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The Ecology and Faunal Diversity of two Floodplain Ox-Bow Lakes of South-Eastern West Bengal

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R. A. Khan

Zoological Survey of India, 234/4, AJC Bose Road, Nizam Palace (13 Floor), Kolkata-700 020

Edited by the Director, Zoological Survey of India, Kolkata

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INTRODUCTION

Floodplain wetlands, defined as low lying areas bordering large rivers, which are seasonally inundated by over-spills from the main river channel, are integral components of Ganga and Brahamputra river basins and constitute important freshwater resources of the states of Bihar, West Bengal and Assam. Such wetlands, which include ox-bow lakes, (cut off portion of river meander bends), sloughs, meander scroll depressions, back swamps, residual channels and tectonic depressions are considered as biologically sensitive habitats as they play a vital role in the recruitment of fish population in the riverine ecosystem (Maltby, 1991; CIFRI, 2000a). Besides, they also support rich floral and faunal diversity of macrophytes, plankton, benthos and macrophytes associated macro-invertebrates. The country's floodplain resources and their importance have been discussed in details (Sugunan, 1995, 1997).

In the state of West Bengal, commonly known as *beel / jheel* (closed, lake-like) and *baors* (ox-bow lakes), these wetlands occur in abundance mainly in the districts of Murshidabad, Nadia and North 24 Parganas along the tributaries/distributories of main river Ganga *viz.* Icchamati, Bhagirathi and Jalangi. There are nearly 150 large and small beels and baors in the state constituting nearly 22 % of the its total freshwater resources (CIFRI, 2000a). In southeastern portion of the state, a large number of *beels* and *boars* occur along the river Icchhamati in the district of North 24 Parganas.

Although a few reports on the floodplain wetlands of Ganga and Brahamputra systems in the eastern and north-eastern regions of the country are available (from Assam-Sugunan, 1995, 2000; CIFRI, 2000a, from Bihar-Rai and Datta Munshi, 1988; Singh and Roy, 1990; Rai and Sharma, 1991; Singh *et al.,* 1994; Sanjar and Sharma, 1995; Sinha and Jha, 1997; Baruah *et al.,* 1997; Sinha. *et al.,* 1994; and from West Bengal-Vaas, 1989; Mitra, 1997; Vinci and Mitra, 2000; CIFRI, 2000), the attention of the above workers remained mainly confined to general limnological conditions and fishery potentials but lacked information on faunal diversity of different biotic communities. The few available reports on faunal occurrence (Rai and Datta Munshi, *op. cit.*) in some wetlands of north Bihar do not portray reasonable picture of the faunal diversity excepting the work of Roy *et al.* (1988) on aquatic insects. In fact, the information on faunal diversity of floodplain wetlands of the country in general is fragmented, scanty and far from satisfactory, barring some reports from Kashmir (Khan, 1987).

The diversity and taxonomy of various zooplankton and macroinvertebrate groups of freshwaters of this region have been studied in considerable details by several workers. Among zooplankton, Cladoceran fauna was mainly studied by Gurney (1906, 1907), Sewell (1935), Sharma (1978a), Sharma and Michael (1987), Michael and Sharma (1988),

Venkataraman and Das (1992) and Venkataraman (1998). The taxonomy of the Rotifers has been dealt by Anderson (1889), Sewell (1934, 1935), Sharma (1978b, 1978c, 1979a, 1979b, 1983, 1999a) and Sharma and Michael (1980) in considerable details. The freshwater Copepods of the region have been studied by Gurney (1907), Sewell (1934), Pillai (1971), Rajendran (1973), Sehgal (1983) and Roy (1998). The literature on the taxonomy of entomofauna includes the reports of Distant (1902, 1906, 1910) and Bal and Basu (1994a, 1994b) on Hemiptera; Frasser (1933, 1934, 1936) and Srivastava and Sinha (1993) on Odonata; Srivastava (1993) on Ephemeroptera and d'Orchyment (1928), Oshes (1930), Vazirani (1968, 1970, 1977, 1984), Roy (1982), De and Sengupta, (1993), Biswas and Mukhopadhyay (1995a, 1995b) and Biswas *et al.* (1995) on Coleoptera and Roy *et al.* (1988) on general entomofauna of some wetlands of Bihar.

Realising the importance of such wetlands and paucity of information on the faunal composition and abundance, detailed studies were carried out during last three years (1998-2000) in order to work out the general physico-chemical conditions of water and soil, phytoplankton, macrophytes, zooplankton, macrophytes associated and benthic macro-invertebrates, Fish, Amphibia and Avifauna of some selected floodplain wetlands located in southeastern part of West Bengal state. The present report deals with the qualitative and quantitative diversity of fauna and flora belonging to different communities in two large oxbow wetlands, situated in the Bongaon Sub-Division of the district of North 24 Parganas, along the river Icchamati.

DESCRIPTION OF THE STUDY AREA

Beri Gopalpur Baor, an oxbow lake, is situated near Panchpota, Gopalpur in Bongaon Sub Division of North 24 Parganas District of West Bengal State, India, near India-Bangla Desh border. It is located nearly 15 km south east of Bongaon town (Fig. 1) close to Icchamati River. It is a big horseshoe-shaped open type oxbow wetlands covering an approximate area of 400 ha with depth ranging between 5 to 6 m. It's one end remains connected with the river Icchhamati during monsoon months. Fishermen control the inflow/ outflow of water by creating barriers. The main source of water supply is precipitation, surface run-off as well as from the river. Heavy monsoonal discharge raises the water level during the season, which gradually decreases during post monsoon and premonsoon months. The wetland is moderately infested with thick littoral as well limnetic submerged macrophytes belonging to a large number of species. The sources of nutrient inputs are both autochthonous, mainly through the rapid decay of macrophytes, as well as allochthonus. Organised fishing is carried out on regular basis by a cooperative of fishermen. Fingerlings of Indian Major carps, common carp, silver carp and grass carps are released periodically.

Sosadanga Baor, another ox-bow wetland taken for study, is situated nearly 5 km away from Beri Gopalpur wetland in the north. This baor has also connection with river Icchamati from its northestern tip (Fig. 1) and gets connected during monsoon month. It is comparatively smaller in size covering an area of nearly 100 ha with depth of 4-5 m. Heavy infestation of macrophytes was observed throughout the year in the entire wetland. No organised fishery takes place in the baor.

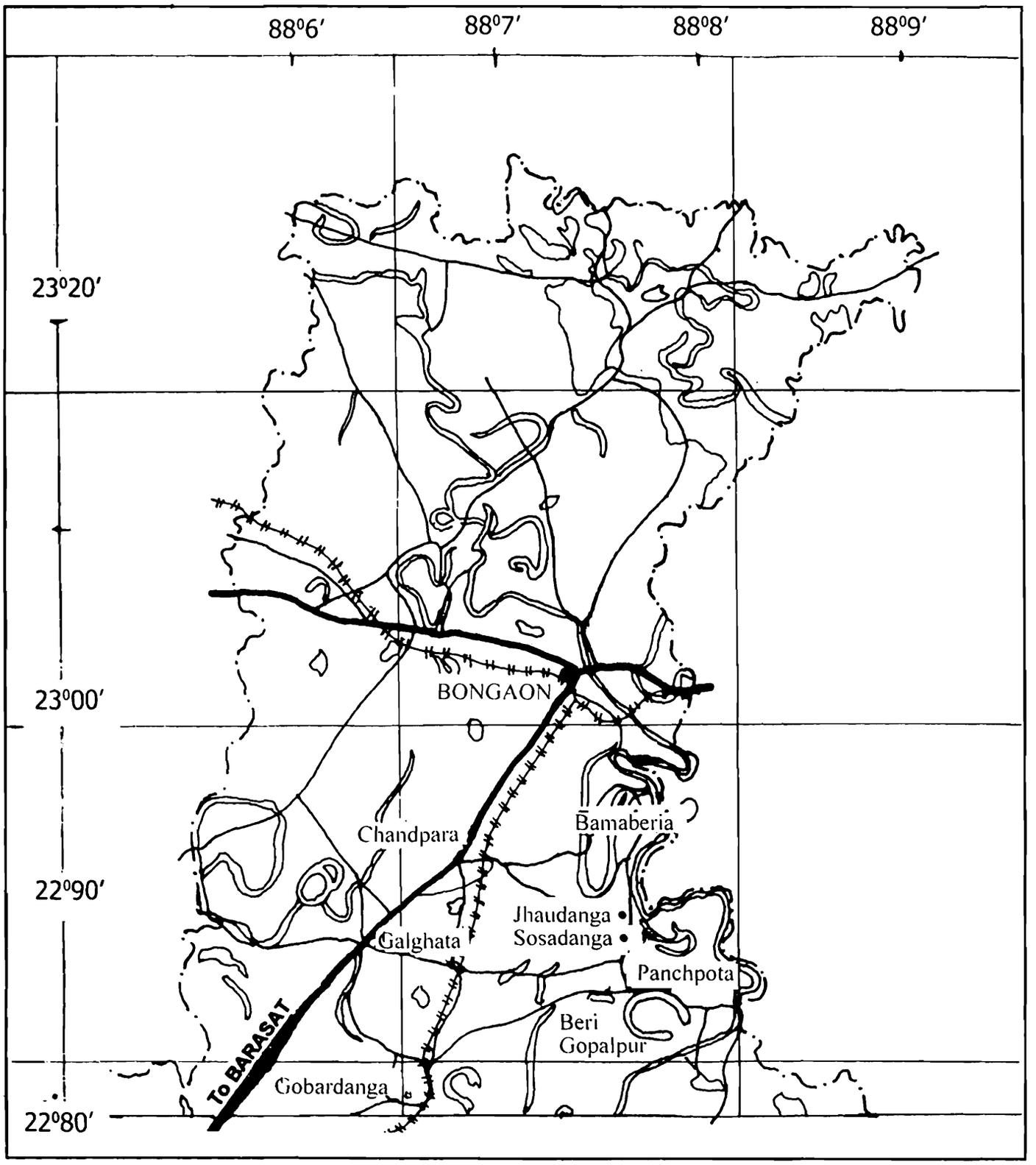


Fig. 1. Map of Bongaon region of North 24 Parganas, West Bengal showing ox-bow lakes and the two study areas.

MATERIAL AND METHODS

Sample collection and analysis

The studies were carried out for three consecutive years, (1998, 1999 and 2000) during different seasons. The seasons were defined as pre-monsoon (PRM, March to June). Monsoon (MON, July to October) and Postmonsoon (POM, November to February).

