premonsoon. The various species recorded are shown in Table 10.

The fish fauna of this zone of the estuary was also varied and composed of a number of species of marine and estuarine origin. A list of the fishes recorded from the area during extensive surveys of sundarban estuaries (1985-90) are given in Table 10. A total of 43 common species belonging to 39 genera and 24 families were recorded. The most important species which constituted substantial fishery were *Pelona ditchela*, *Coilia ramkarti*, *Setipinna phasa*, *Thryssa hhamiltoni*, *Mystus gulio*, *Pangasius pangasius*, *Lates calcalifer*, *Daysciaena albida*, *Liza persia*, *Rhinomugil corsula*, *Eleutherenema tetradactylum* and *Polynemus paradiseus* etc. Most of these were basically brackishwater fishers and occurred at wide range of salinities. Similarly seed resources of this estuary at this station was also very rich as fries and fingerlings of many species were observed almost throughout post monsoon and premonsoon periods.

TABLE -10. OCCURRENCE OF DIFFERENT SPECIES OF FISHES AND PRAWNS AT STATION K-4 NAZAT

Species	Premonsoon	Monsoon	Postmonsoon
FISHES			
Family Clupeidae			
Sub-family: Pristegasterinae			
<i>Pelona ditchela</i> Valenciennes	+	+	+
<i>Raconda russeliana</i> Gray	+	-	+
Sub-family : Pellonulinae			
<i>Corcia sabornia</i> (Hamilton)	+	+	+
Sub-family: Drosomatidae			
<i>Anodonstoma chacuda</i> (Hamilton)	+	+	+
Sub-family : Coilinae			
<i>Coilia ramcarati</i> (Hamilton)	+	-	+
<i>Coilia dussumeiri</i> Valenciennes	+	+	+
Sub-family : Engraulidae			
<i>Setipinna phasa</i> (Hamilton)	+	+	+
<i>Thryssa hamiltonei</i> Gray	+	-	+
Family : Bagaridae			
<i>Mystus gulio</i> (Hamilton)	+	+	+
Family Pangasidae			
<i>Pangasius pangasius</i> (Hamilton)	+	+	+
Family : Anguillidae			
<i>Anguilla bengalensis bengalensis</i> (Gray)	+	+	+
Family : Ophichthidae			
<i>Psiodonopsis boro</i> (Hamilton)	+	-	+
Family : Chanidae			
<i>Chanos chanos</i> (Forsskal)	+	+	+
Family : Ariidae			
<i>Arius sagor</i> (Hamilton)	+	-	+
<i>Arius sona</i> (Hamilton)	+	-	+
<i>Oesteogeniosus militaris</i> (Linn.)	+	-	-
Family Herpadontidae			
<i>Harpodon nehereus</i> (Hamilton)	+	-	-
Family Hemiramphidae			
<i>Zenarchopterus dispar</i> (Valenciennes)	+	+	+
Family Balonide			
<i>Strongylura strongylura</i> (Van Hassalt)	+	+	+
<i>Xenontodon cancila</i> (Hamilton)	+	+	+

TABLE -10.contd.

Species	1	2	3
Family Platycephalidae			
<i>Platycephalus scaber</i> Linn	+	-	-
Family Centropomidae			
<i>Lates calcarifer</i> (Bloch)	+	+	+
Family Ambassidae			
<i>Ambassis commersoni</i> (Valenciennes)	-	+	+
Family Teraponidae			
<i>Terapon jarbua</i> (Forsskal)	+	+	+
Family Sillaginidae			
<i>Sillago sihama</i> (Forsskal)	+	-	+
Family Leognathidae			
<i>Leiognathus blochii</i> (Valenciennes)	+	-	+
Family Lutjanidae			
<i>Lutjanus johni</i> (bloch)	+	-	+
Family Sciaenidae			
<i>Daysciaena albida</i> (Cuvier)	+	+	+
<i>Pama pama</i> (Hamilton)	+	+	+
<i>Johnius belangeri</i> (Cuvier)	-	-	+
Family : Scatophagidae			
<i>Scatophagus argus</i> (Linn.)	+	+	+
Family Mugilidae			
<i>Liza persia</i> (Hamilton)	+	+	+
<i>Liza tade</i> (Frosskal)	+	+	+
<i>Rhinomugil corsula</i> (Hamilton)	-	+	+
Family : Polynemide			
<i>Eleutheronema tetradactylum</i> (Shaw)	+	+	+
<i>Polynemus paradiseus</i> Linn	+	+	+
Family Gobidae			
<i>Apocryptes bato</i> (Hamilton)	+	+	+
<i>Boleophthalmus boddaerti</i> (Valenciennes)	+	+	+
<i>Glossogobius giuris</i> (Hamilton)	+	+	+
<i>Gobiopterus chuno</i> (Hamilton)	+	+	+
<i>Periophthalmodon schlosseri</i> (Valenciennes)	+	+	+
Family Trichiuridae			
<i>Trichiurus savala</i> (Cuvier)	+	-	+

TABLE -10.contd.

Species	1	2	3
Family Cynoglossidae			
<i>Cynoglossus cynoglossus</i> (Hamilton)	+	+	+
PRAWNS			
Family Penaeidae			
<i>Penaeus indicus</i> Milne-Edw	+	+	+
<i>Penaeus monodon</i> Fabricius	+	+	+
<i>Panaeus semisulcatus</i> De Mann	+	-	+
<i>Metapenaeus brevicornis</i> (Milne-Edw)	+	+	+
<i>Metapeenaeus affinis</i> (Milne -Edw)	+	-	+
<i>Metapenaeus monoceros</i> (Fabracious)	+	-	-
<i>Metapenaeus lysianasa</i> (de Man)	+	+	+
<i>Parapenaeopsis sculptilis</i> (Heller)	+	+	+
Family Palaemonidae			
<i>Palaemon styliferus</i> Milne-Edw.	+	+	+
<i>Macrobrachium malcomsonii</i> (Milne-Edw.)	+	+	+
<i>Macrobrachium lamarrei</i> (Milne-Edw.)	+	+	+
<i>Macrobrachium rude</i> (Heller)	+	+	-
Family Sergestidae			
<i>Acetes indicus</i> (Milne-Edw.)	+	+	+

Fishery practices in the region are mainly confined to collection of prawn seed, i.e. post larval stage which invade estuaries from marine zone immediately after their birth. This sector constitute the main fishery operations. These prawn seed are collected for their culture in salt water fish ponds, scattered all around the deltic region in lower reaches. As these ponds require very selected seed specially of *Penaeus monodon*, the tiger prawn, locally known as 'Bagda chingri', all attempt are made to collect the seeds of this species only and during sorting of each haul, the seeds of all other species are thrown away mercilessly.

DISCUSSION

Regarding the impact of calcutta Metropolitan sewage on ecology of the estuary, varied accounts have been given by few workers who paid attention to this aspect. As far as plankton are concerned, David (1959) gave a long list of species of both phyto and zooplankton, most of which are also recorded during present investigations. However, the data provided by him were only qualitative and pooled one for the entire stretch of the estuary studied by him without demarcating area at the outfall and away from outfall. Therefore it is difficult to assess the relative impact of wastewater over space and compare the results of present investigations in strict sense. Ray *et al* (1981) reported almost comparable densities of phytoplankton and zooplankton from different areas

of the estuary, However, their list of zooplankton is so small to make any comparison with the present observations. Similarly, in case of benthos, David reported the occurrence of burrows of fiddler crabs throughout the year except during low saline period of August-October. The observations of David (1952) that many crabs like *Seasarma*, *Metaplax* and *Dotilopsis* etc. were available below Minakhan (above Station K-3) was further substantiated by present study where several species of crab were recorded from Station K-3. The once or twice a year mortality of crabs as noticed by him, could not be observed. The strange phenomenon of the absence of any molluscan species, as observed by David (1959), did not change even after 33 years as the estuary upto Station K-3, from Station K-1 was totally devoid of both gastropods and bivalves. However, Station K-4 harboured most of the species of mollusca found elsewhere in sundarban estuaries. Like earlier observations many dead and broken shells of freshwater snails were also seen in marginal areas which were generally brought from nearby ponds and agricultural field through monsoonal drainage

The impact of wastewater on fish fauna of polluted stretch was also severe as no fish could survive within this stretch during premonsoon period. This indicated non congenial conditions of the estuary in this zone for survival, growth and reproduction. Nair (1944) recorded some thirteen species of fishes from polluted zone of the estuary. Except three species, *Pangasius*, *pangasius*. *Anabus testudineus* and *Pseudiperyptessp*, all other were found dead or dieng conditions. David (1959) reported the occurrence of some 80 species from the estuary between Haroa and Minakhan at one time or other but all of them except *Mystus gulio* and *Pangasius, Pangasius*, were classified as 'very rare', 'rare' or 'stray' During present studies not a single species of his list was observed at polluted stations during premonsoon. However above mentioned two species and also some gobioids occurred in moderate numbers at station 3 during monsoon and postmonsoon seasons, forming small fishery of the area. Similar observations were made by Ray *et. al.* (1981). While surveying the estuary for fish seed resources during main breeding season of September-May, Thakur (1975) reported that upper stretches contained seeds of only few non-commercial fishes. In lower stretches, fry and fingerlings of a number of commercially important brackishwater fishes like, *Liza persia*, *Setipinna phasa*, Polynomids, *Mystus gulio*, *Herpodon neherius* etc. alongwith seeds of many non-commercial fishes were recorded. Beside fishes, he also recorded the availability of large number of post larvae and juveniles of several prawn species including *Penaeus indicus*, *P. mondon*, *Matapenaeus bravicornis*, *M. affinis*. *Parapenaeopsis sculptilis* and *Paleomon styliferus*. Their absence from above the outfall, which besides being highly polluted, was also low in salinity, is quite natural, as most of these fishes and prawns were either of marine or brackishwater origin and very much salinity dependent. Thakur's (1975) observations that dissolved oxygen associated with low salinity were probably the factors for non availability of prawn seeds, holds good in the light of present observation.

The ecology of the estuary in nonpolluted zone was completely different from polluted stretches. The conditions were similar to other parts of Hugli-Matla-Raimangal estuarine complex not subjected to any kind of environmental distress (Zones 3 & 4 of Hugli-Matla estuarine system, Khan, 1994 a). The availability of a large number of fishes, prawns, benthos and plankton species indicated the good health of the estuary at this point. Ray *et. al.* (1981) observed heavy prawn seed

collection from this centre (Nazat) which ranged between 1.906-33.877 million seeds per four hour per month

When the factors responsible for the deterioration of Kulti estuary due to discharge of metropolitan wastes were closely examined, then only one factor, the availability of dissolved oxygen, emerged as the most important factor governing the entire biotic cycle. The drastic reduction in D.O. in the polluted stretch during most part of the year, made the estuary sterile. The D.O. content of the estuary was always below the critical level for survival of most biota. David (1959) rightly attributed the pollution of the estuary and resulting loss of life almost solely to lack of oxygen rather than any other physico-chemical, physiological or parasitological factors. He observed that periodic fish kill was not due to any infection or chemical coagulants but simply due to asphyxiation which was evident by swollen membranes of gills and distended opercular cavities. The importance of dissolved oxygen as a limiting factor in the estuary was also established by Nair (1944) who conducted bioassay experiments with raw sewage taking fingerlings of major carps as test animals. He observed that fishes could survive in raw sewage provided it is well agitated and properly aerated, and concluded that the physiological responses of fishes depended upon the amount of dissolved oxygen present in sewage, as the impact was visible in the form of respiratory embarrasments which subsided as soon as the medium was mechanically aerated.

The longer retention period of highly enriched effluents in the estuary and their suspension/oscillation between low and high tides probably consumed available oxygen thereby increasing the demand heavily. This coupled with complete suspension of photosynthesis was responsible for such disastrous effects on biota.

The other factors contributing in minor ways to the deterioration of the estuary in the affected zones were lowering of pH, and high suspension due to scouring effects of low and high tides as opined by Ray *et al.* (1981). The silting of the bed and reduction in supply of water from upland were the natural factors adding to the misery of the estuary.

The plankton were the most affected group as revealed by very poor diversity as well as density in a very long stretch of the estuary, both above and below the outfall. Such a disastrous situation was not observed even in highly polluted industrial outfall areas in Hugli estuary (Khan, 1994 c). This may be attributed to considerably lower discharge (water flow) in Kulti required for dilution.

Ray *et al* (1981), like Nair (1944) carried out bioassay experiments on the toxicity of sewage, taking major carps as test animals and reported that fishes could survive for more than 10 days at 5.0 mg/l D.O. However, they rightly commented that survival did not mean that fishes were not physiologically affected due to the presence of any other pollutants particularly hazardous heavy metals in sublethal doses. Although no direct impact of heavy metals on the biota was established by their studies, the presence of various heavy metals in the solid phase of metropolitan wastes and also soil sediment of the entire Kulti estuary in appreciable quantities, was itself alarming. Though the contribution of dissolved and suspended metals in water fraction

was not very high, their sublethal impacts on biota through the process of bioaccumulation, over longer period of time, can not be ruled out. The long term impact of sublethal doses of heavy metals include the impairment of metabolism, growth and reproduction, both in plants and animals. However, in the absence of sufficient data, no definite conclusions can be drawn. This requires further detailed investigations.

SUMMARY

1. The impact of huge quantity of Calcutta Metropolitan wastewater discharges on physico-chemical and biological conditions of Kulti estuary was studied between 1988-92. The Kulti is a part of an offshoot of Raimangal estuary of Hugli-Matla- Raimangal estuarine complex, and flows some 35 km south east of the city. There was no perennial source of upland water supply and the estuary depends either on tidal water on monsoonal drainage from its catchment area.
2. The wastewater was highly organic in nature with nil dissolved oxygen, low pH and excessively high solids, B.O.D. and Oxygen consumed load. The average discharge of wastewater was estimated to be about 59.074 mld which generated solid load of 95.097 t/day and B.O.D. load of 8.583 t/day.
3. The impact of sewage on the estuary was studied at three stations, above, below and at the outfall. The outfall region was drastically affected. There was almost total absence of dissolved oxygen and flora and fauna throughout the year. The conditions at stations above (8km) and below (5km) the outfall were also extremely bad during premonsoon when only few stray organism were recorded, The conditions improved a little during monsoon and few species of phytoplankton, zooplankton, benthos and fishes were visible in restricted numbers. The conditions during post monsoon was slightly better than premonsoon.
4. The detailed ecology of the estuary in unpolluted zone, situated about 25km below the outfall at Nazat was studied. There was no sign of alternation due to pollution. The physico-chemical and biological conditions of this zone were good with high dissolved oxygen contents, moderate pH, extremely low B.O.D., O.C, solid and nutrient load and abundant flora and fauna. A large number of prawn and fish species and their seeds were available in this zone during major part of the year. Forty three species of common fishes and 13 species of important prawn species were recorded.
5. The availability of dissolved oxygen was found to be almost only factor governing the entire biotic cycle of the polluted stretch of estuary. The drastic reduction in D.O. made the polluted stretch biologically sterile. The longer retention of highly organic sewage in the estuary due to their suspension/oscillation between low and high tide probably consumed all oxygen and affected the diversity and density of biota drastically.

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THE POLLUTION PROBLEM OF HUGLI ESTUARINE SYSTEM

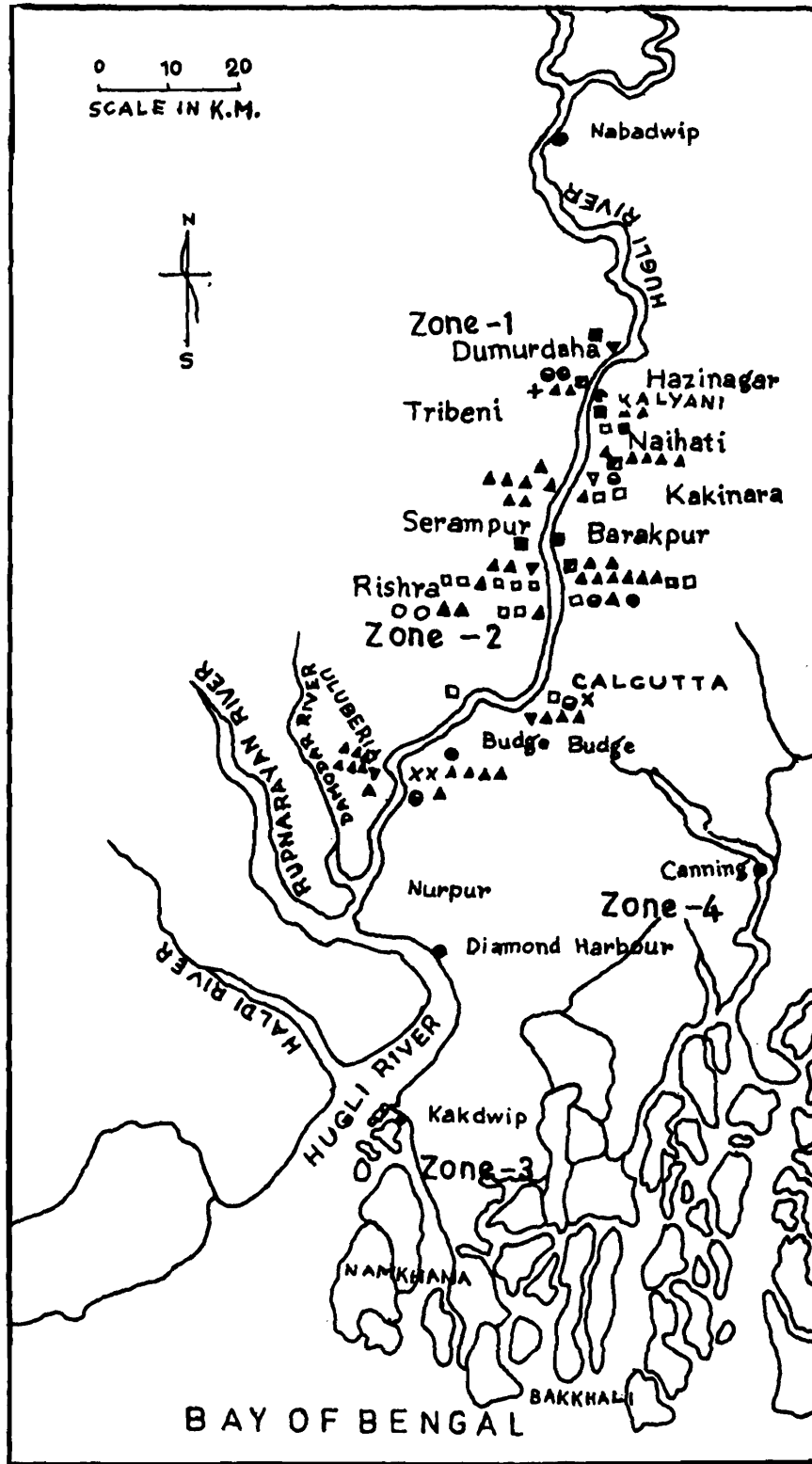
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INTRODUCTION

The pollution problem of Hugli estuary has attracted the attention of both, common men and scientists for quite sometimes. Being a river passing through one of the greatest industrial centres of the country—the Calcutta metropolitan district and adjoining areas, it has been vigorously exploited for drawl of large amount of water on one hand, and for disposal of enormous quantities of wastewaters, arising from industries and municipalities, on the other hand. A large number of industries situated on both banks of the river, which include chiefly pulp and paper, rayon and natural textiles, tannery, distillary and yeast, rubber, metal and steel, paints and varnishes, chemicals, hydrogenated vegetable oil and soap, safety matches, shellac, liquid insecticide, polythene, fertilizers and mineral oil etc., discharge their untreated or partially treated effluents into the estuary in upper and middle zones between Dumurdaha and Birlapur (Fig. 1). Besides, few municipalities and a number of jute mills also discharge domestic wastewaters. With the result the quality of water, flora and fauna are affected in this zone during hot dry months of premonsoon, specially around outfalls, inspite of the fact that it is a tidal and turbulent estuary where natural mixing, dilution and flushing take place regularly. The gradual accumulation of slimy toxic wastes, coupled with overall reduction in freshwater flow over the years have resulted in destruction of benthic habitat, which is probably responsible for the decreased availability of many species of fishes and prawns and their seeds.

Researches on the pollution of Hugli started sometimes in late forties when Roy (1949) reported some potamological aspects of the river in relation to Calcutta water supply. Thereafter Seth and Bhaskaran (1950) reported the results of their studies on industrial wastewater disposal and its impact on the river around Calcutta. However, organised efforts were started during mid sixties, when a team of few scientists from Central Inland Fisheries Research Institute undertook the work. Their studies were chiefly confined to the nature and characteristics of industrial and domestic effluents, pollution types and load and general impact on plankton around outfalls of few industries. Some bioassay studies with industrial effluents and impact of pollution on general ecology of the estuary have also been reported. The pulp and paper mills were found to discharge huge quantity of wastewaters. Rajagopalan *et al.* (1965), Basu (1966), Dhaneshwar *et al.* (1969), Basu *et al.* (1973), Ghosh *et al.* (1977, 1980), Ray *et al.* (1979) and Ray and Mitra (1980) studied in detail the quantity, nature and characteristics of the pulp and paper effluents and their impact on plankton. Ray (1981) also reported the results of cage culture experiments conducted around the outfall of a tissue paper mill. The viscos rayon factory effluents, containing acidic and alkaline wastes were studied for their impact on plankton density around outfall by Ghosh *et al.* (1976).



- | | | | | |
|--------------------|---------|---------------------|---------------|------------|
| PULP & PAPER | TEXTILE | TANNERY | RUBBER | JUTE MILLS |
| DISTILLERY & YEAST | OIL | THERMAL POWER PLANT | MISCELLANEOUS | |

Fig.-1 : Industries around Hugli Estuarine

The effluents from a chemical factory at Rishra (Ghosh and Basu, 1968), a distillery (Ray *et al.* 1977), a tannery (Ghosh *et al.*, 1980 a), a rubber factory (Ghosh *et al.* 1977a) and an oil refinery complex in the lower zone (Ghosh and Bagchi, 1979) have also been studied. Bioassay experiments with some industrial effluents and few test fishes, daphnids and shrimps have also been conducted by few workers which has been summarised by Ray (1981).

Ghosh *et al.* (1973) carried out an extensive survey of the industries discharging their wastes into the estuary in a 92 km stretch alongwith the study of nature and characteristics of the effluents and pollution load of the estuary. Earlier, a survey on similar lines was also carried out by Seth and Bhaskaran (1950) and F.A.O. (1967).

The general biological conditions of the estuary as influenced by pollution was observed by Basu (1965), Gopalakrishnan *et al.* (1973) and Ray and Ghosh (1976). Basu (1970) made a comparative study of the polluted river Hugli and unpolluted Matla of the Hugli-Matla estuarine system.

An analysis of the works done reveals that most of the studies carried out on the impact on ecology of the estuary and its biota are of very general nature and no definite conclusions could be drawn regarding the actual impact of specific pollutants and its mechanism. There is a general dearth of literature on the systematic studies of impact upon various groups of flora and fauna. This is probably due to very complex nature of the estuary which made it difficult to evolve and standardise strategies and methods for impact studies.

The present paper reviews important works done on pollution ecology of the estuary alongwith the presentation of the results of certain observations made during present investigation on the impact of pollution on plankton and benthos around outfalls of few important industries.

MATERIAL AND METHOD

The impact of industrial effluents on phytoplankton, zooplankton and benthos around outfall of four important industries viz. a viscose rayon factory near Dumordaha, a paper and pulp mill using soda process near Tribeni, a paper and pulp mill using sulphite process near Hazinagar and a tannery near Batanagar (Fig. 1) were studied during different seasons of 1983-85. Six stations were fixed for each outfall, first above 250 m (approx) of outfall, second at outfall, third about 250 m below the outfall, fourth around 500 m below the outfall, fifth nearly 1000 m below the outfall and sixth on the opposite bank of outfall. Physico-chemical analyses of water and plankton were done as per methods described in earlier chapter (Khan 1994a).

The structure of biotic communities viz phytoplankton, zooplankton and benthos were analysed separately by computing Shannon Wiener diversity index (\bar{H}) based on Magalef's formula derived from information theory as suggested by Wilhm (1972) :

$$\bar{H} = - \sum_{i=1}^s (n_i/N \log_2 n_i/N)$$

Where s = number of species, n = number of individuals of each species and N = total number of individuals.

A. REVIEW OF EARLIER WORK

1. Survey of Industries around Hugli estuary :

A detail survey of industries and municipalities discharging their wastewaters into the estuary, directly or through municipal drainage canal, between Dumardaha and Birlapur, a stretch of 92 km, was carried out by Ghosh *et al.* (1973). The survey revealed the existence of 40 major industries discharging their effluents in the estuary. Beside these industries, several municipalities and 55 jute mills also discharged domestic wastes into the estuary. Table 1 gives the details of these industries, raw material used, quantum of effluents produced, mode of discharge and number of outfalls. There were six paper and pulp mills using both soda and sulphite processes, five textile mills including rayon and cotton, two distilleries, one yeast, one tannery, one rubber factory, 3 petroleum storage and filling centres, 6 thermal power stations and 15 miscellaneous industries consisting of hydrogenated vegetable oil and soap, metal and steel, paint and varnishes, shellac, matches, chemicals, liquid insecticide, polythene and phosphate fertilizer etc. The jute mills, though do not produce any trade effluent, discharged sewage from their estates. There were 22 industries (Table-2) on left bank and 18 on right bank (excluding jute mills). The oil refinery complex at Haldia was not included in the original list which was added later on, after its establishment (Ray 1981).

TABLE 1. DETAILS OF INDUSTRIAL AND DOMESTIC SOURCES DISCHARGING WASTEWATER IN HUGLI ESTUARY

Source	Number of units	Raw Materials used	Mode of Disposal
A. INDUSTRIAL WASTES			
Pulp and paper	6	Wood, Bamboo, straw, bagasse, paper savings, rags, sulphite, sulphate and soda pulp, caustic soda, alum, soda ash, dye, bleach	Direct to estuary alongwith other effluents/municipal wastes.
Textiles	5	Wood, pulp, sulphur, Zn, NaOH, NaCl, H ₂ SO ₄ , HCl, H ₂ O ₂ , chlorine, bleach	Direct to estuary with other effluents through pond
Distillery & yeast.	3	Molasses, H ₂ SO ₄ , (NH ₄) ₂ SO ₄ , lime	Direct to estuary
Tannery	1	Hide, rubber, rubber chemicals	Direct to estuary
Rubber	1	Natural & synthetic rubber, latices, cotton, rayon nylon, whiting, china clay, carbon black, ZnO, naphtha, organic accelerators, pintar, mineral oil, stearic acid etc.	To estuary through waste drain

TABLE 1. (Contd.)

Source	Number of units	Raw Materials	Mode of Disposal
Miscellaneous	15	Litharge, white lead, ZnO, Na ₂ SO ₄ , H ₂ SO ₄ , HCl, HNO ₃ , FeSO ₄ , KClO ₄ , K ₄ Fe(CN) ₆ , resins, oil, thinners, dyes, lead, chrome, BaCl ₂ , alum, red oxide	Direct to estuary
(i) Paint & Varnish			
(ii) Metal and steel		Metal salt	To estuary through canal
(iii) Matches (safety)		Timber, paper topioca, animal glue, KClO ₄ , glass powder, Mn, red phosphorus, NaOH, NH ₃ , Sulphur, Sb, amber etc.	Direct to estuary
(iv) Shellac		Lac (stick & seed)	Through municipal drain to estuary
(v) Combined wastes of Rishra Canal		Salt, alcohol, benzene, solvents, pigments, extender, drying oil, chlorine, quick lime, acid, NH ₃ , soda ash, phosphates, tanin, DDT malathion, lindane	Through Bag canal
(vi) Hydrogenated vegetable oil		oil like talo, coconut, groundnut, linseed, sal seed, cotton seed, acids, caustic soda, domain, oleium	Through municipal drain to estuary
Petroleum oil refinery	4	Lubricating based chemicals & additives, mineral oil wastes	Through drain after removing oil, to estuary
Thermal power plants	6	—	only cooling water, not taken into consideration
B. SEWAGE/DOMESTIC WASTES			
(i) Jute mills	55	—	Estate wastes, direct to estuary
(ii) domestic & municipal wastes	—	—	Direct to estuary
TOTAL UNIT	96		

Based on Ghosh *et al.* (1973) and Ray (1981)

TABLE 2. NUMBER OF INDUSTRIES ON DIFFERENT BANK OF HUGLI ESTUARY

Industries	Number		Total
	right bank	left bank	
Pulp and paper	4	2	6
Textile	2	3	5
Tannery	1	—	1
Rubber	—	1	1
Distillaery & Yeast	—	3	3
Paint and varnishes	1	—	1
Metal and Steel	2	—	2
Match	1	—	1
Shellac	1	—	1
Hydrogenated oil & Soap	2	1	3
Petroleum oil handling	3	—	3
Petroleum refinery	—	1	1
Industries in Rishra discharging through Bagh Canal			
Polythene	—	1	1
Chemical	—	1	1
Rubber chemical	—	1	1
Paint and Varnishes	—	2	2
Insecticides	—	1	1
Phosphate fertilizer	—	1	1
Vegetable oil & Soap	—	1	1
Thermal power plants	5	1	6
Jute	33	22	55
TOTAL	55	41	96

After Ghosh *et al.* (1973)

The number of industries reported by Ghosh *et al.* (op. cit.) was different from those of Seth and Bhaskaran (1950) who reported the existance of 215 industries and F.A.O. (1967) report which mentioned 159 industries. The apparent differences was probably due to the fact that Ghosh *et al.* (op cit.) took into consideration only those industries which were situated on or very near to bank and discharged their trade wastes directly into the estuary. Another reason cited was a number of non operational industries.

2. Nature and characteristics of effluents :

Table 3 gives the chemical characteristics of industrial and municipal/domestic effluents discharged into the estuary as reported by Ghosh *et al.* (1973). Salient features are given below :

(a) **Pulp and paper** :—Both types of pulp and paper mills, using soda as well as sulphite processes discharged their wastes. The soda process wastes were brownish or whitish in colour having undesirable odour. Temperature ranged between 21 and 41°C with high turbidity. It was both acidic and alkaline in nature. pH ranged between 6.5 and 9.4 (mean 7.4). B.O.D. values were also very high with a mean of 144 mg/1. The sulphite process wastes were almost similar to soda process. However, B.O.D., O.C., total solids were higher with almost nil D.O. It was acidic in reaction.