Physicochemical Parameters of water and soil quality

Surface Water samples were collected from 3 different points of the baor. Water for dissolved oxygen determination was collected in a 300 ml capacity BOD bottle from just below the surface slowly, so as to avoid any air bubble entering into the bottle. Water samples for the determination of physico-chemical parameters to be carried out in the field were collected in a clean beaker of 500 ml. capacity and for laboratory analysis in a 500 ml bottle. Limnological parameters, *viz,* temperature, pH, Sechi disc transparency, conductivity, dissolved oxygen, free CO_2, total alkalinity, total hardness and chlorides were estimated in the field and other parameters were analysed in laboratory. Measurements of temperature and pH were done with the help of pen type meter (Hana, Japan), conductivity by a portable meter and transparency by Sechi disc. Determination of chemical parameters was chiefly based on Standard Methods (APHA, 1991).

Phytoplankton and Macrophytes

Quantitative phytoplankton samples were collected by filtering 1 lit. of water on a Whatman filter paper No. 4 and washed thoroughly with a small quantity of water and fixed in Lugol's solution. Common macrophytes were collected qualitatively from different points. Their relative composition was grossly determined by allotting points arbitrarily by eye estimation according to their abundance. Phytoplankton samples were identified and counted under a high powered binocular microscope and generic identification was done following Smith (1950) and Edmondson (1959). Macrophytes identification followed Subramanyam (1962).

Zooplankton

Qualitative zooplankton samples were collected with the help of a plankton net made of bolting cloth No 25, Mesh size 56μ). Sweeps were made in all directions in the littoral zone. For the collection from open water, net was thrown to some distance from inside the baor and then towed avoiding littoral macrophytes. Nets were also towed from the boat for some distance as and when available. For quantitative samples, 50 lit. of water was filtered through the net, both from littoral and open water zones. Samples were carefully transferred to a small enamel tray. The inside of the net was also washed so as to collect any sticking plankter. Few drops of formalin were put to narcotize the animals and when they became motionless and settled down, the supernatant water was discard slowly and concentrated

samples were collected. All samples were preserved in 4 % formalin. Preserved zooplankton samples were examined under a binocular microscope with different magnifications. Detailed taxonomic identification was carried out following Edmondson (1959), Pennak (1978), Michael and Sharma (1988), Sehgal (1983), Battish (1992), Ray (1998) and Sharma (1998). Quantitative analysis, identification and enumeration were done simultaneously on a Sedgwick Rafter counter cell by taking 1 ml subsample and then raising to total volume of water filtered.

Macroinvertebrates

For qualitative faunal diversity studies, macro-invertebrate specimens were collected by thoroughly netting and handpicking from different areas of the wetland. Macrophytes associated (both attached and free swimming) macroinvertebrates (Neuston and nekton) were collected with the help of a hand operated D framed sweep net of the size of 50 cm length and 25 cm maximum breadth of the D. The frame was attached to a bag net made up of fine muslin cloth with mesh size of approximately 200μ. The net was fixed on a long pole. The design and operation of the net was roughly based on that described by Junk (1977). For collection of fauna, the net was slowly pushed upside down to the bottom of littoral zone and quickly lifted after turning upwards the mouth of the net. After pulling the net near the shore, the vegetations projecting outward from the marginal area of the net frame, were cut off. The total area covered by the net was calculated. Three replicate samples from each sites were collected. The macrophyte leaves and roots were then washed thoroughly several times in the net itself removing all attached fauna manually from each strand with the help of a magnifying glass. The bulbs of water hyacinth were thoroughly examined. The contents of the net as well as macrophytes were again washed on a sieve of 0.5 mm and all fauna retained on the sieve were collected. Animals were first killed or narcotized slowly by putting a few drops of 5% formaldehyde solution and then preserved either in 70% alcohal or 5% formalin.

Quantitative benthic samples were collected with the help of a tray type sampler (size 30 x 25 x 5 cm approx.) with a sliding, thin but hard, iron plate covering the entire mouth of the tray. After sliding away iron plate, the tray of the sampler was placed firmly on the bottom by hand and then the mouth was covered by inserting the plate. Samples were collected from the littoral zones only.

Macroinvertebrates were identified to the lowest possible taxa with the help of Subba Rao (1989) for Mollusca; Vazirani (1970, 1984), Biswas *et al.* (1995a, 1995b) and Biswas and Mukhopadhyay (1995) for Colepotera; Bal and Basu (1994a, 1994b) for Hemiptera and Srivastava and Sinha (1993) for Odonata.

For relative abundance and density measurements, the quantitative samples were used. The animals were sorted out into different taxonomic groups and identified up to lowest possible taxon under low–powered stereo binocular microscope. Enumeration and size

measurements were carried out simultaneously. For dry weight biomass determination, the counted samples were divided into major taxonomic and size groups, dried for 3 days at 65°C and weighed separately groupwise. The weight of all counted individuals of each group was determined and mean individual weight of the group was worked out. This was done only once in the beginning. In all further sample analysis, the mean number of the group was multiplied with the mean individual weight.

Vertebrates

Fishes and amphibian samples were collected randomly as and when available. Information regarding the availability of different species in the baor and also nearby wetlands of the area was also collected from local people as well as from earlier reports. Similarly, the list of common marsh and aquatic birds were compiled based on both, the observation made during the present study and the observations of earlier workers.

The identification of fishes was made following Jayaram (1984) amphibia following Sarkar *et al.* (1992) and the birds following Ali (1990).

Measurement of Diversity

The number of species, density of individual species and total macrofaunal density were used to compute following diversity indices :

1. Species Richness Index (Simpson, 1949)

$$d = \frac{S - 1}{\log_e N}$$

S = no. of species, N = no. of individuals

2. Shannon-Weiner Index

$H = - \{ni/ N \log_2 ni/ N\}$ (Shannon-Weiner, 1949, after Wilhm, 1972).

S = total number of species, N= total density, ni = density of individual species

Similarly Analysis

Coefficient of community, CC = 2C/A = B (Sorensen, 1948).

Where A = number of species in sample A, B = number of species in sample B and C = number of species common to both samples.

RESULTS

Physico-chemical characteristics

Water Only a few important parameters of water quality were studied. Table I summarizes the values recorded during different seasons in the two wetlands. Except for a brief period during post monsoon when a noticeable drop in mean water temperature was recorded (around 22°C), it fluctuated narrowly (32 ± 1°C) during major part of the year. Neither increase nor decrease in the water temperature was severe during any time of the year. Mean depth of both wetlands varied considerably between premonsoon and postmonsoon. Beri Gopalpur wetland was comparatively deeper than Sosadanga. The mean depth at sampling stations of the former varied between 525 cm and 610 cm and latter between 410 cm and 482 cm during pre and post monsoon. The Sechi disc transparency did not differ much

Table 1. Seasonal variations in Physico-chemical parameters of water quality in the two oxbow wetlands

	Beri Gopalpur wetland			**Sosadanga wetland**		
Parameters	Pre-monsoon	Monsoon	Post-monsoon	Pre-monsoon	Monsoon	Post-monsoon
Water temp (°C)	32.40	31.50	22.50	33.00	32.0	21.0
Depth at sampling stations (cm)	525.00		610.00	410.00		482.0
Sechi Disc Transparency (cm)	95.50	65.50	125.50	70.50	50.0	108.0
pH	8.20	7.500	8.00	8.70	7.60	8.20
Sp conductivity (μ mhos/cm)	465.00	485.00	330.20	490.00	536.35	460.00
Dissolved Oxygen mgl^{-1}	7.80	5.20	8.80	8.50	4.80	10.2
Total alkalinity mgl^{-1}	172.00	125.00	160.50	220.00	155.50	195.80
Free CO2 mgl^{-1}	1.80	1.20	Nil	3.20	2.60	1.50
Chloride mgl^{-1}	35.50	38.50	17.50	16.50	26.60	28.5
Total Hardness mgl^{-1}	180.50	125.00	165.00	162.00	108.50	135.6
Nitrate mgl^{-1}	0.15	0.22	0.12	0.10	0.15	0.12
Phosphate mgl^{-1}	0.033	0.028	0.036	0.030	0.025	0.042
Silicate mgl^{-1}	1.70	2.85	1.80	2.20	4.50	2.50

between the two wetlands and varied between 125.00-65.50 cm in Beri Gopalpur and between 50.0-108 cm in Sosadanga, being highest during postmonsoon and lowest during monsoon. Both the wetlands were alkaline as pH values were always above 7.5. Sosadanga had slightly higher pH regime than Beri Gopalpur. Season-wise highest values were recorded during premonsoon in both wetlands. Specific conductivity values of both wetlands were almost similar and fluctuated between 330 and 536 micomhos/cm, highest during monsoon and lowest in postmonsoon. The wetland waters were always well oxygenated and except slight fall during monsoon period, the values were well above the optimum level. In Sosadanga values above 9 mgl^{-1} were recorded during postmonsoon months. Free carbon dioxide was recorded in small quantities during premonsoon and monsoon seasons in Beri Gopalpur and in all seasons in Sosadanga. Total alkalinity was quite high in both wetlands throughout the year ranging above 125 mgl^{-1} Water of both the wetlands was hard as hardness values were quite high. The values dropped slightly during monsoon months. Chlorides were in moderate quantities as the values never exceeded 38.5 mgl^{-1} The nutrients, Nitrate and Phosphate were recorded in comparatively lower concentrations. The nitrate concentration fluctuated between 0.12 and 0.22 mgl^{-1} and phosphate between 0.025 and 0.042 mgl^{-1} in the two wetlands, exhibiting a very narrow range of fluctuation. While nitrate concentration was higher during monsoon in both the wetlands, phosphate values peaked during postmonsoon. Like nitrates, silicates were also in higher concentrations during monsoon months. As a whole, the physico-chemical condition of the water of two wetlands did not differ markedly.

Soil : The mean concentrations of some parameters of soil quality studied are given in Table 2. The pH of the soil of both wetlands remained alkaline throughout the year and there were not much differences in the corresponding seasonal values of the two wetlands. The soil of the two wetlands was sandy-loamy as the composition was dominated by sand (70.2

Table 2. Seasonal variations in Physico-chemical properties of soil in the two oxbow wetlands.