(b) **Textiles** :—The effluents from cotton textiles were generally colourless with odour of bleaching powder and kerosine etc. It was moderately acidic to strong alkaline in reaction with pH values ranging between 5.6 and 10.5 (mean 8.0). The turbidity was highly variable. The effluents from synthetic rayon were characterised by highly acidic nature with pH values varying between 2.0 to 4.9 (mean 2.). it contained a high concentration of the heavy metal zinc.

(c) **Tannery** :—The effluents arising from tannery were organic in nature with very foul odour. It was moderately acidic to alkaline in nature. pH from 5.2 to 8.1 (mean 7.2). It contained high ammonia and chloride.

(d) **Rubber** :—The effluents were chiefly inorganic in nature with low B.O.D. values. pH ranged between 6.6 and 8.0 (mean 7.3).

(e) **Distillery and Yeast** :—The effluents were deep brownish in colour with comparatively high temperature, turbidity and solid contents. It was acidic in nature with very high B.O.D. values. indicating its organic character. The immediate oxygen demand was fairly high.

(f) **Shellac** :—The effluents from shellac factory was highly turbid and total solid load ranged from 9,040 to 11,650 mg/1. D.O. was almost absent with huge chloride content. pH ranged between 5.0 to 7.3 (mean 6.3).

(g) **Safety Matches** :—The effluents were inorganic in nature as indicated by low B.O.D. and sufficiently high D.O. contents.

(h) **Hydrogenated vegetable oil and Soap** :—The effluents were generally in the form of hot water resulting from the cooling system with traces of oil.

(i) **The combined wastes of Rishra complex** :—The effluents were the mixture of eight industries which included paints and varnishes, rubber chemicals, liquid insecticide, polythene, hydrogenated vegetable oil, phosphate fertilizer and domestic wastes of municipality and jute mill estates. It was almost black with undesirable stench, and slightly acidic to alkaline in nature (pH 6.9-8.2).

TABLE-3 CHEMICAL CHARACTERISTICS OF INDUSTRIAL AND DOMESTIC WASTEWATERS DISCHARGED INTO HUGLI ESTUARY (approx average values)

Sources of wastewater	pH	Alkalinity mg/l	D.O. mg/l	sp. Conductivity m mhos	B.O.D mg/l 20°C	O.C. 30 min. 100°C mg/l	Chloride mg/l
INDUSTRIAL							
Pulp & Paper							
Sulphate	7.4	286.0	2.3	2191	144	120	332
Sulphite	6.2	169.0	Nil	9095	986	1899	222
Textile							
Natural	8.0	564.0	2.1	2996	380	162	236
Synthetic	2.8	1.0	0.3	3697	331	141	171
Distillery	5.5	1135.0	Nil	5160	15687	8502	1032
Yeast	6.6	564.0	Nil	1866	3387	1216	322
Tannery	7.2	292.0	0.6	7173	404	339	2954
Rubber	7.3	271.0	4.8	697	40	51	29
Petroleum oil refinery	7.5	126.0	4.3	3090	7	—	—
Miscellaneous							
Paint and Varnishes	8.1	370.0	3.0	1513	137	88	191
Metal & Steel	7.2	194.0	2.4	1161	46	40	156
Match	7.5	308.0	3.0	3345	39	79	881
Shellac	6.3	1137.0	Nil	9250	963	900	3114
Combined waste of Rishra Canal	7.8	407.0	1.6	6969	136	80	417
DOMESTIC AND MUNICIPAL WASTEWATERS							
	7.7	412	0.4	4048	187	198	561

Based on Ghosh *et al.* (1973), Ray (1981)

(j) **Thermal power plants** :—Thermal power plants discharge hugh quantity of hot water arising from cooling system. The average temperature was around 36°C with chloride contents.

(k) **Domestic and municipal sewage** :—The effluents were black with undesirable smell and high B.O.D. load. The average pH was around 7.7.

3. Pollution Load of the Estuary :

Ghosh *et al.* (1973) estimated the total quantity of effluent discharged, both from industrial and municipal sectors, as 1153.8072 million liter per day. This generated a B.O.D. load of

106.268 ton and solid load of 2318.413 t/day (Suspended solids, 1057.542 t/day and dissolved solids, 1260.871 t/day).

(a) **Industrial wastewaters :**

The volume of wastewaters discharged by 41 industries (including oil refinery) was estimated to be 35.8257 mld which compared 31.05% of the total discharge. This contributed to the B.O.D. load of 61.188 t/day and contribution of total solids, suspended solids and dissolved solids were 891.053, 412.142 and 481.91 t/day respectively. This did not include the huge quantity of hot water discharged by thermal power plants. Nearly half of the industrial wastewater was contributed by pulp and paper mills (40.80%). The total B.O.D. and solid load generated by this sector was around 28.59 and 547.40 t/day. Followed by paper and pulp mills were textile industries. Their share in total industrial discharge, B.O.D. and solid load were 5.685%, 10.97% and 10.146% respectively. Next to textile was tannery discharging 11.365 mld of effluents, which generated a B.O.D. load of 4.54 t/day and solid load of 86.70 t/day. The details of all industries and their discharges are given in Table 4.

TABLE-4 POLLUTION LOAD OF THE HUGLI ESTUARY

Source	Vol. of wastewater mld	B.O.D. 5day t/day	Total solids, t/day	Suspended solid t/day
Pulp & Paper	178.6123	28.59	547.40	299.20
Textile	20.3661	7.26	71.80	41.82
Tannery	11.3650	4.54	86.70	13.50
Distillery & Yeast	0.6751	10.29	5.24	0.40
Rubber	10.9104	0.43	8.70	1.70
Hydrogenated oil	14.1835	0.56	18.40	4.80
Miscellaneous				
Paint & Varnish	11.5778	1.49	9.20	2.40
Metal & Steel	11.4468	0.20	11.73	3.30
Matches	1.0911	0.04	2.60	0.20
Shellac	0.4091	0.39	3.70	2.10
Combined wastes of Rishra	90.9200	12.24	128.60	42.50
Petroleum refinery	6.6000	0.16	9.98	0.21
Domestic and				
Municipal wastewater	795.5500	40.08	1424.36	645.40
TOTAL	1153.8072	106.2700	2318.4130	1057.542

Based on Ghosh *et al.* (1973), Ray (1981)

(b) Domestic/Municipal sewage :

This sector was the major contributor to the pollution of Hugli estuary adding about 79.555 mld (68.95% of total discharge). This resulted in B.O.D. load of 1424.36 t/day (61.44%). Table 4 also gives the total load exerted by this sector on the estuary.

4. Classification of wastewaters :

It was observed that while industrial effluents contributed only 31% of the total discharge, it generated B.O.D. load of 62% as against 38% contributed by domestic/municipal sector. This was mainly due to the huge quantity of biological wastes discharged by industries like pulp and paper, cotton textile, distillery and yeast etc, which were very rich in oxidisable organic matter. The highest load in terms of both, flow and B.O.D., was contributed by pulp and paper sector.

From analytical viewpoint, the industrial effluents were classified into three categories viz. (1) Organic wastes of biological origin, (2) organic wastes of non biological origin and (3) wastewater of chiefly inorganic (mineral) origin. The volumes of wastewater under each category, their B.O.D. and solid loads are shown in Table 5 (Ghosh *et al.* 1973). Category-1 included the effluents of pulp and paper mills, cotton textile, tannery and distillery etc. Category-2 included (i) wastewater from a rubber industry and (ii) effluents from paint, varnishes, oil storage and refinery and hydrogenated vegetable oil. The effluents from rayon, metal and steel were put under Category-3.

TABLE-5 CLASSIFICATION OF VARIOUS INDUSTRIAL AND DOMESTIC WASTES DISCHARGED INTO HUGLI ESTUARY

Type of wastewater	Volume mld	B.O.D. 5 t/day	Solids t/d		
			Suspended	Dissolved	Total
Organic wastes of biological origin	196.4713	45.910	346.522	334.12	68.64
Organic wastes of non-biological origin	43.6808	3.028	11.22	38.76	49.98
Wastewaters chiefly of inorganic substances	27.1850	5.010	11.90	32.93	44.83

Ghosh *et al.* (1973), Ray (1981).

The organic wastewaters comprised 89.83% (240.1521 mld) of the total discharge while inorganic wastes contributed only 10.17% (27.1850 mld). The load generated by organic wastes in term of B.O.D. and total solids were 90.72% and 96.79% of the total B.O.D. and solid load of the estuary respectively. The pollutants from organic wastes of biological origin contained highly decomposable matter such as lignin from paper and pulp mills.

Mineral wastes also contained some organic matter specially those arising from synthetic rayon factory. The effluents were highly acidic in nature and contained zinc in appreciable quantities. It was estimated to be 2.0 mg/l in water and 3.84 mg/l in the bottom sediment around outfall. The wastewater of many other industries also contained heavy metals in sublethal concentrations. The amount of zinc in the effluents of paint and varnish and rubber industry was 0.6 and 0.02 mg/l in water and 2.28 and 3.86 mg/l in soil respectively. Heavy metals generally mix with suspensoids and move considerable distance before settling. Their longer period of retention in estuarine water affects considerably the biota. In case of paper and pulp (soda process) some effect was felt to considerable distance downstream (Ray & Mitra, 1980).

5. Impact of Pollution on Flora and Fauna :

The studies pertaining to impact of pollution of the estuary on biota are few and preliminary. These were undertaken mainly in respect of variation in total number of plankton around outfall, toxicity evaluation of some industrial effluents and general observations on the impact on estuary. Most of the studies on the impact on biota deal with very general account without specifically assessing the differential impact of various pollutants on different kind of plants and animals. In fact no direct and definite evidence has been produced regarding the sole impact of pollution on the occurrence and abundance of different species of plants and animals except around outfall regions in localised areas that too during dry premonsoon months. There are a number of other factors influencing simultaneously the ecology of the estuary, of which reduced discharge and increased temperature during hot premonsoon months are among some of the important factors. However, indirect effects, particularly decrease in the abundance of important species of fishes, prawns and their larvae over the years are definite proof of the poor health of the estuary. Some of the important work are summarised below :

1. Impact on Biota Around Outfall :

(a) Synthetic Rayon Industry :

Ghosh *et al.* (1976) carried out studies on the impact of wastewater discharged from a viscose rayon industrial complex near Dumurdaha on the occurrence and abundance of plankton around outfall. The factory manufactures mainly viscose rayon and tissue paper (cellulose film) by sodium sulphite process. Wood pulp is digested in sodium hydroxide to remove hemicellulose. The pulp sheet is shredded, aged and xanthated with caustic lime and then filtered. The solution, known as viscose is matured and spun into an acid bath containing sulphuric acid, sodium sulphate and zinc sulphate. The semifinished product is washed with water. This water constitutes the major wastewater discharged by the factory. This is followed by sulphide bath and alternate acid and alkali bleach which further generates wastewater. The process of manufacture of cellulose paper is somewhat similar to that of viscos excepting the application of zinc sulphate. The total quantity of the wastewater discharged was estimated to be around 17,000 m³. The primary characteristics of the wastewaters are given in Table 6.

TABLE-6 PHYSICO-CHEMICAL CHARACTERISTICS OF WASTEWATERS OF RAYON FACTORY DURING DIFFERENT SEASONS

SEASONS	Temperature °C	pH	Turbidity (mg/l)	Alkalinity (Total) (mg/l)	D.O. mg/l	O.C. 30 min 100°C mg/l	Zinc mg/l
Premonsoon	33.4	4.7	85.00	41.0	2.0	51.2	116.0
Monsoon	31.9	2.6	247.00	—	2.2	16.0	15.0
Postmonsoon	27.7	5.0	85.0	37.5	4.5	19.5	91.0

Ghosh *et al.* (1976)

The impact on plankton was studied from above the outfall to 600 m below the outfall at seven stations, both from marginal and mid stretches. The results are summarized in table 7. The average plankton population was affected during summer which was attributed to adverse chemical condition with respect to pH and alkalinity. General condition was found to improve within few hundred meters below the outfall and the impact was confined to marginal areas only.

TABLE-7 PHYSICO-CHEMICAL PARAMETERS OF WATER AND DENSITY OF PLANKTON AROUND OUTFALL OF RAYON INDUSTRY

Seasons	Factors	Marginal stretch STATIONS*						Mid stretch STATIONS*					
		1	2	3	4	5	6	1	2	3	4	5	6
PRE MONSOON	Temperature (°C)	30.0	34.7	—	31.5	31.2	—	—	30.1	—	29.4	29.4	29.4
	pH	8.2	6.1	7.4	7.7	7.4	8.1	—	7.7	8.0	8.0	8.2	—
	Alkalinity (mg/l)	191.0	90.0	136.0	182.0	177.0	216.0	—	173.0	206.0	289.0	205.0	—
	Phytoplankton (no/l)	140	37	43	70	54	223	126	90	74	90	30	31
	Zooplankton (no/l)	55	12	23	25	21	27	30	70	40	39	65	30
POST MONSOON	Temperature (°C)	28.8	27.0	—	25.5	—	—	—	27.5	—	—	23.0	26.0
	pH	8.1	6.6	7.9	8.0	8.0	—	—	7.4	8.0	8.1	8.1	8.1
	Alkalinity (mg/l)	129.0	77.0	204.0	183.0	—	—	—	163.0	147.0	192.0	154.0	—
	Phytoplankton (no/l)	180	96	120	46	148	74	—	200	—	66	140	—
	Zooplankton (no/l)	56	34	40	12	34	32	—	63	—	16	40	—

*STATIONS : 1 —above outfall, 2—at outfall, 3—50m below outfall,
4 —150 m below outfall, 5—250m below outfall, 6—600m below outfall.

Ghosh *et al.* (1976)

(b) Pulp and paper mill (sode process) :

The impact of the effluents from a paper mill using soda process near Tribeni was studied by Ray *et al.* (1979). The impact was studied during low tide period under neap tide phase when pollutants cause maximum possible damage. The factory manufactured different grades of tissue paper by cooking raw hemp, old gunny cloths and hemp roaps etc. with caustic soda and sodium sulphide. After cooking, the black liquor is drained out from the pulp. The pulp is then washed, bleached with calcium hypochlorite and again washed. The water arising from such was constituted the wastewater. It was predominately alkaline in nature and associated with high amount of suspended organic matter (Table-8). Most of the effluents were discharged from main outfall and the remaining from second outfall situated about 250 m below. The impact on plankton was studied from above the outfall to 600 m below the outfall at 7 marginal and 6 lateral stretches.

TABLE-8
PHYSICO-CHEMICAL CHARACTERISTICS OF
WASTEWATER OF A PULP AND PAPER MILL
(SODA PROCESS)

	1ST OUTFALL			2ND OUTFALL		
	PRE MONSOON	MONSOON	POST MONSOON	PRE MONSOON	MONSOON	POST MONSOON
Temperature °C	30.5	29.7	29.5	31.7	30.8	28.6
pH	8.5	8.3	8.9	8.6	8.1	8.4
D.O./mg/l	3.8	3.2	0.0	5.0	2.9	5.8
Alkalinity mg/l	664.0	863.0	786.0	356.0	654.0	330.0
O.C. 30 min. 100°C	283.0	178.0	35.0	110.0	98.0	40.0
B.O.D. 5day	185.0	65.0	45.0	29.0	22.00	18.0
Turbidity mg/l	445.5	500.0	685.0	461.0	767.0	460.0

Ray *et al.* (1979)

The stations at lateral stretch were about 20-25 m from the margin. The results are summarised in Table 9. A fall in plankton concentration was noted below the outfall in marginal stretches but no significant impact was observed in lateral stretches. The recovery in respect of chemical factor was apparent around 50 m below the outfall in the marginal stretch. However all adverse effects were totally neutralised within 100 m below the outfall. The trend of plankton abundance was erratic with no definite pattern. This irregular pattern was attributed to occasionally changing character of the effluents, movement of wastewater either towards the marginal area or to a wider area across the estuary depending upon flow, wind action, topographical condition etc. This was simply the opinion of the authors without any substantiative data. From the data presented it can be seen that the impact was very much localised in a smaller area of this vast and agile estuary.

TABLE-9 PHYSICO-CHEMICAL CHARACTERISTICS OF WATER
AND PLANKTON DENSITY AROUND OUTFALL OF A PAPER
& PULP (SODA PROCESS) INDUSTRY

REASON	PARAMETRES	ABOVE OUTFALL	OUTFALL	LATERAL TO OUT- FALL	200 m BELOW OUTFALL	250 m BELOW OUTFALL*	300m BELOW OUTFALL	600 m BELOW OUTFALL	
PRE MANSOON	Temperature °C	31.3	30.7	—	30.4	31.9	31.2	30.8	
	pH	8.2	8.1	8.3	8.3	8.5	8.2	8.1	
	D.O. mg/l	5.6	3.7	6.0	6.0	5.3	6.2	6.3	
	B.O.D. 5d mg/l								
	O.C 30 min 100° C mg/l	5.0	96.0	6.7	18.0	22.0	18.0	6.0	
		7.0	116.0	8.0	10.0	22.0	18.0	6.0	
	Alkalinity mg/l	163.0	279.0	201.0	212.0	207.0	199.0	97.0	
	Phytoplankton No/l	65.0	49.0	—	52.0	—	133.0	260.0	
	Zooplankton No/l	43.0	30.0	—	33.0	—	47.0	90.0	
	MONSOON	Temperature °C	29.6	29.6	—	29.4	30.1	30.3	30.3
pH		8.0	8.0	8.1	8.1	8.2	8.1	8.1	
D.O. mg/l		5.7	4.0	6.0	4.4	4.1	5.6	5.6	
B.O.D. 5g mg/l		1.5	5.2	—	1.9	—	2.1	—	
O.C. 30 min 100°C		4.0	68.0	4.0	9.0	24.0	7.0	7.0	
Alkalinity mg/l (CaCO ₃)		104.0	265.0	101.0	15.0	182.0	118.0	101.0	
Phytoplankton (No/l)		50.0	17.0	12.0	20.0	—	60.0	—	
Zoopankton No/l		13.0	13.0	—	13.0	—	0.0	0.0	
		Temperature °C	24.7	25.5	—	23.9	—	24.5	—
		pH	8.1	8.2	8.1	8.0	—	8.2	8.1
	D.O. mg/l	7.1	5.1	7.6	7.1	—	6.3	6.9	
	B.O.D. 5d mg/l	4.0	33.2	12.2	4.4	—	28.0	—	
	O.C. 30 min 100°C mg/l	3.0	110.0	18.0	21.0	—	25.0	25.0	
	Alkalinity mg/l (CaCO ₃)	175.0	288.0	511.0	176.0	—	231.0	212.0	
	Phytoplankton (No/l)	2020.0	20.0	90.0	715.0	—	—	—	
	Zooplankton (No/l)	300.0	40.0	20.0	85.0	—	—	—	

Data of Ray *et al.* (1979) * 2nd minor outfall

(c) **Pulp and paper mill (sulphite process) :**

A paper and pulp factory situated near Hazinagar, adopted sulphite process for the manufacture. The raw material used were bamboo, starw, bagasee, pulp, wood, rags and paper

cutting etc. The wastewaters were generally acidic in reaction and highly organic in nature (Table-3). The wastewater discharged from the bleaching plant contained high chlorine content. Ray and Mitra (1980) studied the impact on biota around outfall in considerable details. The most important feature of the wastewaters from this unit was the high load of suspensoids specially consisting of lignin. Continuous discharge of this substance raised the bed of the estuary, reduced plankton and benthic fauna and destroyed the spawning ground. The studies were conducted in a four km. stretch around outfall. It was noticed that during hot dry months of premonsoon, high temperature enhanced the decomposition of organic matter in the sediment thereby reducing the dissolved oxygen concentration at the soil water interface and producing the undesirable gases like carbon-dioxide and hydrogen sulphide. This created almost an anaerobic zone at the bottom which may not be reflected in the water at surface. The number of invertebrate species reduced considerably at the out-fall and increased slowly below the outfall. Benthic community was constituted by several species of snails, *Macrobrachium* sp., chironomid larvae and oligochaetes. Emergence and propagation of phytoplankton from soil samples of different stations were also studied. No significant information can be drawn from this study. The number of plankton in water was however affected considerably during premonsoon months at the outfall where percentage reduction between 'above the outfall' and 'at the outfall' was 92% for phytoplankton and 82% for zooplankton (Table 10). Further major damage to plankton took place during transitional period of low and high tides and vice versa during neap tide phase in premonsoon months, when the dilution ratio was low and effluents spread over the larger areas. The pollutants remained for considerable period of time in the vicinity of the out fall and oscillated between low and high tides. 'above the outfall' and 'at the outfall' was 92% for phytoplankton and 82% for zooplankton (Table 10).

TABLE-10 COMPARATIVE IMPACT OF DIFFERENT WASTEWATERS
ON PLANKTON AROUND OUTFALL

Industry	Plankton	Premonsoon			Monsoon		
		Above outfall	Outfall	Percent reduction	Above outfall	Outfall	Percent reduction
Rayon	Phytoplankton	140.0	37.0	73.0	180.0	96.0	46.0
	Zooplankton	55.0	12.0	78.0	56.0	34.0	39.0
Pulp & paper (Soda)	Phytoplankton	133.0	45.0	59.0	555.0	7.0	99.0
	Zooplankton	38.0	33.0	23.0	102.0	13.0	87.0
Pulp and paper (sulphite)	Phytoplankton	37.0	3.0	92.0	259.0	41.0	84.0
	Zooplankton	22.0	4.0	82.0	80.0	36.0	55.0
Distillery & Yeast	Phytoplankton	45.0	30.0	33.0	48.0	32.0	33.0
	Zooplankton	25.0	25.0	0.0	41.0	25.0	39.0
Rubber	Phytoplankton	37.0	3.0	92.0	259.0	41.0	84.0
	Zooplankton	22.0	4.0	82.0	80.0	36.0	55.0

Ray & Ghosh (1976), Ray *et al.* (1979)

(d) Distillary and yeast :

A distillary and yeast factory near Bhadrakhali discharged highly organic wastes. The factory manufactured alcohol and yeast from mollasses which was treated with sulphuric acid and lime. The wastewater was characterised by almost nil dissolved oxygen and very high B.O.D. and O.C. load. Ray *et al.* (1977) studied the impact on plankton around outfall and reported a reduction rate of 33% in case of phytoplankton and no change in case of zooplankton between stations 'above' and 'at' the outfall during premonsoon months (Table 10). Gopalakrishnan *et al.* (1973) reported the total absence of benthic organisms in outfall area and effects were found to extend to a distance of 1000 m horizontally and 25 m laterally.

2. Impact on primary productivity :

Ghosh *et al.* (1979 b) studied the variations in primary productivity around outfall of a paper and pulp mill using soda process. During summer and monsoon, the primary productivity was low but improved considerably during post monsoon (Table 11). Similarly, in case of sulphite paper and pulp mill, primary productivity was significantly affected during all seasons as compared to above outfall. In case of a tannery outfall, gross and net productivity was 71% and 81% during premonsoon, 87% and 74% during monsoon and 43% and 41% during post monsoon respectively, as compared to above outfall (Ghosh *et al.* 1980).

TABLE-11 EFFECT OF WASTEWATERS ON THE PRIMARY PRODUCTIVITY AROUND OUTFALL

Season	Primary productivity (mg C/m ³ -hr)											
	Paper & Pulp (Soda)						Paper & Pulp (Sulphite)					
	Above outfall		Outfall		Below outfall		Above outfall		Outfall		Below outfall	
	Gross	net	Gross	net	Gross	net	Gross	net	Gross	net	Gross	net
Premonsoon	15.0	4.8	7.7	2.7	11.3	14.7	145.5	58.1	41.4	3.0	71.6	54.6
Monsoon	20.2	5.3	4.4	0.7	11.5	0.9	104.0	31.8	0.0	0.0	104.5	62.1
Postmonsoon	101.3	49.2	39.0	43.8	72.0	39.6	56.7	27.1	10.1	0.0	89.3	15.0

From Ray (1981), Ghosh *et al.* (1979b) modified average values.

3. Bioassay Studies :

Ray (1981) summarised the results of bioassay studies carried out with effluents of some industries taking fishes, shrimps and Daphnids as test animals (Table 12). Different dilutions of the effluents were tested and LC₅₀ values in terms of percentage dilution by volume were worked out. Taking into consideration the amount of dilution available during different seasons, daphnids were found to be affected considerably during premonsoon months when dilution ratio at the outfall

of many industries was lesser than LC₅₀ values. It was concluded that during very low water level, when there is no possibility of enough supply of freshwater either from upstream or rains, the simultaneous discharge of effluents from all the industries can undoubtedly bring the dilution ratio to a critical level and prolong exposure may be injurious to microorganism.

TABLE-12 SUMMARY OF SOME IMPORTANT BIOASSAY STUDIES WITH INDUSTRIAL WASTEWATERS

Test animal	Effluents	period	Temperature range °C	LC ₅₀ values % by volume	Reference
A-DAPHNIDS					
<i>Daphnia simillis</i>	synthetic rayon	96 hrs	27.5-34.0	1.75 5.6-7.5	As cited by Ray (1981)
-do-	Paints & varnishes	-do-	29.5-32.0	6.0-	-do-
<i>Daphnia lumholtzi</i>	Oil refinery	24 hrs	28.0	10.0	Ghosh & Baqchi (1976) As cited by Ray (1981)
B-SHRIMPS					
<i>Machribrachium sp.</i>	Synthetic rayon	96 hrs	27.5-34.0	31-49	As cited by Ray (1981)
-do-	Paint & Varnishes	-do-	29.5-32.0	19.0-20.0	-do-
-do-	Rubber	-do-	29.0-31.0	32.0	-do-
-do-	Textile	-do-	26.0-30.0	6.5	-do-
C-FISHES					
<i>Puntius sophore</i>	Distillery	24 hrs	19.0-25.0	6.7	Ray (1961)
-do-	Paper & pulp	-do-	21.0-25.0	20.8	-do-
-do-	Tannery-Sulphide	-do-	30.6-32.8	10.2	Ray & David (1960) As cited by Ray (1981)
-do-	Tannery-Vegatable	-do-	-do-	6.9	-do-
-do-	Tannery-Chrome	-do-	-do-	6.9	-do-
-do-	Textile-Kier	-do-	30.6-32.8	5.0	-do-
-do-	Textile-dye	-do-	-do-	11.7	-do-
-do-	Textile-Bleach	-do-	-do-	0.07	-do-

4. Overall Impact on the Ecology :

The impact of pollution on the ecology of the estuary has been studied by Gopalakrishnan *et al.* (1973) and Ray & Ghosh (1976). Nine centers were selected between Dumurdaha and Birlapur and samples for physicochemical conditions, plankton and bottom fauna were collected during

lowest water level under neap tide condition of premonsoon and late post monsoon (Jan-Feb) seasons Table 13 summarizes the physicochemical conditions and plankton density of the estuary during different months. Only the mean values of all nine stations are included as per the data of Ray and Ghosh (1976).

TABLE-13 GENERAL ECOLOGICAL CONDITIONS OF THE ESTUARY AT DIFFERENT POINTS

Station	Plankton (No/l)	Jan.	Feb.	Mar.	Apr.	May.	June
Dumurdaha	Phytoplankton	1664	60	40	115	30	40
	Zooplankton	120	20	10	50	20	35
Tribeni	Phytoplankton	1662	105	60	45	25	40
	Zooplankton	140	65	20	25	20	20
Naihati	Phytoplankton	813	140	40	35	15	25
	Zooplankton	80	50	20	25	8	25
Nawabgunj	Phytoplankton	284	40	40	50	30	25
	Zooplankton	80	20	15	10	10	8
Titagarh	Phytoplankton	80	40	50	20	25	25
	Zooplankton	100	30	15	8	10	18
Bagh Bazar	Phytoplankton	160	20	40	55	25	25
	Zooplankton	100	15	10	10	10	10
Garden Reach	Phytoplankton	170	22	55	45	35	30
	Zooplankton	45	10	22	15	30	10
Batanagar	Phytoplankton	70	25	80	30	12	20
	Zooplankton	30	20	8	10	20	15
Birlapur	Phytoplankton	50	20	50	50	25	25
	Zooplankton	20	8	6	8	15	10

Values approximated from Ray and Ghosh (1976)

Ghosh *et al* (1979) studied the primary productivity of the estuary at different centres during different seasons, mainly in relation to pollution (Table 14). Lower production rates were observed at Tribeni, Kakinada and Titagarh where mostly pulp and paper mills were situated. Higher density of plankton was found during postmonsoon (winter) while during premonsoon considerable reduction occurred. From February onwards there was a significant fall upto June. However, it is

not clear whether pollution was solely responsible for such decline or it was due to normal seasonal cycle governed by lower freshwater discharge, higher temperature and salinity, other ecological factors and of course, pollution.

TABLE-14 SEASONAL VARIATIONS IN PRIMARY PRODUCTIVITY OF THE ESTUARY AT DIFFERENT CENTRES

Centres	Primary productivity mg C/m ³ -hr					
	Pre-monsoon		Monsoon		Post-monsoon	
	Gross	net	Gross	net	Gross	net
Kalna	69.0	52.1	37.7	50.2	60.6	84.5
Tribeni	7.3	2.6	31.5	8.3	150.5	92.1
Hazinagar	145.5	58.1	10.4	31.8	56.7	27.1
Kakinara	13.5	0.9	7.0	1.7	23.8	0.0
Barakpur	46.9	24.7	29.3	8.4	24.7	20.1
Titagarh	13.8	12.6	5.2	5.2	12.1	12.3
Batanagar	56.2	27.4	11.2	9.8	12.9	14.7
Dimond Harbour	30.9	25.5	25.5	51.6	74.3	51.4
Kakadwip	57.5	15.5	43.0	44.5	79.2	42.2

Ghosh *et al.* (1979)

B. PRESENT INVESTIGATIONS

RESULTS

Impact on biota around outfall

The studies were conducted on the impact of the effluents from industries on plankton around outfall, in order to compare the results of earlier workers who conducted their studies almost a decade ago. As already mentioned, impact was studied around the outfall of (1) a viscose rayon factory, (2) a pulp and paper mill using soda process, (3) a pulp and paper mill using sulphite process and (4) a tannery and shoe complex (Fig. 1).