	Beri Gopalpur wetland			**Sosadanga wetland**		
Parameters	Pre-monsoon	Monsoon	Post-monsoon	Pre-monsoon	Monsoon	Post-monsoon
pH	8.10	7.20	7.70	8.22	7.85	8.10
Specific conductivity (μ mhos/cm)	460.50	210.40	315.00	540.20	230.05	340.0
Soil composition (%)						
Sand	76.20	73.50	70.30	70.20	76.50	72.50
Silt	5.50	10.00	12.20	9.50	12.50	8.80
Clay	18.30	16.50	17.50	20.30	11.00	18.70
Organic carbon (%)	1.90	1.65	1.05	4.85	4.50	4.65
Nitrogen (mg/100 gm)	21.00	12.50	18.50	36.00	30.50	45.50
Phosphate (mg/100 gm)	4.20	2.50	3.80	2.80	1.50	2.12

- 76.5%), followed by clay (16.5 to 20.3%) and silt (5.5 - 12.2%). The sediments were quite rich in the organic carbon and nutrients. Sosadanga was comparatively richer in organic carbon and nitrogen but the concentration of phosphate was significantly higher in Beri Gopalpur.

Biological Characterstics

Species composition and abundance : Both floral and faunal diversity of the two wetlands were quite rich. The total number of taxa belonging to different groups is shown in Fig. 2. This included 31 taxa of macrophytes, 43 of phytoplankton, 72 of zooplankton and 78 of macroinvertebrates.

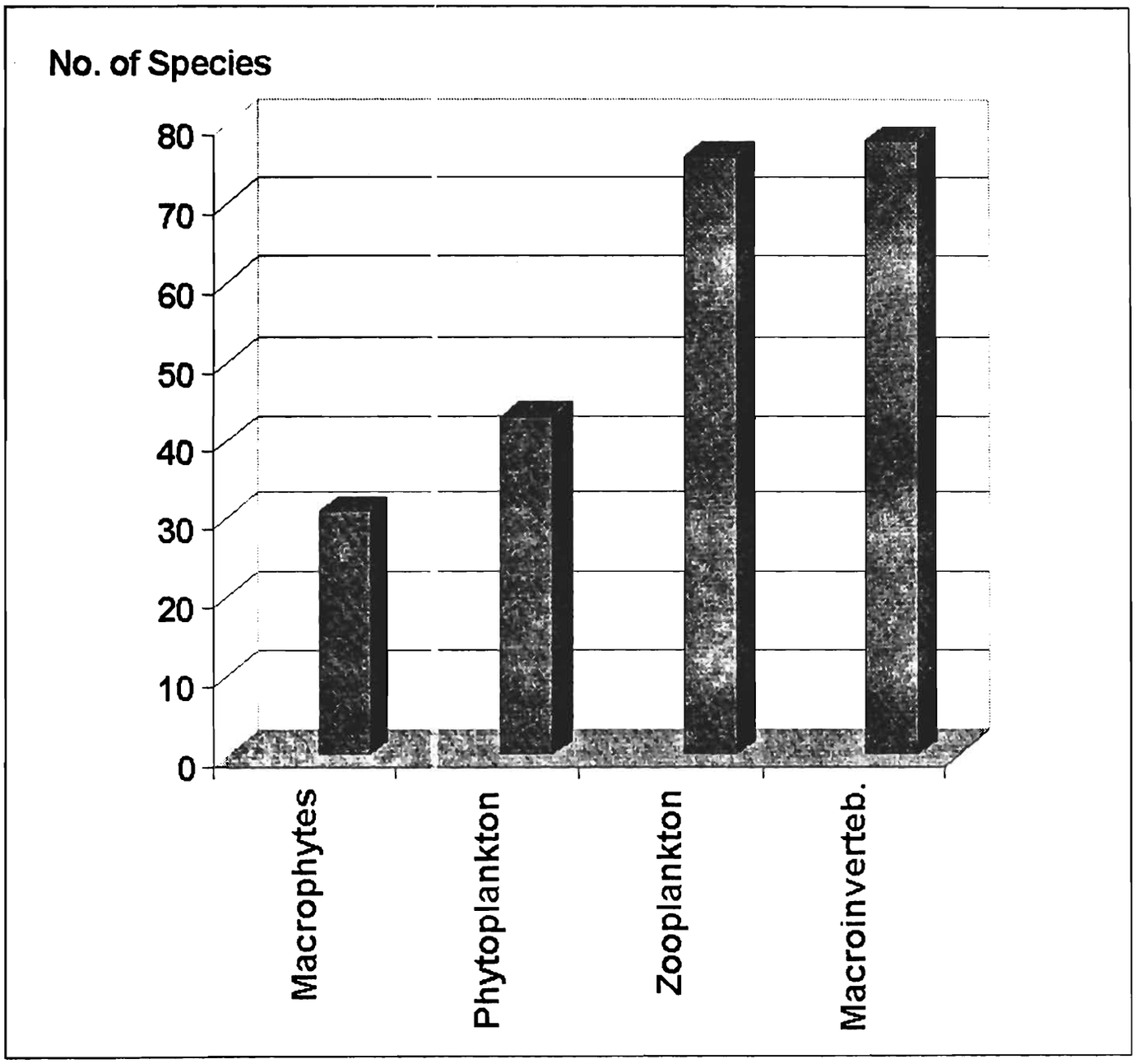


Fig. 2. Total number of species recorded from the two ox-bow wetlands

(A) MACROPHYTES

Both wetlands were considerably infested with a variety of macrophytes. Altogether 31 taxa belonging to 12 families were recorded during the period of study (Table 3). These were divided into three main categories, floating, submerged and emergent. The floating types, consisting of both free floating and rooted floating, were comprised of largest number of species (12). Among rooted floating, *Nymphoides indicum* was the commonest species occurring throughout the year in both wetlands. Another species, *Nymphaea pubiscens* also occurred throughout the year in both wetlands. The most abundant free-floating species was *Eicchornia crassipes,* which dominated all other macrophytes throughout the year in both wetlands. Thick strands were observed in littoral zone. The other common free-floating species were *Pistia stratiotes* and *Lemna perpusilla.* The submerged macrophytes were both, rooted as well as free submerged. Among the former, *Blyxa roxburghi* and *Hydrilla verticillata* were abundant species. *Vallisnera spiralis* also occurred but in smaller strands. The free submerged category was comprised of only one species, *Ceratophyllum demersum,* which occurred abundantly throughout the year. Three species of the family Cyperaceae contributed mainly to erect emergent type. Prostate emergent species were *Ipomea aquatica* and *Alternanthera philoxeroides.*

Table 3. List of macrophyte taxa recorded from the two ox-bow wetlands
C-Present/Common,
CC-Abundant, R Rare, Absent

	Beri Gopalpur			**Sosadanga**		
	Pre-monsoon	Mon-soon	Post-monsoon	Pre-monsoon	Mon-soon	Post-monsoon
A. FLOATING **Rooted floating** **Family Nymphaceae**						
Nymphaea pubiscens	C	C	C	C	C	C
Nelumbo nucifera	-	-	-	C	C	C
Nymphoides indicum	CC	CC	CC	C	CC	CC
Family Scrophularineae						
Limnophila heterophylla			-	C	C	C
Limnophila indica	C		C	-	-	-
Free Floating						
Family Aroideae						
Pistia stratiotes	CC		CC	CC	CC	CC
Family Lemnaceae						
Lemna perpusilla	C		CC	CC	CC	CC

	Beri Gopalpur			Sosadanga		
	Pre-monsoon	Mon-soon	Post-monsoon	Pre-monsoon	Mon-soon	Post-monsoon
Spirodella polyrrhiza				CC		C
Wolffia arrhiza	C		CC			C
Family Onagraceae						
Trapa bispinosa		C	C		C	C
Family Pontederiaceae						
Eichhornia crassipes	CC	CC	CC	CC	CC	CC
Family Salviniaceae						
Azolla pinnata				C	C	C
Family Hydrocharidae						
Hydrocharis cellulosa	C	C	C			C
B. SUBMERGED						
Rooted Submerged						
Family Characeae						
Chara branchypus	C	C	C	CC	C	CC
Family Hydrochorideae						
Blyxa roxburghi	C	C	C	CC	C	CC
Hydrilla verticillata	CC	C	CC	CC	C	CC
Otellia alismoides				CC	C	CC
Vallisneria spiralis	C	C	C		C	C
Family Naiadaceae						
Potamogeton crispus	CC		C	CC		CC
Family Najadaceae						
Naja indica						CC
Naja minor	CC		CC			
Free submerged						
Family Lentibullariaceae						
Utricularia stellaris	C	R	C	C	C	CC
Family Ceratophyllaceae						
Ceratophyllum demersum	CC	C	CC	CC	CC	CC