(a) Rayon factory :

The factory produced viscose rayon and tissue paper and wastewater was discharged into the estuary directly. The nature and characteristics of the effluents have already been given (Table 3) as reported by Ghosh *et al.* (1973). The physico-chemical and biological conditions around outfall are given in Table 15. There was a sudden alteration in almost all characteristics of water at station 2 (at outfall) as compared to station 1 (above outfall). The conditions started improving soon after the outfall. During premonsoon, pH and dissolved oxygen dropped from 8.1 and 5.7 mg/l to 6.8 and 3.2 mg/l respectively and B.O.D. and O.C. increased from 3.5 mg/l and 6.5 mg/l to 95.0 mg/l and 11.5 mg/l respectively. Similarly, phytoplankton, zooplankton, and macrobenthos were also affected considerably near the outfall. The rate of reduction (between station 1, above the outfall and station-2, at the outfall) and rate of immediate recovery (between station 1 and station 3, about 250 m below the outfall) were in the order of 71.5% and 76% for primary productivity, 84.8% and 92.0% for phytoplankton, 49.3% and 76% for zooplankton and

TABLE 15

**PHYSICO-CHEMICAL AND BIOLOGICAL CONDITIONS
AROUND OUTFALL OF A RAYON FACTORY**

Seasons	Pre-monsoon						Monsoon						Post-monsoon					
	1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6
FACTORS																		
Temperature °C	30.5	34.5	31.5	31.2	30.5	31.0	30.5	31.5	31.0	31.0	30.5	31.0	27.8	29.2	27.5	27.0	27.0	26.8
pH	8.1	5.3	7.8	8.0	8.2	7.9	7.8	7.0	7.7	7.6	7.9	7.9	8.2	7.3	8.0	8.1	8.2	8.1
Dissolved Oxygen (mg/l)	6.8	3.2	6.2	6.5	7.2	6.6	6.5	4.8	6.6	5.8	6.2	6.4	7.2	4.5	6.5	7.0	7.2	7.1
Alkalinity (mg/l)																		
CaCO ₃	210.0	112.0	185.0	190.0	215.0	205.0	125.0	98.0	130.0	125.0	142.0	135.0	185.0	95.0	160.0	190.0	195.0	18
B.O.D. 5 day (mg/l)	3.5	95.0	10.0	5.0	3.0	3.5	1.2	25.0	5.0	6.9	7.3	7.1	1.2	75.0	8.0	2.5	2.8	1
C.O.D. 100°C 30 min (mg/l)	6.5	115.0	15.0	9.0	5.0	7.0	1.8	35.0	2.0	2.2	2.5	2.6	4.2	90.0	6.0	6.2	5.0	4.5
Phytoplankton (No/l)	185.0	25.0	110.0	165.0	205.0	170.0	75.0	50.0	67.0	88.0	70.0	75.0	235.0	105.0	185.0	220.0	225.0	210
Zooplankton (No/m ³)	5025	1205	3825	4865	5913	5315	2510	1720	2280	2700	2200	2850	4560	1580	3980	4220	4680	420
Macrobenthos (No/m ²)	55.0	2.0	32.0	32.0	48.0	50.0	18.0	6.0	12.0	18.0	13.0	20.0	45.0	6.0	35.0	40.0	50.0	42.0
Primary Productivity-Gross (mg C/m ³ -hr)	55.0	20.2	38.0	49.1	52.2	50.1	18.2	14.2	14.5	19.7	17.5	14.1	60.0	16.0	62.0	68.0 ^a	65.0	59.0
Net	20.0	5.7	15.2	18.8	18.9	20.0	20.1	14.8	15.1	21.2	18.0	16.1	38.0	5.1	29.7	42.0	42.0	35.0

95.3% and 58.0% for macrobenthos (Table 16). This shows that while the impact was severe at outfall the immediate recovery was also rapid in all cases. the conditions at Station 4 (500 m below the outfall) was found to improve further and effect of pollution appeared to be almost eliminated, except for macrobenthos whose recovery was still underway. No sign of alteration was visible at Station 5 (1000 m below the outfall) and station 6 (on opposite bank of outfall).

TABLE-16
PERCENTAGE OF REDUCTION
(BETWEEN STATIONS 1 AND 2) AND IMMEDIATE
RECOVERY (BETWEEN STATIONS 1 AND 3) OF BIOTIC
COMPONENTS AROUND OUTFALL

RAYON INDUSTRY

Season	Factors	Station-1 (above out- fall)	Station-2 (at out- fall)	Percent Reduction	Station-3 (below out- fall)	Percent Recovery
Pre-monsoon	Net Primary Productivity (mg C/m ³ -hr)	20.0	5.7	71.5	15.2	76.0
	Phytoplankton (No/l)	185.0	25.0	84.8	170.0	92.0
	Zooplankton (No/m ³)	5025.0	1205.0	49.3	3825.0	76.0
	Macrobenthos (No/m ²)	55.0	2.0	95.3	32.0	58.0
Monsoon	Net Primary Productivity (mgC/m ³ -hr)	20.0	10.0	50.1	15.0	75.0
	Phytoplankton (No/l)	75.0	50.0	33.3	67.0	89.3
	Zooplankton (No/m ³)	2510.0	1720.0	68.5	2280.0	90.8
	Macrobenthos (No/m ²)	18.0	6.0	33.3	13.0	72.2
Post-Monsoon	Net Primary Productivity (mgCm/3-hr)	38.0	5.0	86.5	29.7	78.1
	Phytoplankton (No/l)	230.0	105.0	54.3	185.0	82.1
	Zoolpankton (No/m ²)	4566.0	1580.0	65.3	3980.0	87.1
	Macrobenthos (No/m ²)	45.0	6.0	86.6	35.0	77.7

TABLE 17
+ Present - Absent

DISTRIBUTION OF IMPORTANT BIOTA AROUND OUTFALL REGION
RAYON

Species	Pre-monsoon						Monsoon						Post-monsoon					
	Stn. 1	Stn. 2	Stn. 3	Stn. 4	Stn. 5	Stn. 6	Stn. 1	Stn. 2	Stn. 3	Stn. 4	Stn. 5	Stn. 6	Stn. 1	Stn. 2	Stn. 3	Stn. 4	Stn. 5	Stn. 6
PHYTOPLANKTON																		
<i>Syndera sp.</i>	+	+	+	+	+	+	+	+	+	-	-	-	+	+	+	+	+	+
<i>Coscinodiscus sp.</i>	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
<i>Surirella sp.</i>	+	-	+	+	+	+	-	-	-	-	-	-	-	+	-	+	+	+
<i>Cyclotella sp.</i>	+	-	+	+	+	+	-	-	+	+	+	+	+	-	+	+	+	+
<i>Lithodesmus sp.</i>	-	-	-	-	-	-	-	-	-	-	-	-	+	-	+	+	+	+
<i>Fragillaria sp.</i>	+	-	-	+	+	+	+	-	+	+	+	+	+	-	+	+	+	+
<i>Naviculla sp.</i>	+	+	+	+	+	+	+	-	+	+	+	+	+	-	+	+	+	+
<i>Stephanodiscus sp.</i>	+	-	+	+	+	+	-	-	-	-	-	-	-	-	-	-	-	-
<i>Pediastrum sp.</i>	+	-	-	+	+	+	+	+	+	+	+	+	+	-	+	+	+	+
<i>Ankistrodesmes sp.</i>	+	-	+	+	-	+	+	-	+	+	+	+	-	+	-	+	+	+
<i>Scenedesmus sp.</i>	+	-	+	+	-	-	-	-	-	-	-	-	+	-	-	-	+	+
<i>Spyrogyra sp.</i>	+	-	+	+	-	-	-	-	-	+	+	+	+	+	+	+	+	+
<i>Oscillatoria sp.</i>	+	+	+	+	+	+	+	+	-	-	+	+	+	+	+	+	+	+
<i>Microcystis sp.</i>	+	+	+	+	+	+	+	+	+	-	-	-	+	-	+	+	+	+
<i>phormidium sp.</i>	+	-	+	+	+	+	+	-	-	-	-	-	-	-	-	-	-	-
<i>Euglena sp.</i>	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
ZOOPLANKTON																		
<i>Keratalla Sp.</i>	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
<i>Brachionus calciflorous</i>	+	-	+	+	+	+	+	-	+	+	+	+	+	+	+	+	+	+
<i>B. rubems</i>	+	-	+	+	+	+	+	+	-	-	+	+	+	-	+	-	+	+
<i>Asplanchna brightwelli</i>	+	-	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
<i>Daphnia lumholtzi</i>	+	-	+	+	+	+	+	+	-	-	-	-	+	+	+	+	+	+
<i>Ceriodaphnia cornuta</i>	+	-	-	+	+	+	+	-	+	+	+	+	-	-	+	+	+	+
<i>Monia micrura</i>	+	-	+	+	+	+	+	-	+	-	+	-	+	-	-	-	-	-

TABLE 17 (Contd.) DISTRIBUTION OF IMPORTANT BIOTA AROUND OUTFALL REGION
 + Present - Absent RAYON (Contd.)

Species	Pre-monsoon						Monsoon						Post-monsoon					
	Stn. 1	Stn. 2	Stn. 3	Stn. 4	Stn. 5	Stn. 6	Stn. 1	Stn. 2	Stn. 3	Stn. 4	Stn. 5	Stn. 6	Stn. 1	Stn. 2	Stn. 3	Stn. 4	Stn. 5	Stn. 6
<i>Heliodiaptomus contortus</i>	+	+	+	+	+	+	+	-	+	+	+	+	-	+	+	+	+	+
<i>H. viduus</i>	-	-	-	-	-	-	+	-	+	+	+	+	-	+	+	+	+	+
<i>Mesocyclops leuckarti</i>	+	-	+	+	+	+	+	-	+	+	+	+	+	-	+	+	+	+
<i>Mesocyclops hylinus</i>	+	-	+	+	+	+	-	-	-	-	-	-	+	-	+	+	+	+
<i>copepodites</i>	+	-	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
<i>Machrobrachium sp.</i>	+	-	+	+	+	+	+	-	+	+	+	+	+	-	+	+	+	+
<i>Limnodrilus hofmeinsteri</i>	+	+	+	+	-	-	-	+	+	-	-	-	+	+	+	+	+	+
<i>Thiara lineata</i>	+	+	+	+	+	+	+	+	+	+	+	+	-	-	-	-	-	-
<i>T. intermediata</i>	-	-	-	-	-	-	+	+	+	+	+	+	+	+	+	+	+	+
<i>Littorina sp.</i>	+	-	+	+	+	+	-	-	-	-	-	-	-	-	-	-	-	-
<i>Lymnea sp.</i>	+	-	+	+	+	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>Dipteran larvae</i>	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
<i>Crustacean larvae</i>	+	-	+	+	+	+	+	-	-	+	+	+	+	+	+	+	+	+
<i>Fish larvae</i>	-	-	-	-	-	-	+	-	-	+	+	-	+	-	-	+	+	+
<i>Others</i>	+	+	+	+	+	+	+	+	+	+	+	-	-	-	-	-	-	-

TABLE 18
PHYSICO-CHEMICAL AND BIOLOGICAL CONDITIONS
AROUND OUTFALL OF PAPER AND PULP MILL (SODA PROCESS)

Seasons	Pre-monsoon						Monsoon						Post-monsoon					
STATION	1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6
FACTORS																		
Temperature °C	30.5	31.5	31.4	30.8	31.0	30.1	30.3	30.2	30.0	30.0	29.0	30.5	26.5	26.3	25.5	25.7	25.0	25.5
pH	8.0	8.55	8.3	8.2	8.2	8.1	7.9	8.2	8.1	8.1	8.2	8.1	8.2	8.4	8.3	8.2	8.2	8.1
Dissolved Oxygen (mg/l)	6.9	1.5	6.5	7.1	7.0	6.8	5.2	3.6	5.0	5.1	5.5	5.2	7.6	3.9	6.9	7.5	7.9	7.7
Alkalinity (mg/l) CaCO ₃	195.0	305.0	215.0	175.0	190.0	205.0	85.0	190.0	105.0	95.0	90.0	82.0	210.0	314.0	250.0	215.0	210.0	215.0
B.O.D. 5 day (mg/l)	2.5	65.0	10.6	3.6	2.1	2.0	1.2	10.5	3.0	3.2	2.0	1.3	2.9	40.0	8.6	2.2	2.0	1.8
C.O.D 100°C 30min (mg/l)	4.0	84.0	15.0	4.0	3.8	6.0	2.2	27.0	7.0	7.0	5.5	2.0	2.0	92.0	6.5	3.5	2.5	2.5
Phytoplankton (No/l)	160.0	22.0	112.0	225.0	160.0	172.0	75.0	10.0	88.0	82.0	75.0	70.0	240.0	35.0	280.0	210.0	225.0	230.0
Zooplankton (No/m ³)	4955	1240	3095	5135	5815	4950	2015	985	2410	2250	2100	1945	4215	1920	4650	4350	4010	4150
Macrobenthos (No/m ²)	45.0	4.0	14.0	35.0	36.0	40.0	14.0	4.0	11.0	12.0	16.00	12.0	36.0	4.0	27.0	29.0	40.0	32.0
Primary Productivity-Gross (mgCC/m ³ -hr)	45.0	8.0	28.0	40.0	40.0	36.0	22.0	4.5	16.0	20.0	21.0	21.0	39.0	13.0	45.0	56.0	48.0	40.0
Net	16.0	4.2	11.5	16.2	15.8	14.3	18.0	4.0	13.0	15.0	16.0	17.0	30.0	4.0	31.0	29.5	35.0	32.0

The occurrence of different species/group of phytoplankton, zooplankton and macrobenthos at different stations, above and below the outfall are given in Table 17. It may be seen that only few species could resist the severe impact of pollution at the outfall region. During premonsoon, among phytoplankton only two species of diatoms, two of blue green algae and euglenoids occurred in greatly reduced numbers near the outfall. In case of zooplankton, the rotifer, *Brachionus calyciflorus* and *Keratella tropica* and copepod, *Heliodiaptomus contortus* were seen in scanty numbers. Among benthos, the oligochaete, *Limnodrilus hoffmeisteri* and some dipteran larvae including mainly chironomids were recorded from mucous soil during low tide periods. Few individuals of gastropod *Thiara lineata* also occurred near the outfall. At Station 3, as conditions improved, more number of species appeared. Almost all the planktonic species of unpolluted zone returned to the estuary at station 4. Macrobenthos, though improved considerably, were still short of original unpolluted zone. However, Stations 5 and 6 did not show any noticeable alteration caused by the pollution.

Because of high dilution ratio, during monsoon, the impact of pollution caused by the industry was not severe. Although the effects were clearly felt near the outfall, the recovery was rapid and conditions returned almost to normal before station 3. The season was as such characterised by lower primary productivity, and lower diversity and density of flora and fauna. The primary productivity rate was erratic, sometimes net exceeding gross. The rates of reduction and immediate recovery were 50% and 67% for phytoplankton, 50% and 75% for primary productivity, 68.5% and 90.8% for zooplankton and 33.3% and 72.2% for macrobenthos. The phytoplankton flora of outfall region included two most important species of diatoms, three species of blue green algae and euglenoids. Among zooplankton, almost similar set of species, as during premonsoon, could withstand the severe impact of pollution near outfall. The benthic fauna of this station included oligochaetes and dipteran larvae. Station 3 was marked by the occurrence of almost all species of unpolluted zone, except macrobenthos whose contribution was slightly lower.

The post monsoon period was characterised by the optimal environmental conditions, which mitigated the impact of pollution quickly. Though, like other seasons the outfall region was affected, as evident from reduction rate (86.5% for primary productivity, 54.3% for phytoplankton, 65.1% for zooplankton and 86.6% for benthos), the conditions improved rapidly. Station 3 depicted a condition very close to unpolluted zone above outfall. Barring few, almost all species of station 1 were visible at station 3.

The diversity index (H) values fluctuated widely between polluted and non-polluted stations (Table 27). It followed the pattern of increase and decrease at different stations around outfall as other factors. Lowest values were always recorded at Station 2 and values increased substantially at Station 3. During premonsoon, lowest values were 1.05, 1.28 and 1.35 for phytoplankton, zooplankton and macrobenthos respectively. Highest values were mostly at station 1 or stations 5 & 6. Similar pattern was observed during other seasons too.

2. Pulp and Paper mill (soda process) :

As already mentioned a factory near Tribeni manufactured pulp and paper using soda process. The wastes were predominately alkaline in nature and associated with high amount of turbidity due to suspended organic matter. The nature and characteristics of the effluents have already been shown in Table-3. There were two out falls, one main and other a smaller one situated some 200 m below main outfall. Because of this, station 3 was shifted to nearly 300 m below the

outfall. Since no significant differences were noticed either 25 meters above or equal distance below this point, the selection of the point was assumed to be reasonable. Alteration in values of both, physico-chemical and biological factors were visible at stations above, at and below the out fall (Table 18), similar to rayon factory. During premonsoon, the pH suddenly increased from 8.0 to 8.5, D.O. dropped from 6.9 to 1.5 mg/l, and B.O.D. and O.C. increased from 2.0 and 4.0 mg/l to 655.0 and 84.0 mg/l respectively. Although the physico-chemical conditions improved considerably at station 3, the recovery was completed only around station 4.

The rate of reduction and immediate recovery of various biotic factors are given in Table 19. The values were 73.8% and 71.9% for primary productivity, 86.2% and 70.0% for phytoplankton, 79.1% and 62% for zooplankton and 91.0% and 62% for macrobenthos respectively. The noticeable feature of this outfall was that concentration of phytoplankton and zooplankton increased considerably at station 4 which was even higher than station 1. However, macrobenthos recovery was again comparatively slower.

TABLE-19
PERCENTAGE OF REDUCTION
(BETWEEN STATIONS 1 AND 2) AND IMMEDIATE
RECOVERY (BETWEEN STATION 1 AND 3) OF BIOTIC
COMPONENTS AROUND OUTFALL
PULP & PAPER (SODA PROCESS)

Season	Factors	Station-1 (above out fall)	Station-2 (at out- fall)	Percent Reduction	Station-3 (below out fall)	Percent Recovery
Pre-monsoon	Net Primary Productivity (mg C/m ³ -hr)	16.0	4.2	73.8	11.5	71.9
	Phytoplankton (No/l)	160.0	22.0	86.2	112.0	70.0
	Zooplankton (No/m ³)	4955.0	124.0	79.0	3095.0	62.0
	Macrobenthos (No/m ²)	45.0	4.0	91.0	24.0	53.3
Monsoon	Net Primary Productivity (mgC/m ³ -hr)	18.0	4.0	77.7	13.0	72.2
	Phytoplankton (No/l)	75.0	10.0	86.6	88.0	144.0
	Zooplankton (No/m ³)	2015.0	985.0	51.1	2410.0	119.0
	Macrobenthos (No/m ²)	14.0	4.0	71.4	11.0	78.0

TABLE-19 (Contd.)

Season	Factors	Station-1 (above out fall)	Station-2 (at out- fall)	Percent Reduction	Station-3 (below out fall)	Percent Recovery
	Net Primary Productivity (mgC/m ³ -hr)	30.0	4.0	86.6	21.0	70.0
Post-Monsoon	Phytoplankton (No/1)	240.0	25.0	85.4	280.0	116.0
	Zooplankton (No/m ³)	4215.0	1920.0	54.4	4650.0	109.0
	Macrobenthos (No/m ²)	36.0	4.0	86.9	27.0	75.0

The pattern of occurrence of different species at different station was almost similar to Rayon factory. The number and density of almost all species/group reduced considerably at Station 2. The set of species occurring in highly polluted zone of station 2 was also not much different from that of Rayon outfall (Table 20). Stations 5 and 6 were not affected.

During post-monsoon months conditions appeared to be most suitable in the estuary when the impact of pollution from the factory was not severe. The recovery rate was rapid and biotic conditions at station 3 were sometimes better than station 1 as sufficiently high densities of almost all group were noticed. The reduction and recovery rates for primary productivity were 86.6% and 70.0%, for phytoplankton 85.4% and 116.0%, for zooplankton 54.4% and 109% and for macrobenthos these were 88.9% and 75% respectively. The important species of different groups of this season and their occurrence at different stations are shown in Table 20. It is evident that maximum number of species occurred during this season but the set of species which could tolerate the impact of pollution in the immediate vicinity of the outfall were not much different from premonsoon period. However, the diversity and density of species increased tremendously at station 3 as compared to premonsoon period.

The species diversity index (\bar{H}) values were maximum during this season (Table 27). However, the index never crossed '3'

During monsoon months the conditions were better than premonsoon in the respect that the impact was confined mainly to outfall region. Because of high flooding, the overall condition of the estuary was not as good as during post-monsoon. There were very little alterations in the values of physico-chemical parameters like pH, D.O, B.O.D. and O.C. due to dilution. However, the high turbidity affected the primary productivity in general which resulted in poor biological diversity and density in the estuary. The conditions at station 3 was found to be slightly better than station 1 in respect of plankton density. The reduction and recovery rates were 77.7% and 72.2% for primary productivity, 86.6% and 144% for phytoplankton, 51.1% and 119.0% for zooplankton and 71.4% and 78% for macrobenthos respectively. The variations in the occurrence of different species at different stations are given in Table 20.

TABLE 20
 + Present - Absent
 DISTRIBUTION OF IMPORTANT BIOTA AROUND OUTFALL REGION
 PULP AND PAPER (SODA)

Species	Pre-monsoon						Monsoon						Post-monsoon					
	Stn. 1	Stn. 2	Stn. 3	Stn. 4	Stn. 5	Stn. 6	Stn. 1	Stn. 2	Stn. 3	Stn. 4	Stn. 5	Stn. 6	Stn. 1	Stn. 2	Stn. 3	Stn. 4	Stn. 5	Stn. 6
PHYTOPLANKTON																		
<i>Syndera So.</i>	+	-	+	+	-	-	+	+	+	+	+	+	+	-	+	-	+	+
<i>Coscinodiscus sp.</i>	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
<i>Surirella sp.</i>	+	-	+	+	-	-	+	-	+	+	+	+	+	-	+	+	+	+
<i>Cyclotella sp.</i>	-	-	-	-	-	-	+	-	+	-	-	+	+	-	+	+	+	+
<i>Lithodesmus sp.</i>	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	+	+	+
<i>Fragillaria sp.</i>	+	-	+	+	+	+	+	-	-	+	-	-	+	-	+	+	+	+
<i>Naviculla sp.</i>	+	+	+	+	+	+	+	-	-	+	-	-	+	+	+	+	+	+
<i>Stephanodiscus sp.</i>	+	-	+	+	+	+	-	-	-	-	-	-	-	-	-	-	-	-
<i>Pediastrum sp.</i>	+	-	-	+	+	+	-	-	-	+	+	-	+	+	-	+	+	+
<i>Ankistrodesmes sp.</i>	-	-	-	-	-	-	+	-	+	+	+	+	+	-	+	+	+	+
<i>Scenedesmus sp.</i>	-	-	-	+	+	+	-	-	-	-	-	-	+	-	+	+	+	+
<i>Spyrogyra sp.</i>	+	-	+	+	-	+	+	+	-	+	+	+	+	-	-	-	-	-
<i>Oscillatoria sp.</i>	+	+	+	+	+	-	+	+	+	+	-	+	-	+	+	-	-	-
<i>Microcystis sp.</i>	+	+	+	+	+	+	-	-	-	-	-	-	+	+	+	+	-	-
<i>phormidium sp.</i>	-	-	-	-	+	+	-	+	+	-	-	-	+	+	+	+	+	+
<i>Euglena sp.</i>	+	+	+	-	-	+	+	+	+	+	+	+	+	+	-	-	-	-
ZOOPLANKTON																		
<i>Keratalla Sp.</i>	+	+	+	+	+	+	+	+	+	-	-	+	+	+	+	+	+	-
<i>Brachionus calciflorous</i>	+	+	+	-	-	+	+	+	-	-	+	+	+	-	+	+	+	-
<i>B. rubems</i>	+	-	+	+	+	+	-	-	-	-	+	+	+	+	+	+	+	+
<i>Asplanchna brightwelli</i>	+	+	+	+	+	+	+	-	-	-	+	+	-	+	+	-	-	+
<i>Daphnia lumholtzi</i>	+	+	-	+	+	+	+	-	-	-	+	+	+	-	-	-	+	+
<i>Ceriodaphnia cornuta</i>	+	-	-	-	-	+	+	-	+	+	-	+	+	-	+	+	+	+
<i>Monia micrura</i>	+	-	+	+	-	-	-	-	-	-	-	-	+	-	+	-	+	+
<i>Heliodiaptomus contortus</i>	+	-	-	+	+	+	+	+	+	-	+	+	+	+	+	+	+	+

TABLE 20
+ Present - Absent
DISTRIBUTION OF IMPORTANT BIOTA AROUND OUTFALL REGION
PULP AND PAPER (SODA)—*CONTD.*

Species	Pre-monsoon						Monsoon						Post-monsoon					
	Stn. 1	Stn. 2	Stn. 3	Stn. 4	Stn. 5	Stn. 6	Stn. 1	Stn. 2	Stn. 3	Stn. 4	Stn. 5	Stn. 6	Stn. 1	Stn. 2	Stn. 3	Stn. 4	Stn. 5	Stn. 6
<i>H. viduus</i>	+	-	+	+	+	+	+	-	-	-	-	-	+	-	+	+	+	+
<i>Mesoclops leuckarti</i>	+	-	+	+	+	+	+	-	+	+	-	+	+	-	+	+	+	+
<i>Mescyclops hylinus</i>	+	-	+	+	+	+	-	-	+	-	-	+	+	+	+	+	+	+
<i>copopodites</i>	+	-	+	+	+	+	+	-	+	+	-	+	+	+	+	+	+	+
<i>Machrobrachium sp.</i>	+	-	+	-	-	+	+	-	-	-	+	+	+	-	+	-	+	+
<i>Limnodrilus hofmeinsteri</i>	+	+	+	+	+	-	-	+	+	+	-	-	+	+	-	+	-	-
<i>Thiara lineata</i>	+	-	+	+	+	+	+	-	-	+	+	-	-	+	+	+	+	+
<i>T. Intermediata</i>	+	+	-	-	+	+	-	-	-	-	-	-	+	+	-	-	+	-
<i>Litorina sp</i>	+	-	+	+	+	+	-	-	-	-	-	-	+	+	+	+	+	+
<i>Lymnea sp.</i>	+	+	-	+	-	+	-	-	-	-	-	-	+	+	+	+	-	-
<i>Diptaran larvae</i>	-	+	+	+	-	-	+	+	+	+	-	-	+	+	+	+	-	-
<i>Crustacean larvae</i>	+	-	-	+	+	+	+	-	+	+	+	-	+	-	+	+	+	+
<i>Fish larvae</i>	+	-	-	-	-	-	+	-	-	+	-	+	+	-	+	+	-	+
<i>Others</i>	+	-	-	+	+	+	-	-	-	-	-	-	+	-	+	+	+	+

TABLE 21

**PHYSICO-CHEMICAL AND BIOLOGICAL CONDITIONS
AROUND OUTFALL OF A PULP & PAPER MILL (SULPHITE)**

Seasons	Pre-monsoon						Monsoon						Post-monsoon					
STATION	1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6
FACTORS																		
Temperature °C	30.8	31.9	31.1	31.0	31.0	30.6	30.3	30.8	30.5	30.7	30.6	30.5	27.0	26.8	27.0	26.7	27.0	27.0
pH	8.2	7.2	8.1	8.1	8.2	8.2	7.9	7.3	8.1	8.2	8.2	7.8	8.2	7.1	8.1	8.2	8.2	8.9
Dissolved Oxygen (mg/l)	6.8	3.2	6.0	6.1	6.6	7.0	5.5	2.8	5.2	5.8	5.8	5.6	7.8	3.2	6.8	6.9	7.5	7.6
Alkalinity (mg/l) CaCO ₃	225.0	185.0	215.0	220.0	235.0	215.0	100.0	80.0	95.0	110.0	105.0	105.0	205.0	180.0	295.0	205.0	210.0	220.0
B.O.D. 5 day (mg/l)	5.5	60.0	12.0	6.3	6.0	5.0	1.0	20.2	3.5	2.0	3.2	1.8	1.8	36.0	9.0	2.2	2.0	2.0
C.O.D 100°C 30min (mg/l)	12.5	110.0	120.0	10.2	10.0	11.0	3.1	25.2	4.7	3.5	2.8	2.0	2.0	100.0	1.6	11.8	2.0	2.2
Phytoplankton (No/l)	135.0	20.0	110.0	215.0	180.0	145.0	92.0	15.0	110.0	100.0	95.0	85.0	220.0	35.0	215.0	285.0	265.0	230.0
Zooplankton (No/m ³)	5020	952	3890	4950	5120	5100	850	150	1050	1150	950	890	3300	1400	3100	3350	3350	3081
Macrobenthos (No/m ²)	30.0	3.0	18.0	38.0	26.0	25.0	10.0	5.0	12.0	11.0	16.0	12.0	29.0	8.0	16.0	35.0	32.0	30.0
Primary Productivity-Gross (mg C/m ³ -hr)	85.0	15.3	65.0	69.0	95.0	80.0	27.0	12.0	16.0	25.0	30.0	25.0	95.0	21.0	65.0	81.0	85.0	90.0
Net	32.0	9.5	21.2	28.0	35.0	37.0	23.0	12.0	18.0	19.0	21.0	18.0	42.0	11.0	28.0	35.0	38.0	37.0

The diversity index (\bar{H}) was also found to be affected near the outfall. However, the values were lower at all stations during this season as compared to other seasons. It varied between 1.10 and 2.10 for phytoplankton, 1.05 and 1.90 for zooplankton and 1.10 and 1.70 for macrobenthos.