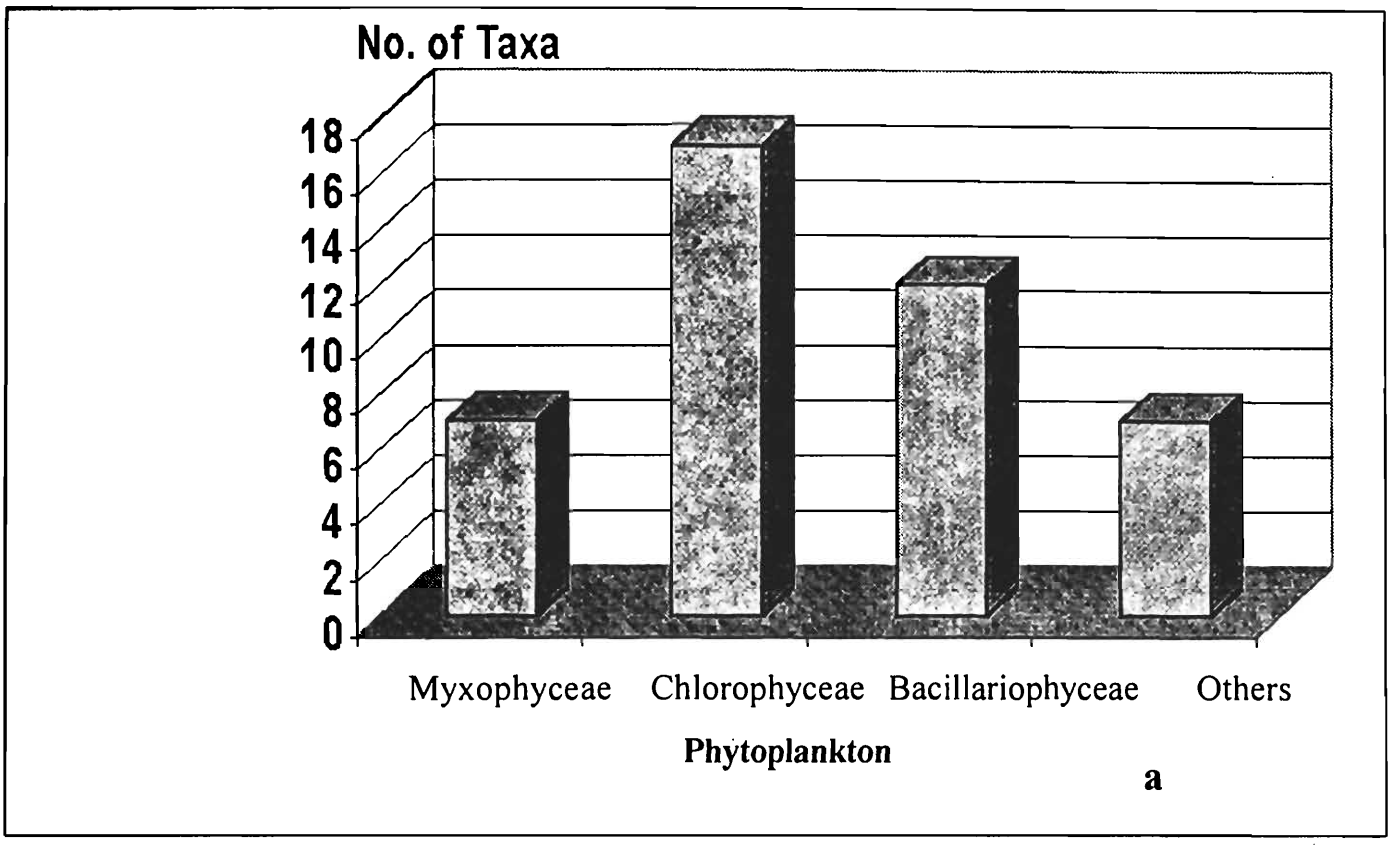
	Beri Gopalpur			Sosadanga		
	Pre-monsoon	Mon-soon	Post-monsoon	Pre-monsoon	Mon-soon	Post-monsoon
C. EMERGENT						
Errect						
Family Cyperaceae						
Cyperus exaltatus	C		C	C		CC
Elocharis dulcis	C	C	C	C	C	-
Scirpus articulatus	C	C	C	C	C	C
Family Typhaceae						
Typha angustata		C	C	C		C
Family Polygonaceae						
Polygomum barbatum	C		R			-
Family Leguminasae						
Aeschynomene indica	R	C	C	C	C	C
Prostate						
Family Amaranthaceae						
Alternanthera philoxeroides	C	C	C	C	C	C
Family Convolvulaceae						
Ipomia aquatica	C	C	C	C	C	C
NO. OF TAXA 31	**23**	**17**	**25**	**23**	**21**	**27**

Variations in the occurrence of macrophyte species were less pronounced during premonsoon as compared to monsoon season. During monsoon, there was a general reduction in the species occurrence and abundance. The effect was more visible in Beri Gopalpur than Sosadanga. Post monsoon season was characterised by the largest number of species in both wetlands.

Not much significant differences were recorded in the macrophytic diversity of the two wetlands, as most of the species were common. Altogether 25 taxa from Beri Gopal and 27 from Sosadanga were recorded. However, the density of macrophytes were significantly higher in the latter where entire littoral zone upto a distance of nearly 10 ft was covered with macrophytes.

(B) PHYTOPLANKTON

Diversity : A total of 43 taxa of phytoplankton belonging mainly to families Myxophyceae (blue green algae) Chlorophyceae (Green algae) and Bacillariophyceae (diatoms) were



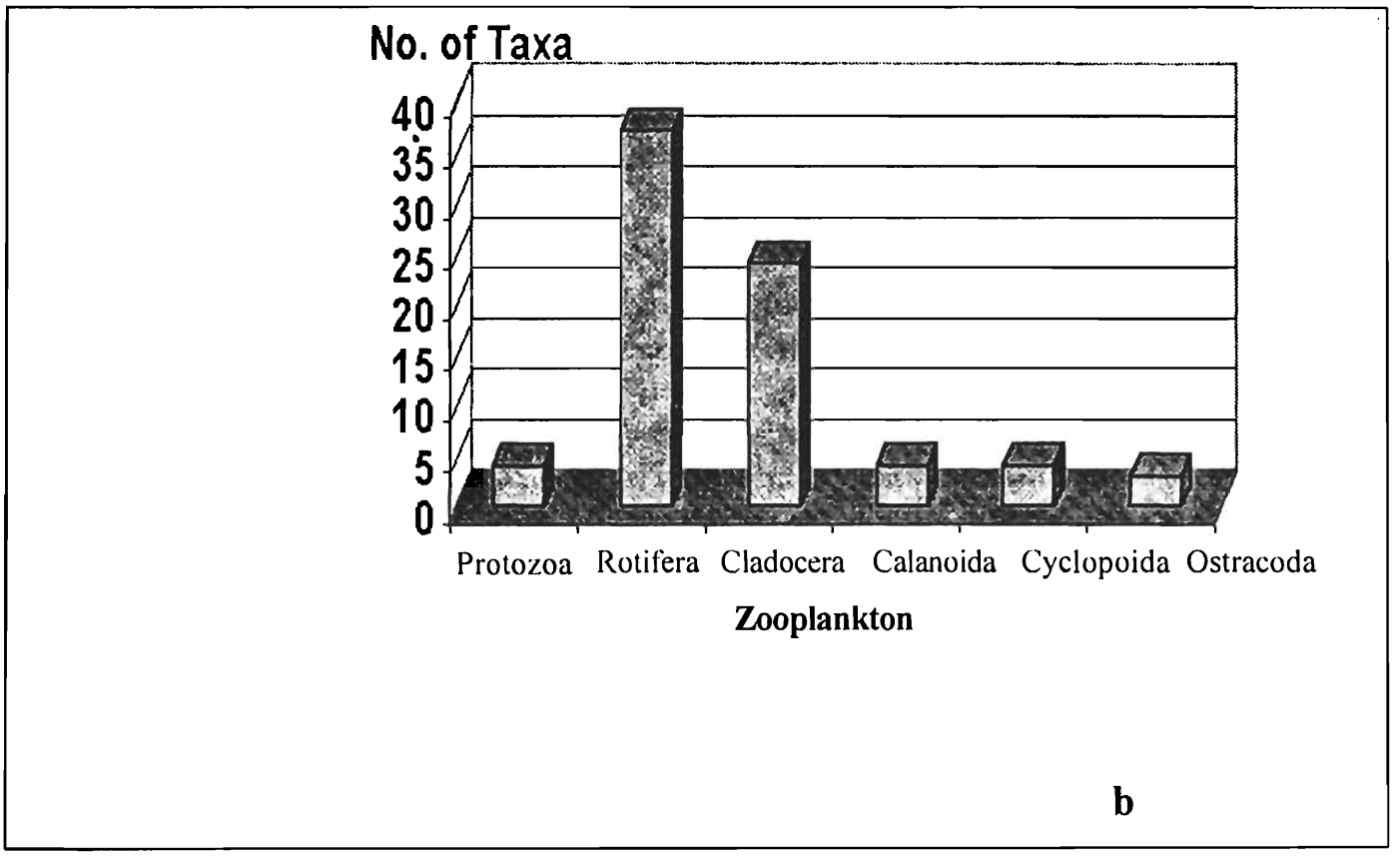


Fig. 3 (a & b). Number of taxa belonging to various major groups of phytopankton and zooplankton

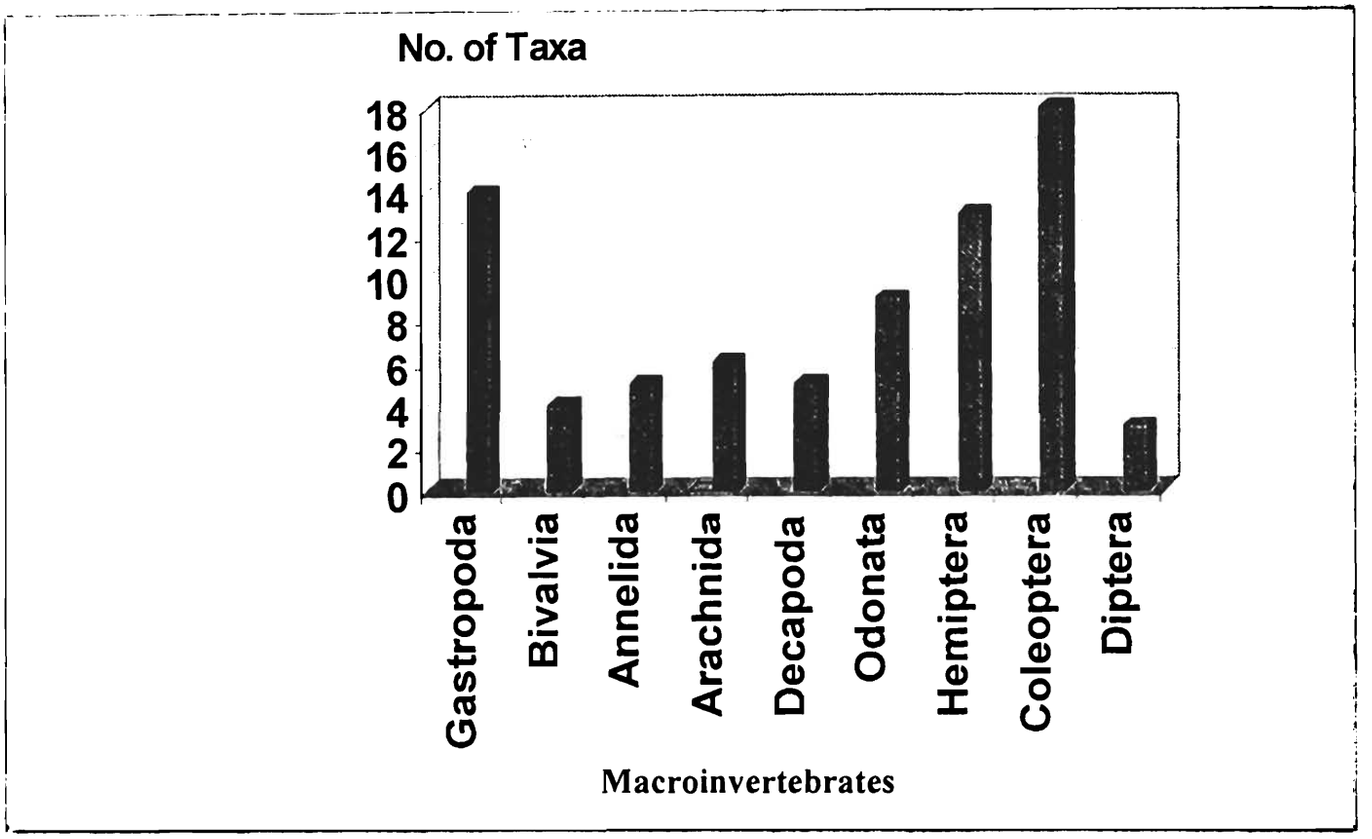


Fig. 3c. Number of taxa belonging to various major groups of macroinvertebrates

recorded from the two wetlands during the period of the study (Table 4). Besides these three major families, species belonging to families Charraphyceae, Chryssophyceae, Dinophyceae and Euglenophyceae were also recorded. Blue green algae were represented by 7 taxa, green by 17 taxa, diatoms by 12 taxa, and rest of the families by 2 taxa each except, Charraphyceae which was represented by a lone taxa (Fig. 3a).