3. Pulp and Paper (Sulphite process) :

This factory near Hajinagar adopted sulphite process for the manufacture of paper. The wastewater discharged were generally acidic in nature. The characteristics of the effluents, as reported by Ghosh *et al.* (1973) as already been given (Table 3). The physico-chemical and biological conditions around outfall of this factory are shown in Table 21. The pattern of alteration and recovery followed almost similarly to soda process. During premonsoon months, pH, D.O. and alkalinity were found to be affected considerably at the outfall where values fell sharply from 8.2 to 7.9 for pH, from 6.8 to 3.2 for D.O. and from 225.0 mg/l to 185 mg/l for alkalinity. The B.O.D. and O.C values increased significantly at the outfall. The reduction and immediate recovery rates were 76.3% and 78.1% for primary productivity, 85.2 and 81.4% for phytoplankton, 81.2% and 77.5% for zooplankton and 90% and 60% for macrobenthos, respectively (Table 22). Although considerable recovery was noticed at station-3, the rate was lower than soda process. Full recovery

TABLE-22
PERCENTAGE OF REDUCTION
(BETWEEN STATIONS 1 AND 2) AND IMMEDIATE
RECOVERY (BETWEEN STATION 1 AND 3) OF BIOTIC
COMPONENTS AROUND OUTFALL
PULP & PAPER (SULPHITE)

Season	Factors	Station-1 (above out fall)	Station-2 (at out- fall)	Percent Reduction	Station-3 (below out fall)	Percent Recovery
Pre-monsoon	Net Primary Productivity (mg C/m ³ -hr)	32.0	9.5	70.3	25.0	78.1
	Phytoplankton (No/l)	135.0	20.0	85.2	110.0	81.4
	Zooplankton (No/m ³)	5020.0	952.0	81.2	3890.0	77.5
	Macrobenthos (No/m ²)	30.0	3.0	90.0	18.0	60.0
Monsoon	Net Primary Productivity (mgC/m ³ -hr)	23.0	12.0	52.1	18.0	78.2
	Phytoplankton (No/l)	92.0	15.0	83.7	110.0	119.0
	Zooplankton (No/m ³)	850.0	150.0	82.5	1050.0	123.5
	Macrobenthos (No/m ²)	10.0	5.0	50.0	12.0	120.0

TABLE-22 (Contd.)

Season	Factors	Station-1 (above out fall)	Station-2 (at out- fall)	Percent Reduction	Station-3 (below out fall)	Percent Recovery
	Net Primary Production (mg C/m ³ -hr)	42.0	11.0	73.8	28.0	66.6
Post-Monsoon	Phytoplankton (No/l)	220.0	35.0	84.1	215.0	97.7
	Zooplankton (No/m ³)	3500.0	1400.0	60.0	3350.0	101.5
	Macrobenthos (No/m ²)	29.0	8.0	72.4	18.0	62.0

was noticed at Station 4 and onwards. Station 6, like other cases, was not affected. The number of species of all groups of biota reduced drastically at the outfall (Table 23). There was not much difference in their responses as compare to other cases. The pattern of occurrences and abundance at different stations were almost similar to other seasons. The diversity indices were higher in premonsoon and postmonsoon (Table 28). The values were again below '3'

4. Tannery :

The leather shoe company near Batanagar discharged large quantities of effluents which included scraps of hide, rubber, and chemicals etc. The effluents were brownish in colour and foul in odour.

During premonsoon, D.O. dropped to 2.0. mg/l from 7.0 mg/l and B.O.D. and O.C. increased from 3.5 mg/l and 8.0 mg/l to 205 mg/l and 230 mg/l respectively between station 1 and 2. However, the conditions near the outfall were not as adverse as in case of rayon and paper outfall (Table 24). Besides the quick recovery, stations below the outfall had better condition in term of plankton. The rates of reduction and immediate recovery were (Table 25) in the order of 76% and 80% for primary productivity, 77% and 130.4% for phytoplankton, 62% and 91.5% for zooplankton and 85.0% and 75.0% for macrobenthos respectively. It may be seen that before the impact of pollution was totally eliminated, the density of plankton increased considerably at Station 3, which was caused by the sudden increase in the population of few species. The density of other available species was either considerably reduced or they were still absent. The condition was changed at Station-4 where the population of these few species reduced considerably allowing other species to establish themselves.

The occurrence of different species around outfall during different seasons are shown in Table 26 in the outfall region. The macrobenthic funna mainly comprised of oligochaetes and

TABLE-23

DISTRIBUTION OF IMPORTANT BIOTA AROUND OUTFALL REGION
PULP AND PAPER (SULPHITE)

+ Present - Absent

Species	Pre-monsoon						Monsoon						Post-monsoon					
	Stn. 1	Stn. 2	Stn. 3	Stn. 4	Stn. 5	Stn. 6	Stn. 1	Stn. 2	Stn. 3	Stn. 4	Stn. 5	Stn. 6	Stn. 1	Stn. 2	Stn. 3	Stn. 4	Stn. 5	Stn. 6
PHYTOPLANKTON																		
<i>Syndera sp.</i>	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
<i>Coscinodiscus sp.</i>	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
<i>Surirella sp.</i>	+	-	-	+	+	+	-	-	-	-	-	-	+	-	+	+	+	-
<i>Cyclotella sp.</i>	+	-	+	+	+	+	-	-	-	-	+	+	+	-	+	+	+	+
<i>Lithodesmus sp.</i>	-	-	-	-	-	-	-	-	-	-	-	-	+	-	++	+	+	+
<i>Fragillaria sp.</i>	+	-	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
<i>Naviculla sp.</i>	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
<i>Stephanodiscus sp.</i>	+	-	+	+	-	+	-	-	-	-	-	-	-	-	-	-	-	-
<i>Pediastrum sp.</i>	+	-	-	+	+	+	+	-	+	+	-	+	-	+	+	+	+	+
<i>Ankistrodesmes sp.</i>	+	-	+	+	-	-	+	-	-	+	-	+	-	+	+	+	+	+
<i>Scenedesmus sp.</i>	-	-	+	+	-	+	-	-	-	-	-	-	+	-	+	+	-	-
<i>Spyrogyra sp.</i>	+	-	+	+	-	-	+	+	+	+	+	+	+	+	-	-	+	+
<i>Oscillatoria sp.</i>	+	+	-	+	+	+	+	+	-	-	-	+	+	+	+	-	-	-
<i>Microcystis sp.</i>	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
<i>Phormidium sp.</i>	+	-	+	+	+	+	-	-	-	-	-	-	-	-	-	-	-	-
<i>Euglena sp.</i>	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
ZOOPLANKTON																		
<i>Keratalla sp.</i>	+	-	+	+	+	+	+	-	+	+	+	-	+	+	+	+	+	+
<i>Brachionus calciflorous</i>	+	+	+	-	-	+	+	-	-	+	+	+	+	+	+	+	+	+
<i>B. rubens</i>	-	-	-	+	+	-	+	-	+	+	+	+	+	-	+	+	+	+
<i>Asplanchna brightwelli</i>	-	-	-	-	-	-	+	+	+	+	+	+	+	+	+	+	+	+
<i>Daphnia lumholtzi</i>	+	-	+	++	-	+	+	+	+	+	+	+	+	+	+	+	+	+
<i>Ceriodaphnia cornuta</i>	+	-	+	+	-	+	+	-	-	+	+	+	+	-	+	+	-	+
<i>Monia micrura</i>	-	-	-	-	+	+	-	-	-	-	-	-	+	-	+	+	+	+
<i>Heliodiaptomus contortus</i>	+	-	-	+	+	+	+	+	+	+	+	+	+	-	+	+	+	+

TABLE-23

DISTRIBUTION OF IMPORTANT BIOTA AROUND OUTFALL REGION
PULP AND PAPER (SULPHITE)—*CONTD.*

Species	Pre-monsoon						Monsoon						Post-monsoon					
	Stn. 1	Stn. 2	Stn. 3	Stn. 4	Stn. 5	Stn. 6	Stn. 1	Stn. 2	Stn. 3	Stn. 4	Stn. 5	Stn. 6	Stn. 1	Stn. 2	Stn. 3	Stn. 4	Stn. 5	Stn. 6
<i>H. viduus</i>	+	-	-	+	+	+	+	-	-	-	-	-	+	-	+	+	+	+
<i>Mesocyclops leuckarti</i>	+	+	+	+	+	+	+	+	+	+	+	+	+	-	+	+	+	+
<i>Mesocyclops hylinus</i>	+	-	-	+	+	+	-	-	+	+	-	-	+	+	+	+	+	+
<i>copopodites</i>	+	-	+	+	-	+	+	-	-	+	+	+	+	-	+	+	+	+
<i>Machrobrachium sp.</i>	+	-	+	+	+	+	+	-	+	+	+	+	+	-	+	+	+	+
<i>Limnodrilus hofmeinsteri</i>	+	+	+	-	-	+	+	+	-	-	-	+	+	+	+	+	+	+
<i>Thiara lineata</i>	+	-	+	+	+	+	+	-	+	+	+	+	-	-	-	-	-	-
<i>T. Intermediata</i>	-	-	-	-	-	-	-	-	-	-	-	-	+	-	+	+	+	+
<i>Litorina sp</i>	+	-	-	-	-	+	-	-	+	+	+	+	+	-	+	+	+	+
<i>Lynnea sp.</i>	-	-	-	+	-	-	+	+	+	+	+	+	-	-	-	+	+	+
<i>Dipteran larvae</i>	+	+	+	+	+	+	-	-	-	-	-	-	+	-	+	+	+	+
<i>Crustacean larvae</i>	-	-	-	-	-	-	+	-	+	+	+	+	+	-	+	+	+	+
<i>Fish larvae</i>	+	-	-	-	+	+	-	-	-	-	-	-	+	-	+	+	+	+
<i>Others</i>	+	-	-	+	-	+	+	+	-	+	-	+	+	-	+	+	+	+

TABLE-24

**PHYSICO-CHEMICAL AND BIOLOGICAL CONDITIONS
AROUND OUTFALL OF A TANNERY DURING DIFFERENT SEASONS**

Seasons	Pre-monsoon						Monsoon						Post-monsoon					
STATION	1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6
FACTORS																		
Temperature °C	38.8	32.0	31.8	30.8	30.5	30.5	31.0	32.0	31.3	31.0	31.0	31.0	27.0	27.6	27.0	27.1	27.2	27.2
pH	7.8	8.1	8.2	8.2	7.8	7.6	8.2	8.2	8.0	7.7	8.1	7.8	8.1	8.1	—	—	—	—
	8.2	7.6	8.1	8.1	8.2	8.2	7.8	7.6	8.2	8.2	8.1	7.7	8.1	7.8	8.1	8.1	8.2	8.1
Dissolved Oxygen (mg/l)	7.0	2.0	6.5	7.1	6.8	6.8	6.8	2.5	5.8	5.6	5.8	5.9	7.5	2.5	6.6	7.3	7.6	6.0
Alkalinity (mg/l)																		
CaCO ₃	160.0	140.0	170.0	160.0	168.0	150.0	110.0	100.0	105.0	100.0	105.0	105.0	180.0	160.0	170.0	165.0	165.0	135.0
B.O.D. 5 day (mg/l)	3.5	205.0	25.0	3.5	2.5	3.0	1.0	160.0	6.0	2.0	2.0	2.9	1.8	120.0	12.0	3.0	2.5	1.8
C.O.D 100°C 30min (mg/l)	8.0	230.0	18.0	5.0	4.0	5.0	2.0	95.0	5.0	3.0	2.0	2.0	3.0	200.0	16.0	4.0	4.0	2.5
Phytoplankton (No/l)	65.0	15.0	105.0	85.0	60.0	72.0	40.0	10.0	35.0	45.0	40.0	36.0	110.0	28.0	185.0	120.0	98.0	100.0
Zooplankton (No/m ³)	2950	1120	2700	3615	2650	3271	1250	310	1200	1300	310	1200	4150	1210	4520	4120	4850	4100
Macrobenthos (No/m ²)	20.0	3.0	15.0	25.0	20.0	14.0	5.0	1.0	5.0	12.0	8.0	6.0	19.0	2.0	15.0	13.0	14.0	11.0
Primary Productivity-Gross (mg C/m ³ -hr)	49.9	12.0	45.0	43.0	35.0	43.0	1.7	19.0	16.0	18.0	16.0	16.0	57.0	16.0	46.0	40.0	42.0	45.0
Net	25.0	20.0	10.0	13.0	18.0	10.0	17.0	14.0	15.0	14.0	17.0	12.0	31.0	12.0	28.0	14.0	25.0	28.0

chironomids which were present in large numbers. As the diversity of macrobenthos increased at stations 4 and 5, the density of the two abundant groups reduced simultaneously. The maximum number of plankton were observed at station 4. During monsoon and post monsoon no significant impact was noticed at station 3, which revealed that the conditions improved considerably even before this station.

TABLE-25
PERCENTAGE OF REDUCTION
(BETWEEN STATIONS 1 AND 2) AND IMMEDIATE
RECOVERY (BETWEEN STATION 1 AND 3) OF BIOTIC
COMPONENTS AROUND OUTFALL

TANNERY

Season	Factors	Station-1 (above out fall)	Station-2 (at out- fall)	Percent Reduction	Station-3 (below out fall)	Percent Recovery
Pre-monsoon	Net Primary Productivity (mg C/m ³ -hr)	25.0	6.0	76.0	20.0	80.0
	Phytoplankton (No/l)	65.0	15.0	77.0	85.0	130.5
	Zooplankton (No/m ³)	2950.0	1120.0	62.0	2700.0	91.5
	Macrobenthos (No/m ²)	20.0	3.0	85.0	15.0	75.0
Monsoon	Net Primary Productivity (mgC/m ³ -hr)	17.0	4.0	76.4	15.0	88.2
	Phytoplankton (No/l)	40.0	10.0	75.0	35.0	87.5
	Zooplankton (No/m ³)	1250.0	310.0	75.2	1200.0	96.0
	Macrobenthos (No/m ²)	5.0	1.0	80.0	5.0	100.0
Post-Monsoon	Net Primary Production (mgC/m ³ -hr)	31.0	10.0	67.7	28.0	90.3
	Phytoplankton (No/l)	110.0	28.0	74.5	185.0	168.0
	Zooplankton (No/m ³)	4150.0	1210.0	70.8	4520.0	108.0
	Macrobenthos (No/m ²)	19.0	2.0	89.4	15.0	70.0

TABLE-26

DISTRIBUTION OF IMPORTANT BIOTA AROUND OUTFALL REGION

+ Present - Absent

TANNERY

Species	Pre-monsoon						Monsoon						Post-monsoon					
	Stn. 1	Stn. 2	Stn. 3	Stn. 4	Stn. 5	Stn. 6	Stn. 1	Stn. 2	Stn. 3	Stn. 4	Stn. 5	Stn. 6	Stn. 1	Stn. 2	Stn. 3	Stn. 4	Stn. 5	Stn. 6
PHYTOPLANKTON																		
<i>Syndera So.</i>	+	-	+	+	-	+	+	+	-	-	+	+	+	+	+	+	+	+
<i>Coscinodiscus sp.</i>	+	+	+	+	+	+	+	-	-	-	-	-	+	+	+	+	+	+
<i>Surirella sp.</i>	+	-	+	+	+	+	-	-	-	-	-	-	+	-	+	+	+	+
<i>Cyclotella sp.</i>	+	+	+	+	+	+	+	+	+	+	+	+	-	+	+	+	+	+
<i>Lithodesmus sp.</i>	+	-	-	-	+	+	+	-	+	+	+	+	+	-	-	+	+	+
<i>Fragillaria sp.</i>	+	-	+	+	+	+	+	-	+	+	-	+	+	-	+	-	+	-
<i>Naviculla sp.</i>	-	-	-	-	-	-	+	+	+	+	+	+	+	-	+	-	+	-
<i>Stephanodiscus sp.</i>	+	-	+	+	+	+	+	-	+	+	+	+	+	-	+	+	+	+
<i>Pediastrum sp.</i>	-	-	-	-	-	-	+	+	+	+	+	+	+	-	+	+	-	+
<i>Ankistrodesmes sp.</i>	+	-	+	+	+	+	-	-	-	-	-	-	+	-	+	+	+	+
<i>Scenedesmus sp.</i>	-	-	-	-	-	-	+	-	+	+	+	+	+	-	+	+	+	+
<i>Spyrogyra sp.</i>	+	-	-	+	+	-	+	-	+	+	+	+	+	+	+	+	+	+
<i>Oscillatoria sp.</i>	+	+	+	+	+	+	-	-	-	-	-	-	+	-	-	-	-	-
<i>Microcystis sp.</i>	++	+	+	+	+	+	+	+	-	-	-	-	+	+	+	+	-	+
<i>phormidium sp.</i>	-	-	-	-	-	-	+	+	+	+	+	+	+	-	-	+	-	+
<i>Euglena sp.</i>	+	+	-	+	-	+	+	+	+	-	-	-	+	+	+	+	-	+
ZOOPLANKTON																		
<i>Keratalla sp.</i>	+	++	+	-	+	+	+	-	+	-	+	++	+		+	+	+	+
<i>Brachionus calciflorous</i>	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
<i>B. rubens</i>	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>Asplanchna brightwelli</i>	+	+	-	+	-	+	-	-	+	+	+	-	+	+	+	+	+	+
<i>Daphnia lumholtzi</i>	+	-	+	+	-	+	+	-	+	+	+	+	+	-	+	+	+	+
<i>Ceriodaphnia cornuta</i>	+	-	-	-	+	+	+	-	+	+	+	+	+	-	+	-	-	+
<i>Monia micrura</i>	+	-	+	+	+	-	-	-	-	-	-	-	+	-	-	+	+	+
<i>Heliodiaptomus contortus</i>	+	-	+	+	+	+	+	-	+	+	+	+	+	-	+	+	+	+

TABLE-26

DISTRIBUTION OF IMPORTANT BIOTA AROUND OUTFALL REGION
TANNERY—*CONTD.*

Species	Pre-monsoon						Monsoon						Post-monsoon					
	Stn. 1	Stn. 2	Stn. 3	Stn. 4	Stn. 5	Stn. 6	Stn. 1	Stn. 2	Stn. 3	Stn. 4	Stn. 5	Stn. 6	Stn. 1	Stn. 2	Stn. 3	Stn. 4	Stn. 5	Stn. 6
<i>H. viduus</i>	+	-	-	-	-	-	+	-	+	-	-	-	+	-	+	+	+	+
<i>Mesocyclops leuckarti</i>	+	-	-	+	+	+	+	+	+	+	-	+	-	-	-	-	-	-
<i>Mesocyclops hylinus</i>	+	-	-	+	+	+	-	-	+	+	-	+	+	+	+	+	+	+
<i>copopodites</i>	+	+	+	+	+	+	-	-	-	+	+	+	+	+	+	+	+	+
<i>Machrobrachium sp.</i>	+	-	-	+	+	+	+	-	+	+	+	+	+	+	+	+	+	+
<i>Limnodrilus hofmeinsteri</i>	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
<i>Thiara lineata</i>	+	-	+	-	+	-	-	-	+	+	+	+	+	-	+	+	-	+
<i>T. Intermediata</i>	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>Litorina sp</i>	+	-	+	+	+	+	-	-	-	-	-	-	+	-	+	+	+	+
<i>Lymnea sp.</i>	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>Diptoran larvae</i>	+	+	+	-	+	+	+	+	-	-	-	-	+	+	+	+	+	+
<i>Crustacean</i>	+	-	-	+	+	-	-	-	+	+	-	-	+	+	+	+	+	+
<i>Fish larvae</i>	-	-	-	-	-	-	-	-	-	-	-	-	+	-	+	+	+	+
<i>Others</i>	+	-	-	-	-	-	+	+	-	-	+	-	+	-	+	+	-	-

+ Present - Absent

TABLE-27 DIVERSITY INDICES (\bar{H}) OF DIFFERENT BIOTIC COMPONENTS AROUND OUTFALL

Season	Components	RAYON						PULP AND PAPER (SODA)					
		STATION						STATION					
		1	2	3	4	5	6	1	2	3	4	5	6
Pre-monsoon	Phytoplankton	2.70	1.05	2.64	2.68	2.75	2.72	2.62	1.20	2.20	2.80	2.75	2.70
	Zooplankton	2.55	1.28	2.00	2.91	2.80	2.63	2.65	1.04	1.60	2.45	2.70	2.50
	Macrobenthos	1.98	1.35	1.00	1.32	1.60	1.65	1.83	1.15	1.41	1.65	1.70	1.68
Monsoon	Phytoplankton	1.90	1.10	1.75	1.92	1.85	2.00	2.10	1.10	1.80	1.90	2.00	1.90
	Zooplankton	1.85	1.00	1.70	2.00	1.90	1.80	1.90	1.05	1.60	1.70	1.70	1.80
	Macrobenthos	1.40	1.05	1.40	1.45	1.40	1.40	1.15	1.10	1.70	1.65	1.55	1.50
Post-monsoon	Phytoplankton	22.92	11.40	2.10	2.65	2.80	2.90	2.85	1.30	2.65	2.90	2.85	2.80
	Zooplankton	2.70	1.30	2.35	2.82	2.75	2.80	2.72	1.25	2.60	2.85	2.70	2.75
	Macrobenthos	2.30	1.20	1.90	2.20	2.20	2.25	2.20	1.30	1.95	2.30	2.30	2.20

TABLE-28 DIVERSITY INDICES (\bar{H}) OF DIFFERENT BIOTIC COMPONENTS AROUND OUTFALL

		PULP AND PAPER (SULPHITE)						TANNERY					
Season	Components	STATION						STATION					
		1	2	3	4	5	6	1	2	3	4	5	6
Pre-monsoon	Phytoplankton (no./l)	2.50	1.20	2.0	2.45	2.40	2.50	2.25	1.00	1.95	2.20	2.25	2.15
	Zooplankton	2.40	1.10	2.25	2.50	2.50	2.30	2.65	1.20	2.60	2.60	2.65	2.70
	Macrobenthos	1.70	1.00	1.55	1.50	1.80	1.65	2.00	1.25	1.40	1.45	1.85	1.80
Monsoon	Phytoplankton	2.00	1.10	1.85	1.95	1.90	2.05	2.00	1.30	2.00	1.90	1.90	1.80
	Zooplankton	2.00	1.00	1.90	2.05	2.00	1.90	1.85	1.00	2.05	1.80	1.95	2.00
	Macrobenthos	1.75	1.10	1.40	1.80	1.70	1.70	1.55	1.00	1.80	1.45	1.50	1.60
Post-monsoon	Phytoplankton	2.75	1.30	2.20	2.80	2.65	2.75	2.90	1.35	2.85	2.90	2.80	2.80
	Zooplankton	2.80	1.45	2.55	2.75	2.75	2.80	2.75	1.15	2.70	2.70	2.80	2.75
	Macrobenthos	2.00	1.20	1.60	1.95	2.10	2.00	1.90	1.10	1.80	1.70	1.75	1.75

The diversity indices (\overline{H}) at all stations, during different seasons (Table 28) were not much different from other outfalls either in values or in pattern.

DISCUSSION

From the results of the present study, it has become clear that serious impact of pollution on estuarine ecology around outfalls of different industries were confined to hot dry premonsoon periods only. During monsoon and postmonsoon, although the regions close to outfalls were affected, there was almost immediate recovery. This was chiefly due to sufficient freshwater discharge and consequent dilution during these periods. Similar conditions have been reported by earlier workers. Ray *et al.* (1979) reported that the conditions in case of soda process pulp and paper mill improved within 100 m below the outfall and Ghosh *et al.* (1976) found the recovery distance only 50-100 m in case of rayon factory outfall during these seasons. Gopalakrishnan *et al.* (1973) stated that due to high dilution ratio (e.g. 1 : 263 in January), the effect was not appreciable as evident from the density of phytoplankton in the outfall region. The results of present study are different slightly from those of Gopalakrishnan *et al.* (1973) in respect that outfall regions were indeed affected during these periods but the effects were localised and confined to very short distance below the outfalls as revealed by the conditions at stations 2 and 3 in all cases.

The condition were quite different during premonsoon period, especially during latter half (May-June), when freshwater discharges were reduced leading to very low dilution ratio. This lower dilution, coupled with higher temperature, affected the abiotic and biotic conditions below the outfalls seriously. The physico-chemical conditions near the outfalls and upto certain distances below the outfall were not conducive to proper, survival and growth of normal biota in all cases studied. Although physico-chemical and biological conditions improved at station 3 up to certain extent, the recovery was still underway. However, in almost all cases, the impact of pollution seems to be mostly eliminated at Stations 5 and 6, which were not found to be affected during any season. This showed that the impact of any of the industrial wastewater never reached upto 1 km below the outfall or on the bank opposite to outfall. The increased abundance of plankton at stations 3 & 4 of pulp and paper mills outfall was due to increased availability of nutrients liberated by the decomposition of huge quantity of organic matter. However, only few species could utilize this nutrient enrichment thereby increasing their abundance substantially.

It was interesting to note that while physico-chemical conditions and plankton recovered within 500 m below outfall, the benthic faunal diversity as well as density were still under recovery during premonsoon months. This clearly indicated the higher sensitivity of benthos to pollution of the estuary. As already indicated, Ray and Mitra (1980) found that in case of pulp and paper mill using sulphite process, decomposition of organic matter reduced the dissolved oxygen concentration and produced carbon-di-oxide and hydrogen sulphide, which resulted in an anaerobic conditions at soil water interface leading to drastic reduction in all form of bottom biota. This condition was due to settling of highly oxidisable organic substances like lignin. This deterioration of the bottom condition was not reflected in the open water of surface.

Further, it is well known that benthic sessile or slow moving forms are much more affected in any polluted water body than moving organisms as they can not move away swiftly from polluted regions to avoid any sudden impact (Wilhm, 1970, Chandler, 1970, Cook, 1976).

It has been reported by various workers that maximum impact of pollution in the estuary is felt at low tide-high tide juncture of neap tide phase during premonsoon months, when the dilution ratio is minimum, (Gopalakrishnan *et al.*, 1973, Ray, 1980 etc.). Since the samples during present study were collected within this particular period, the data show the maximum impact which pollutants of different industries could generate on the ecology of estuary around various outfalls. Though there was no supporting data, Gopalakrishnan *et al.*, (1973) opined that this maximum impact was due to the fact that pollutants during this specific period remain in the estuary for longer times as compared to other season. With flood tides, the wastewaters already discharged, return back to estuary with certain dilution by sea water, which then get 'fortified' by freshwaters. Thus pollutants remain suspended in this condition for quite sometimes thereby increasing their impact. Since no systematic data were collected on this aspect during present investigations too, it is difficult to comment upon.

In spite of the fact that the impact of pollution was localized and confined to comparatively smaller areas around outfalls, the existence of poor biological quality of this region of the estuary (lower region of zone 1 and upper region of zone 2) indicated that overall conditions was not satisfactory as compared to other regions in lower zones and also in Matla estuary. This fact was already discussed by Bose (1965, 1967). Gopalakrishnan *et al.*, (1973) again indicated that this poor biological quality may be due to existence of pollutants in sublethal levels which are not detectable easily but are affecting the aquatic organisms due to their cumulative effects. Though there are not sufficient data to show the exact mechanism of this phenomenon, it appears to be quite probable. The simultaneous discharge of wastewaters from a number of industries and municipalities, along with reduced freshwater flow and silting, resulting in the destruction of bottom, have probably created a complex condition not congenial for optimum survival and growth of all forms of biota, specially commercially important fishes and prawns.

The diversity indices (\bar{H}) values also indicated the general condition of the estuary in this zone was not good as the values never exceeded 3. It has been reported that a value of 3 and above represents unpolluted conditions, values between 1.5 and 3, indicated moderately polluted conditions and values less than 1.5, heavily polluted conditions. The applicability of this index in such complex estuaries, which are as such poor in biological diversity, to ascertain the impact of pollution needs further investigations. However, comparative values of the diversity indices at different stations around outfalls, their increase and decrease according to intensity of pollution, gave an indication of their utility.

Although the foregoing accounts give some idea of the pollution of the estuary and its impact specially near the outfalls of some industries, it is at the moment rather difficult to precisely assess the extent of pollution, because of the complex nature of the estuary. It requires detailed and systematic studies on all aspects of the dynamics of estuarine system over a longer period of time taking into consideration factors like dilution, mixing pattern, duration of tides,

tidal phase, natural purification, seasonal influences and structure, dynamics and biology of different biotic communities/species.

SUMMARY

1. The paper reviews the earlier works done on the pollution status of Hugli estuary and presents the results of certain observations made during present investigations on the impact of pollution on plankton and benthos around outfalls of few important industries.
2. As per reports of earlier workers, there were 41 major industries between Dumurdaha and Birlapur, a distance of 92 km, situated on both banks, discharging their trade effluents, directly or indirectly, mostly untreated or partially treated into the estuary. Beside this, 55 jute mills and several municipalities discharged domestic wastes. The important industries were pulp and paper mills, natural and synthetic textiles, distillary and yeasts, rubber, tannery, metal and steel, paints varnishes and chemicals, hydrogenated vegetable oil and soaps, shellac, fertilisers, polythene and mineral oil refilling etc.
3. The total amount of wastewaters discharged was estimated to be around 1154 mld which generated a B.O.D load of 106.27 ton/day and total solid load of 2318.5 ton/day. Out of this, industrial wastes contributed about 38.8 mld with B.O.D. load of 61.2 ton/day and solid load of 891.05 ton/day. The rest was contributed by domestic wastes.
4. The nature and characteristics of the wastewaters varied widely from industry to industry. Industrial effluents mainly belonged to three categories viz. (1) organic wastes of biological origin, (2) organic wastes of non biological origin and (3) wastewaters of chiefly inorganic (mineral) origin. Organic wastes comprised around 89.9% of the total industrial discharge.
5. General studies on the impact of industrial wastewaters on biota and primary productivity around outfalls of some industries by earlier workers revealed that productivity and biota were affected considerably during premonsoon hot period.
6. During present investigations, impact of wastewaters of 4 important industries viz (1) a rayon factory, (2) a pulp and paper mill using soda process, (3) a paper and pulp mill using sulphite process and (4) a tannery upon plankton and benthos around outfall regions were studied covering six stations in each case, starting from above the outfall to 1 km below the outfall. The impact was analysed by working out reduction rates (between the stations "above the outfalls" and "at the outfalls"), immediate recovery rates (between the stations "above the outfalls" and "next to outfall") and diversity indices.
7. The pattern of impact in all cases studied were almost similar. There was considerable reduction in the number of species and density of individual species/group at the outfalls and consequent rapid recovery below the outfalls. While during monsoon and post monsoon periods, impact was confined to very short distances below the outfall, during premonsoon period it was felt over longer distances. However, in all cases the impact was not felt either at 1 km distance below the outfalls or at opposite bank of the outfalls. The maximum impact which pollutant could generate was during low tide high tide interval of neap tide

phases of premonsoon period. The recovery of macrobenthos was comparatively slower than plankton which showed their higher sensitivity to pollution.

8. In spite of the fact that impact of industrial wastewaters were confined to certain distances below the outfalls, the existence of poor biological quality of this region of the estuary indicated that overall conditions were not satisfactory as compared to other regions. The simultaneous discharge of wastewaters from a number of industries and municipalities along with reduced freshwater flow and silting have probably created a condition not favourable for optimum growth and survival of all forms of biota, specially important species of fishes and prawns. Further detailed studies on different ecological aspects of pollution are required for the proper understanding of the problem.

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