Among Myxophyceae, *Anabaena* sp., *Oscillatoria* sp. and *Microcysctis* sp. were the most dominant taxa occurring in both wetlands throughout the year. Among Chlorophyceae, excepting few, most of the taxa occurred in fairly common numbers in both wetlands. There were a few taxa, which became abundant for a brief period during post-monsoon season (*Panodorina* sp. and *Eudorina* sp.) in both wetlands and a few taxa occurred only in one wetland (Table 4). Among diatoms, several species *e.g. Amphora* sp., *Navicula* sp. and *Cyclotella* sp. were recorded in abundance in both the wetlands throughout the year. *Surirella* sp. was recorded only from Sosadanga during monsoon and post-monsoon period in small numbers. The family Charraphyceae was represented by only one taxa *viz. Chara* sp. that was abundant in both the wetlands almost throughout the year. Among Dinophyceae while *Peridinum* sp. were recorded from both wetlands, *Ceratium* sp. was found only in Beri Gopalpur. Both species of euglenoids were common in both, Sosacanga and Beri Gopalpur. The peak in the abundance was mainly contributed by only a few species of each group.

The comparative analysis of the occurrence of taxa in the two wetlands showed not much significant differences in the species composition, except that the number of taxa recorded from Sosadanga was slightly higher than Beri Gopalpur. There were a few species that exclusively occurred in a particular wetland.

Table 4. Seasonal variations in the occurrence of phytoplankton taxa in the two ox-bow wetlands.

C Present /Common,
CC-Abundant, R Rare, Absent

	Beri Gopalpur			Sosadanga		
	Pre-monsoon	Mon-soon	Post-monsoon	Pre-monsoon	Mon-soon	Post-monsoon
Family Myxophyceae						
Oscillatoria sp	C	C	CC	C	C	CC
Microcysctis sp	CC	C	C	CC	C	C
Spirulina sp	-	-	C			C
Anabaena sp	CC	CC	CC	CC	CC	CC
Merismopoda sp				CC	C	C
Nostoc sp	CC	C		CC		C
Phormidium sp.	CC		C	CC	C	C
Family Chlorophyceae						
Pandorina sp.	C		CC			CC
Eudorina sp.	C		CC	C	C	CC
Cosmarium sp.			C	C		C
Closterium sp.	C	C	C	C	C	C
Desmidum sp.				C	C	C
Pleodorina sp.	C		CC			CC
Chlorella sp.	C	C	C	C	C	C
Volvox sp.	C	C	C	C	C	C
Ulothrix sp.	C	-	C	C	C	C
Protococcus sp.				C		C
Spirogyra sp.						C
Microspora sp.	C	C	C	C	C	C
Scendesmus sp.	C	C	C			
Ankistrodesmus sp.				C		C
Pediastrum sp.	C	C	C			
Rhizocloneum sp.	C	C	C	C	C	C
Zygnema sp.				C	C	C

	Beri Gopalpur			Sosadanga		
	Pre-monsoon	Mon-soon	Post-monsoon	Pre-monsoon	Mon-soon	Post-monsoon
Family Bacillariophyceae						
Amphora sp.	CC	CC	CC	CC	CC	CC
Naviculla sp	CC	CC	CC	CC	CC	CC
Fragillaria sp.			C	-	-	-
Synedra sp.	C	C	CC	C	C	CC
Melosira sp.	C	C	C	C	C	C
Nitzchia sp.	C	-	C	-	C	C
Rhizosoclenia sp.		-	-	C	-	C
Surirella sp		-	-	-	C	C
Cymbella sp	C		C	C	-	CC
Diatoma sp		-	C	C	-	C
Cyclotella sp.	CC	CC	CC	CC	CC	CC
Stephanodiscus sp.	C	-	C	-	-	C
Family Charraphyceae						
Chara sp.	CC	C	C	C	C	C
Family Chryssophyceae						
Dinobryan sp.	C	C	C	CC	C	C
Synura sp.				C	C	C
Family Dinophyceae						
Ceratium sp.	C	C	CC	-	-	-
Pridinum sp.	C	C	C	C	C	C
Family Euglenophyceae						
Euglena sp	C	CC	CC	CC	CC	C
Phacus sp	C	CC	C	C	CC	C
Number of Taxa 43	**30**	**23**	**34**	**30**	**27**	**39**

The seasonal variations in the occurrence of taxa were quite pronounced in both wetlands. In general highest number of taxa were recorded during post-monsoon and lowest during monsoon (Table 4).

Density Phytoplankton density in Beri Gopalpur varied between 1510 Cell l^{-1} and 4850 Cell l^{-1}, lowest during monsoon and highest in post monsoon. The composition was dominated by green algae (Table 7, Fig 4) during all seasons and their contribution varied between 36.5 and 46.5%, highest during post monsoon. This was followed by blue green algae during monsoon and premonsoon and by diatom in post monsoon. The contribution of blue green algae ranged between 22.3 and 30.2% and the contribution of diatoms was almost steady during all seasons (22.5-25.5%). In Sosadanga the numerical density of phytoplankton was slightly lower than Beri Gopalpur, where it varied between 1115 Cell l^{-1} and 3325 Cell l^{-1}, lowest during monsoon and highest in premonsoon, similar to Beri Gopalpur. Green algae were the dominant component during monsoon and post monsoon. However, unlike Beri Gopalpur, the premonsoon composition was dominated by blue green algae. Like Beri Gopalpur, the diatoms contributed steadily during all seasons, as it varied between 20.6% and 26.8%. Besides the three major groups, Phytoflagellates also contributed steadily throughout the year and their contribution was highest during monsoon season.

Diversity indices : Table 11 shows the results of diversity analysis. All the diversity indices pointed towards high species diversity of phytoplankton in both the wetlands. The Shannon-Weiner ($\bar{H}$) values were always above 3 in both the wetlands. The diversity values in Beri Gopalpur was significantly higher than Sosadanga.

Similarity indices : No significant differences were observed between the two wetlands in respect of their phytoplankton flora as similarity indices were quite high during all seasons (Table 12).

(C) ZOOPLANKTON

Diversity : Zooplankton fauna of the two wetlands was comprised of Protozoa, Rotifera, and 3 groups belonging to Crustacea *viz.* Cladocera, Calanoida-Copepoda and Cyclopoida-Copepoda. Besides, Ostracod crustaceans were also represented by a few species. Altogether, 76 taxa were recorded from the two wetlands (fig. 2). This comprised of 4 taxa of Protozoa, 37 of Rotifera, 24 of Cladocera, 4 of Clanoida, 4 of Cyclopoida and 3 of Ostracoda (fig 3b.).

Among protozoa, all the four taxa belonged to Rhizopoda, of which *Difflugia* sp. was most common. Rotifers were represented by largest number of taxa belonging to 12 families (Table 5). The families Lecanidae and Brachionidae were comprised of 12 and 10 species respectively. Rest of the families were represented by one, two or at the most 3 species. Most commonly occurring species were *Brachionus calciflorus, Keratella tropica, Mytilina ventralis, Lecane (L.) papuana, Lecane bulla, Ascomorpha sp.* and *Polyarthra vulgaris* which occurred abundantly in both wetlands almost throughout the year. Cladocerans were represented by 6 families only. Four species belonged to Sididae, six to Daphniidae and 13 to Chydoridae

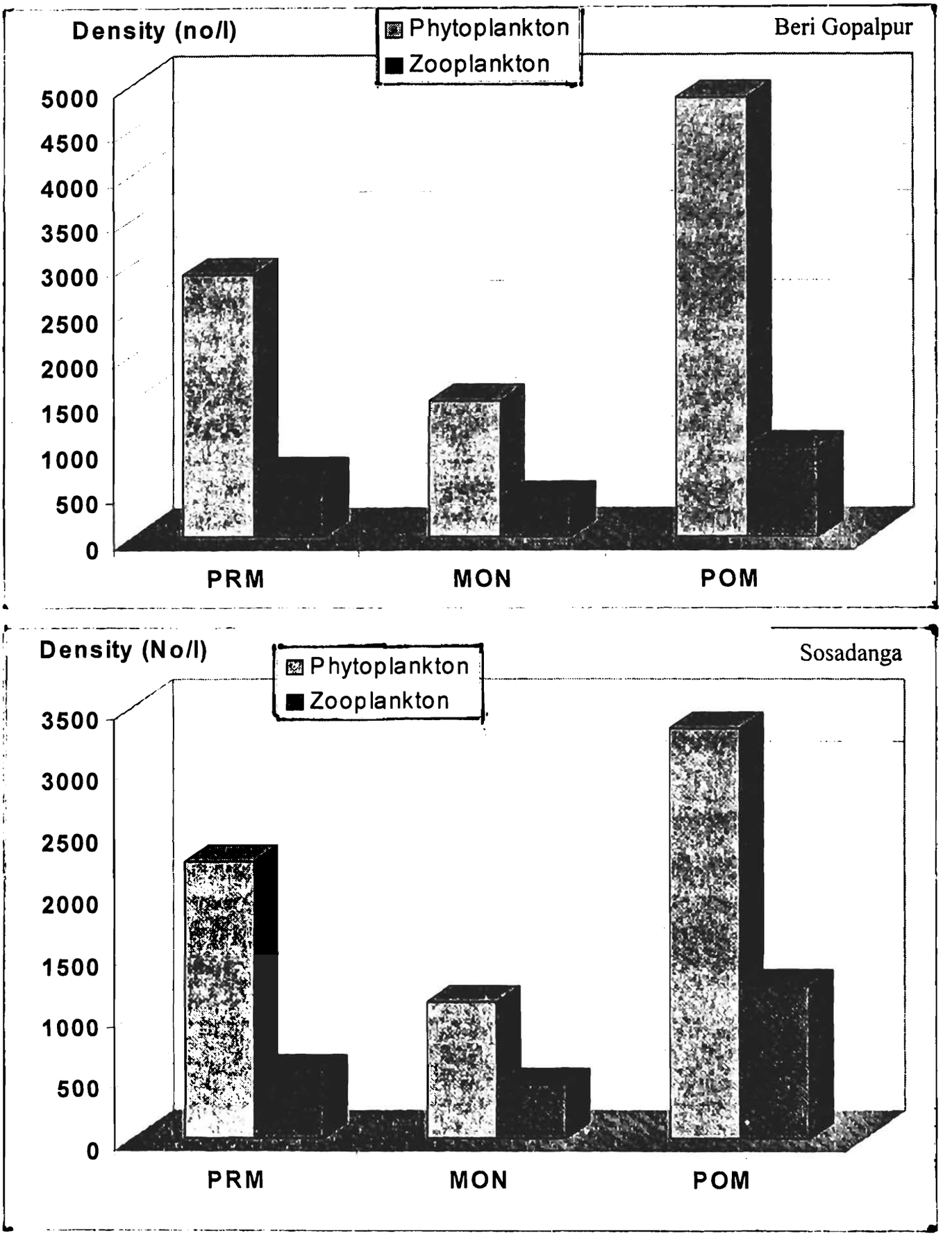


Fig. 4. Mean density of phytoplankton and zooplankton in the two ox-bow wetlands during different seasons.

(subfamily Chydorinae and Aloninae). The other three families, Moinidae, Bosminidae and Macrothricidae had their single representatives in the community. The most common species were *Sida crystiallina, Diaphanosoma sarsi, Ceriodaphnia cornuta, Simocephalus vetulus, and Chydorus sphaericus*. Both species of the genus *Daphnia* were extremely rare and could be collected only at a few occasions in very small numbers. The chydorids dominated the cladoceran component of zooplankton. The copepods were represented by limited number of taxa. Among calanoids, 3 species of the genus *Heliodiaptomus* comprised the calanoid fauna. The other species *Arctodiaptomus keifari* was an uncommon species recorded from Beri Gopalpur. *H. contortus* was the most abundant species and occurred throughout the year in both wetlands. Amongst the four species of cyclopoids, *Mesocyclops leuckarti* and *M. hyalinus* were abundant species in both wetlands. Although all the three species of ostracods were recorded in all seasons in both wetlands, they were not very common in the planktonic samples.

Table 5. Seasonal variations in the occurrence of zooplankton taxa in the two ox-bow wetlands

C-common/ Present, CC Abundant
R uncommon, - Absent.

	Beri Gopalpur			Sosadanga		
	Pre-monsoon	Mon-soon	Post-monsoon	Pre-monsoon	Mon-soon	Post-monsoon
RHIZOPODA 4						
Arcella discoides Ehrenberg	CC	CC	CC	CC	CC	CC
Centropyxix aculeata (Ehrenberg)	C	C	C	C	C	C
C. ecornis (Ehrenberg) Leidy	-	-		C	C	C
Difflugia sp.	CC	CC	CC	CC	CC	CC
ROTIFERA 37						
Family Brachionidae						
Anuraeopsis fissa (Gosse)	C		C	C	C	C
Brachionus angularis Gosses		-	C		-	C
B. bidentata Anderson				C	-	C
B. calcyflorus Pallas	CC	C	CC	C	C	CC
B. caudatus (Barrois & Daday)	C		C	-	-	
B. falcatus Zacharias		-		C	C	C
B. patulus Muller			C			C
B. quadridentatus Hermann	C	C				

	Beri Gopalpur			Sosadanga		
	Pre-monsoon	Mon-soon	Post-monsoon	Pre-monsoon	Mon-soon	Post-monsoon
Keratella tropica (Apstein)	CC	CC	CC	CC	CC	CC
K. procurva (Thorpe)			C	-	-	-
Family Euchlanidae						
Euchalnus dilatata (Ehrenberg)	C	C	C	-	-	-
Family Mytilinidae						
Mytilina ventralis (Ehrenberg)	CC	C	CC	CC	C	CC
Family Colurellidae						
Lepadella accuminita (Ehrenberg)	C	-	C	-		-
L. ovalis (Müller)		-	-	C	C	C
L. Patella (Müller)				C		C
Family Lecanidae						
Lecane (Lecane) acculeata (Jakubski)		-		C	C	C
L.(L.) curvicornis (Murray)	C		C			-
L.(L.) hastata (Murray)		-		C	C	C
L.(L.) leontina (Turner)		R	R			-
L.(L.) luna (Müller)			-	C	R	C
L.(L.) papuana (Murray)	CC	C	CC	C	-	CC
L.(L.) signifera (Jennings)	C		C			
L.(L.) ungulata (Gosse)			-	C	C	C
Lecane (Monostyla) bulla (Gosse)	CC		C	C		CC
L.(M.) furcata (Murray)	C	C	C	-	-	-
L.(M.) hamata (Stokes)			R	-	R	R
Lecane (H.) inopinata (Harring & Myers)		-	C		-	C
Family Notommatidae						
Cephalodella catellina (Müller)	C	-	C	-	-	C
Monommata sp.	C	C	C	-	-	-
Family Gastropodidae 1						
Ascomorpha ovalis (Bergendal)	C	C	C	C	C	C
Family Trichocercidae 2						
Trichocerca rattus (Müller)	R	-	C	C	R	C

	Beri Gopalpur			Sosadanga		
	Pre-monsoon	Mon-soon	Post-monsoon	Pre-monsoon	Mon-soon	Post-monsoon
Trichocerca similis (Wierzejski)	C	C	C			
Family Asplanchnidae						
Asplanchna brightwelli Gosse	C	C	C	C	C	C
Family Synchaetidae						
Polyarthra vulgaris Carlin	CC	C	CC	C		CC
Synchaetia oblonga Ehrenberg						
Family Filinidae						
Filinia longiesta (Ehrenberg)	C	C	C	C		C
Family Testudinellidae						
Testudinella patina (Herman)	C		CC	C		C
CLADOCERA 24						
Family Sididae						
Sida crystallina (O.F.Müller)	C	C	C	C	C	C
Diaphanosoma sarsi Richard	C	C	C	-	C	C
D. excisum Sars					C	C
Family Daphniidae						
Ceriodaphnia cornuta Sars	C	C	CC		C	CC
Daphnia carinata King		-	C	-		
D. lumholtzi Sars		-		C		C
Simocephalus vetulus (O.F.Müller)	C	C	C	C	C	C
S. exspinosus (Koch)				CC	C	CC
Scapholeberis kingi SarS	C	C	C	C		C
Family Mionidae						
Moina micrura Kurz	C	C	C	C	C	C
Family Bosminidae						
Bosmina longirostris (O.F.Müller)	C	C	C	C		C
Family Macrothricidae						
Macrothryx goeldii Richard	C		C			
Family Chydoridae						
Subfamily Chydorinae						

	Beri Gopalpur			Sosadanga		
	Pre-monsoon	Mon-soon	Post-monsoon	Pre-monsoon	Mon-soon	Post-monsoon
Pleuroxus similis Vavra			C	C		C
Chydorus sphaericus (O.F.Müller)	C	C	CC	-	C	CC
C. barrosi (Richard)	R		-			C
Dunhevedia crass King	C	C	C	C		C
Subfamily Aloninae						
Alona quadrangularis (O.F.Müller)	C		C		C	-
A. davidi Richard				-	C	C
A. rectangula Sars		C	C	-		-
Biapertura karua (King)	C	C	C	C	C	C
B. affinis (Leydig)			C	-	-	- -
Oxyurella singalensis (Daddy)		-		C	C	C
Kurzia longirostris (Daddy)	C	C	C		-	C
Natoalona globulosa (Daddy)			-	R	R	R
COPEPODA 8						
Family Diptomidae						
Arctodiaptomus kiefari Reddiah	C		R	-		-
Heliodiaptomus cinctus (Gurney)				C	C	C
H. contortus (Gurney)	C	C	C	C	C	C
H. viduus (Gurney)	C	C	C	-		-
Family Cyclopidae						
Trophocyclops prascinus (Fischer)	C	C	C	-		-
Mesoccyclops hyalinus (Rehberg)	C	C	C		-	-
Mesocyclops leuckarti (Claus)	CC	C	CC	C	C	CC
Microcyclops varicans (Sars)	C	-	C	C	-	C
OSTRACODA 3						
Cypris subglobosa Swerby	C	C	C	C	C	C
Cypris sp.	C	C	C	C	C	C
Strandesia elongata Haratman	C	C	C	-		-
Total No. of Taxa 76	**49**	**37**	**59**	**43**	**37**	**55**

The total number of taxa recorded from the two wetlands did not differ much. The maximum no. of species recorded from Beri Gopalpur (59) was almost similar to that of Sosadanga (55). Like phytoplankton, there were marked seasonal fluctuations in the occurrence of zooplankton species. The maximum number was recorded during postmonsoon period and lowest during monsoon.

Density : The zooplankton densities of both the wetlands were quite moderate almost throughout the year with pronounced seasonal variations (Table 7, Fig. 4). In Beri Gopalpur, the density was slightly higher than Sosadanga during premonsoon and monsoon but during post monsoon season the density in latter was significantly higher than the former. The mean seasonal density varied between 425 l^{-1}-980 l^{-1} and 440 l^{-1}1250 l^{-1} in Beri Gopalpur and Sosadanga respectively. In both wetlands highest density was observed in post monsoon and lowest in monsoon. The composition was always dominated by copepods whose contribution varied between 47.0-50.4% and 40.3-48.2% in Beri Gopalpur and Sosadanga respectively (Fig. 5). This was followed by rotifers and cladoceran. Cladoceran were slightly higher in numbers in Beri Gopalpur during pre and post monsoon but rotifers were significantly higher during monsoon season. In Sosadanga, rotifers were always second to copepods, contributing between 28.0 and 35.2%. The percent share of cladoceran ranged from 16.4 to 22.5 in Sosadanga and from 17.5 to 27.3 in Beri Gopalpur.

Numerically abundant taxa : Out of 76 species of Zooplankton recorded from the two wetlands, Only 19 Taxa were numerically abundant and contributed substantially to total zooplankton density (Table 6). This included 8 species of Rotifers, 7 species of Cladocerans, 3 species of Copepoda and one of Protozoa : Rhizopoda

Table 6. Nomerically abundant Zooplankton taxa

RHIZOPODA	**CLADOCERA**
Difflugia sp.	*Sida crystallina* (O. F. Müller)
ROTIFERA	*Diaphanosoma sarsi* Richard
Brachionus calcyflorus Pallas	*Ceriodaphnia cornuta* Sars
Keratella tropica (Apstein)	*Simocephalus vetulus* (O. F. Müller)
Mytilina ventralis (Ehrenberg)	*Moina micrura* Kurz
Lecane (L.) papuana (Murray)	*Chydorus sphaericus* (O. F. Müller)
Lecane (Monostyla) bulla (Gosse)	*Biapertura karua* (King)
Ascomorpha Ovalis (Begendal)	**COPEPODA**
Asplanchna brightwelli Gosse	*Heliodiaptomus. contortus* (Gurney)
Polyarthra vulgaris Carlin	*Heliodiaptomus. viduus* (Gurney)
	Mesocyclops leuckarti (Claus)

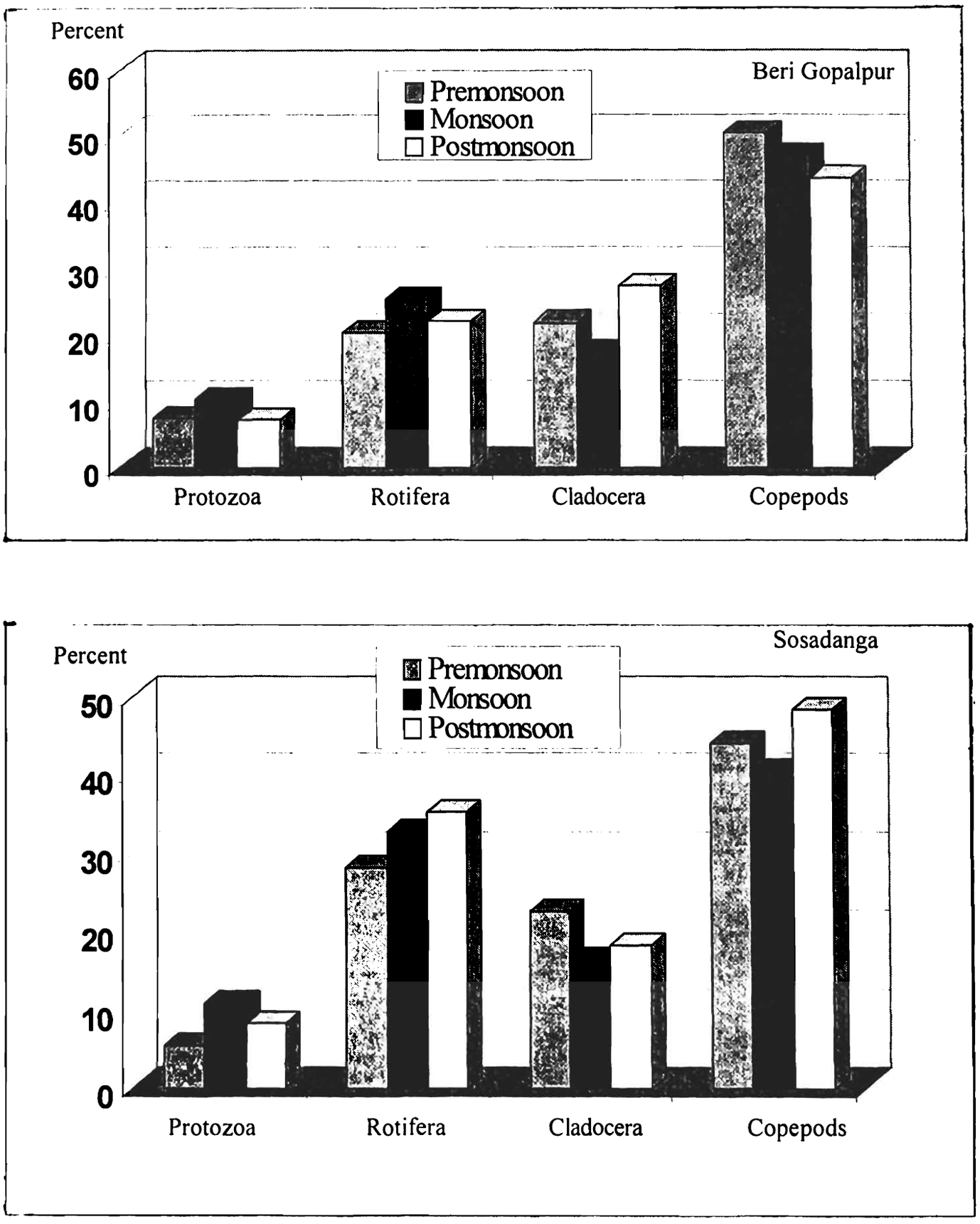


Fig. 5. Major Zooplankton Groups

Diversity indices : Table 11 summerises the results of diversity analysis. Like phytoplankton, the diversity of zooplankton was considerably high in both wetlands. Except during monsoon, the values of Shannon-Wiener diversity index ($\overline{H}$) were always above 4.

Table 7. Seasonal variations in phytoplankton and zooplankton density and relative composition of major groups in the two ox-bow wetland

	Beri Gopalpur wetland			Sosadanga wetland		
	Pre-monsoon	Monsoon	Post-monsoon	Pre-monsoon	Monsoon	Post-monsoon
PHYTOPLANKTON						
Numerical density (Cell l^{-1})	2895	1510	4850	2220	1115	3325
Relative composition (%)						
Myxophyceae	30.2	25.7	22.3	39.5	27.5	30.5
Chlorophyceae	36.5	40.0	46.5	35.5	36.2	42.2
Bacillariophyceae	25.5	22.5	24.4	20.6	26.8	21.3
Others	7.8	10.8	6.8	4.4	9.5	6.0
ZOOPLANKTON						
Numerical density (Cell l^{-1})	695	425	980	555	440	1250
Relative composition (%)						
Protozoa	7.5	10.3	7.2	5.5	10.8	8.4
Rotifera	20.3	25.2	20.0	28.0	32.5	35.2
Cladocera	21.8	17.5	27.3	22.5	16.4	18.2
Copepoda	50.4	47.0	43.5	44.0	40.3	48.2

Similarity indices : Both the waterbodies resembled closely in respect of their zooplankton fauna as coefficient of similarity was quite high during all seasons (Table 12).

(D) MACRO-INVERTEBRATES

Diversity The macro-invertebrate fauna of the wetlands was very diverse and comprised of a large number of species belonging to almost all the major groups. Altogether 78 taxa were recorded from both the wetlands (Fig. 2, Table 8). Among Mollusca, gastropods were represented by 14 species and bivalves by 4 species. *Bellamya bengalensis, Gabbia orcula, Thiara tuberculata, Bortia costula* and *Lymnaea accuminita were the most common* species occurring almost throughout the year in both wetlands. Among bivalves, *Lamnillidens marginalis* and *Psidiium clarkeanum* were common to both wetlands. *Parreysia (R) Caerulea*

were recorded only during postmonsoon months in both wetlands in small numbers. Oligochaetes were represented by only two species and both were abundantly recorded throughout the year. *Limnodrillus hoffmeisteri* was the dominant species. Only three species of leaches were collected from the two wetlands and their numbers were always small. The Arachnids were represented by 6 taxa. *Paradosa* spp were the most common in both wetlands. The other important species belonged to genera *Arrenurus* and *Larina.* Decapod crustacean were represented by 3 species of shrimps and two species of crabs. The shrimps were mainly represented by the species *Macrobrachium lamarrei.* This species occurred abundantly among the littoral macrophytes almost throughput the year. The other two species, *M. hendersoni* and *M. dynaun* also occurred in fair numbers throughout the year in both wetlands. Both the species of crabs were recorded in the bottom samples in the littoral regions but in very small numbers. (Fig. 3c)

Table 8. Seasonal variations in the occurrence of Macro-invertebrates (macrophytes associated and benthic) in the two ox-bow lakes

C-common/ Present, CC Abundant
R - uncommon, - Absent.

	Beri Gopalpur			Sosadanga		
	Pre-monsoon	Mon-soon	Post-monsoon	Pre-monsoon	Mon-soon	Post-monsoon
MOLLUSCA GASTROPODA 14						
Family Bellamyidae						
Bellamya bengalensis (Lamarck)	CC	CC	CC	CC	CC	CC
Family Pilidae						
Pila globosa (Swainson)	-	C	C	C	C	C
Family Bithyniidae						
Gabbia orcula Frauenfeld	CC	CC	CC	CC	CC	CC
Digoniostoma cerameopoma (Benson)	C	C	CC	C	C	CC
Family Thiridae						
Thiara (Tarebia) granifera (Lamarck)		C	C	-	-	-
Thiara (Thiara) lineata (Gray)	C	C	C	C	C	C
Thaira (Thiara) scabra Müller	-	-	-	C	C	C
Thiara (Melanoides) tuberculata (Müller)	CC	CC	CC	CC	CC	CC
Bortia (Antimelania) costula (Rafinesque)	C	C	CC	C	C	C
Family Lymnaeidae						
Lymnaea (P.) accuminata Lamarck	C	C	C	C	C	C
Lymnaea (P.) luteola Lamarck	C	-	-	C	C	C

	Beri Gopalpur			Sosadanga		
	Pre-monsoon	Mon-soon	Post-monsoon	Pre-monsoon	Mon-soon	Post-monsoon
Family Planorbidae						
Indoplanorbis exustus (Deshayes)	CC	C	CC	CC	C	CC
Gyraulus convexiusculus (Hutton)	C	C	C	C	C	C
Gyraulus labiatus (Benson)				R		R
MOLLUSCA : BIVALVIA	**4**					
Family Unionoidae						
Lammellidens corrianus Lea	C	C	-	C		C
Lammellidens marginalis (Lamarck)	C	C	C	C	C	C
Family Amblemidae						
Parreysia (Radiatula) caerulea (Lea)	R	R	C			C
Family Pisidiidae						
Pisidium (A.) clarkeanum G&H Nevill	C	C	C	C	C	C
ANNELIDA **5**						
Oligochaeta 3						
Branchiura sowerbyi Beddard	CC	CC	CC	CC	CC	CC
Limnodrillus hoffmeisteri Claparede	CC	CC	CC	CC	CC	CC
Hirudinea 2						
Glassophonia weberi (Blanchard)	C	C	C		C	C
Helobdella nociva Harding		C	C	-	C	C
Hemiclepsis marginata Muller	C	C	R	C	C	R
ARTHROPODA : ARACHNIDA **6**						
Arrenurus sp.	C	C	C	C	C	C
Lycosa sp.	C		C	C	-	C
Paradosa spp.	CC	C	CC	CC	CC	CC
Tetragnatha sp.				C	C	C
Trochosa sp	C	C	C			
Larina sp.	C	C	C	C	C	C
ARTHROPODA CRUSTACEA						
DECAPODA **5**						
Sartoriana spinigera Wood-Mason	C	C	C	C	C	C

	Beri Gopalpur			Sosadanga		
	Pre-monsoon	Mon-soon	Post-monsoon	Pre-monsoon	Mon-soon	Post-monsoon
Telphusa lugubris Wood-Mason	C		C	C	C	C
Machrobrachium hendersoni deMann	C	C	C	C	C	CC
Macrobrachium lamarrei (H.M. Edwards)	CC	C	CC	CC	C	CC
Macrobrachium dyanum (Henderson)	C	C	C	CC	C	CC
ARTHROPODA – INSECTA						
EPHEMEROPTERA 1						
Cloeon sp.	C	C	C	C	C	C
ODONATA 9						
Family Coegrionoidae						
Ischnura aurora aurora (Brauer)	C	C	C	C	C	C
Ceriagrion coromandelianum Fabricius	CC	C	CC	C	C	CC
Pseudagrion microcephalum Rambur	CC	C	CC	C		CC
Family Platycneminidae						
Copera marginipes (Rambur)	C	C	-	C	C	-
Family Gomphidae						
Ictinogomphus rapax (Rambur)	C	C	C	C	C	C
Family Libellulidae						
Brachydiplax sobrina (Rambur)	C	C	C	C	C	C
Brachythemis contaminata (Fabricius)	CC	C	CC	C	C	CC
Crocothemis servilla (Drury)	-	-	CC	C	C	CC
Orthetrum sabina (Drury)	CC	C	CC	CC	-	CC
HEMIPTERA 13						
Family Corixidae						
Micronecta scuttellaris (Stal)	C	C	CC	C	C	C
Family Notonectidae						
Anisops bouvieri Kirkaldy	C	-	-	CC	-	CC
Anisops breddeni Kirkaldy	CC	C	C	CC	C	CC
Anisops sardea Herrich-Shaffe	C	-	C		-	C
Family Pleidae						
Plea liturata Fieber			C	-	-	R

	Beri Gopalpur			Sosadanga		
	Pre-monsoon	Mon-soon	Post-monsoon	Pre-monsoon	Mon-soon	Post-monsoon
Family Nepidae						
Laccotrephes greseus (Guenin)			C			C
Ranatra filiformis Fabricius	CC	C	CC	C		CC
Family Belostomatidae						
Diplonychus annulatum (Fabricius)	CC	CC	CC	CC	CC	CC
Diplonychus rusticus (Fabricius)	C	-	C	C	C	C
Family Mesoveliidae						
Mesovelia vittigera Horvath	C	C	CC	C	C	CC
Family Hydrometridae						
Hydrometra vittata Stal	C	-	-	C	C	C
Family Gerridae						
Limnogonus (L.) fossarum (Fabricius)	CC	C	CC	CC	C	CC
Limnogonus (L.) nitidus (Mayr)	CC	C	CC	CC	C	CC
COLEOPTERA **18**						
Family Dystiscidae						
Hydrocoptus subvittulus Motschulsky	CC	C	CC	CC	C	CC
Canthydrus laetabilis (Walker)	CC	C	C	CC	CC	CC
Canthydrus morsbachi (Wehnkee)	CC		C		-	
Laccophilus anticatus Sharp	CC	C	C	CC		CC
Laccophilus parvulus Aube	CC	C	CC	C	C	CC
Hydrovatus acuminatus Motschulsky	C	-	C	C	-	C
Guignotus flammulatus (Sharp)	CC	C	CC	CC	C	CC
Hydaticus fabricii (Fabricius)	-	-	-	R	-	R
Cybister limbatus (Fabricius)	-	-	-	C	C	C
Family Gyrinidae						
Dineutus indicus Aube	C	-	-	C	C	C
Family Halipidae						
Haliplus angustifrons Regimbart	C	-	-	C		CC
Family Hydrophilidae						
Spercheus gibbus Champion	C	C	C	C	-	C

	Beri Gopalpur			Sosadanga		
	Pre-monsoon	Mon-soon	Post-monsoon	Pre-monsoon	Mon-soon	Post-monsoon
Helochares ancholaris Sharp	C	-	C	-	-	C
Enochrus esuriens Walker	CC	C	C	C	-	CC
Hydrophilus rufocinctus Motschulsky	C	C	C	C	C	C
Amphiops pedestris Sharp	CC	-	CC	C	C	CC
Berosus indicus (Fabricius)	C	C	C	C	C	C
Regimbartia attenuata (Fabricius)	-	-	-	C	C	C
DIPTERA 3						
Family Chironomidae						
Chironomus sp. A	CC	CC	CC	CC	CC	CC
Chironomus sp. B	CC	C	CC	-	-	-
Chironomus sp. C	-	-	-	CC	CC	CC
Other Dipteran larvae*	CC	CC	CC	CC	CC	CC
Other immature insects*	CC	CC	CC	CC	CC	CC
Number of Taxa 78	**66**	**53**	**66**	**68**	**53**	**74**

* Not considered for species composition and the calculation of diversity indices.

The insect fauna belonging to nekton community was represented by a large number of species belonging to the orders Ephemeroptera, Odonata, Hemiptera, Coleoptera and Diptera. The Mayflies (Ephemeroptera) were represented by only one species i.e. *Cloeon* sp. that occurred in fair numbers in both the wetlands throughout the year. Odonates were mainly represented by 9 species belonging to families Coegrionoidae (3 species) and Libellulidae. (4 species). The other two species belonged to families Platycneminidae and Gomphidae. *Ceriagarion coromandelianum, Pseudagrion microcephalum* and *Brachythemes contaminata* were the most abundant species. The hemipteran fauna were contributed by 13 species belonging to families Corixidae (1 species), Notonectidae (3 species), Pleidae (1 species), Nepidae (2 species), Belostomatidae (2 species), Mesoveliidae (1 species), Hydrometridae (1 species) and Gerridae (2 species). *Micronecta scuttellaris. Anisops bouvieri, A. breddeni, Ranatra filiformis, Diplonichus annulatum. Limnogonus fossarum* and *L. nitidus* were the abundant species. Coleopteran was represented by highest number of species (18). Family Dystiscidae was represented by largest number of taxa (9) followed by family Hydrophilidae (7). Families Gyrinidae and Halipidae were represented by one species each. *Hydrocoptus subvittulus, Laccophilus anticatus, Laccophilus parvulus, Enochrus esuriens, Guignotus flammulatus, Amphiops pedestris* and *Berosus indicus* occurred abundantly in both the wetlands. Dipterans were represented by immature forms belonging mainly to families

Chironomidae and Culicudae. Three different species of the genus *Chironomus* could be ascertained. Since most of the other larvae could not be identified, these were clubbed together and were not taken for the computation of species diversity.

Like zooplankton, the macro-invertebrate fauna of the two wetlands did not differ significantly qualitywise, as most of the species were common. However, total number of taxa recorded from the two wetlands differed slightly. The maximum number of taxa observed in Beri Gopalpur was 66 as compared to 68 recorded from Sosadanga. Significant seasonal variations in the occurrence of taxa were noticed in both wetlands and in general lowest number of taxa were recorded during monsoon and highest during post monsoon (Table 8) in both wetlands.

The Macrophytes associated macro- invertebrate fauna were mainly comprised of all the species belonging to decapod crustacean shrimps, hydroacarines (Arachnida), adult insects of the order Odonata, Hemiptera and Coleoptera. They were exclusively confined to macrophyte strands or were free swimming. The species belonging to gastropods, oligochaetes and chironomids (larvae) occurred both in the macrophyte strands as well as in benthic soil. The bivalves, crabs and other immature dipteran were always associated with benthic soil and these were the only taxa, which were exclusively associated with benthic soil.

Density : The macro-invertebrate density of both the wetlands was quite moderate throughout the year. It varied between 4105/m^3 and 5710/m^3 in Beri Gopalpur and between 4105 and 7250 in Sosadanga. In both wetlands highest density was recorded during postmonsoon and lowest during monsoon. Macro-invertebrate density was comparatively higher in Sosadanga than Beri Gopalpur (Table 10, Fig 6).

The relative composition (Fig. 7) was always dominated by gastropods which on an average contributed between 31.27 and 34.23% in Beri Gopalpur and between 33.25 and 38.45% in Sosadanga. Their contribution was almost substantial throughout the year with very narrow seasonal fluctuations. This was followed by oligochaetes, which were most abundant during premonsoon, contributing 21.20% and 17.50% in Beri Gopalpur and Sosadanga respectively. However, during postmonsoon, their density dropped considerably in both wetlands. Next in the order of abundance were shrimps which formed nearly 11% (7.35-15.15%) of total macro-invertebrate density in Beri Gopalpur and about 15% (12.65-18.10%) in Sosadanga. The density of water mites (Hydroacarina : Arachnida) was always very low and varied between 1.0 and 2,22% in the two wetlands. Among insects, several species of the order Hemiptera, Coleoptera and Odonata contributed substantially to the density of macrophyte associated fauna. However, Chironomids were equally abundant in the benthic soil as well as macrophytes strands and contributed substantially, between 5 and 10%. Their density was much higher during premonsoon in both wetlands. There were several other unidentified dipteran larvae, which were clubbed together. This group also formed a substantial portion of the Macro-invertebrate density.

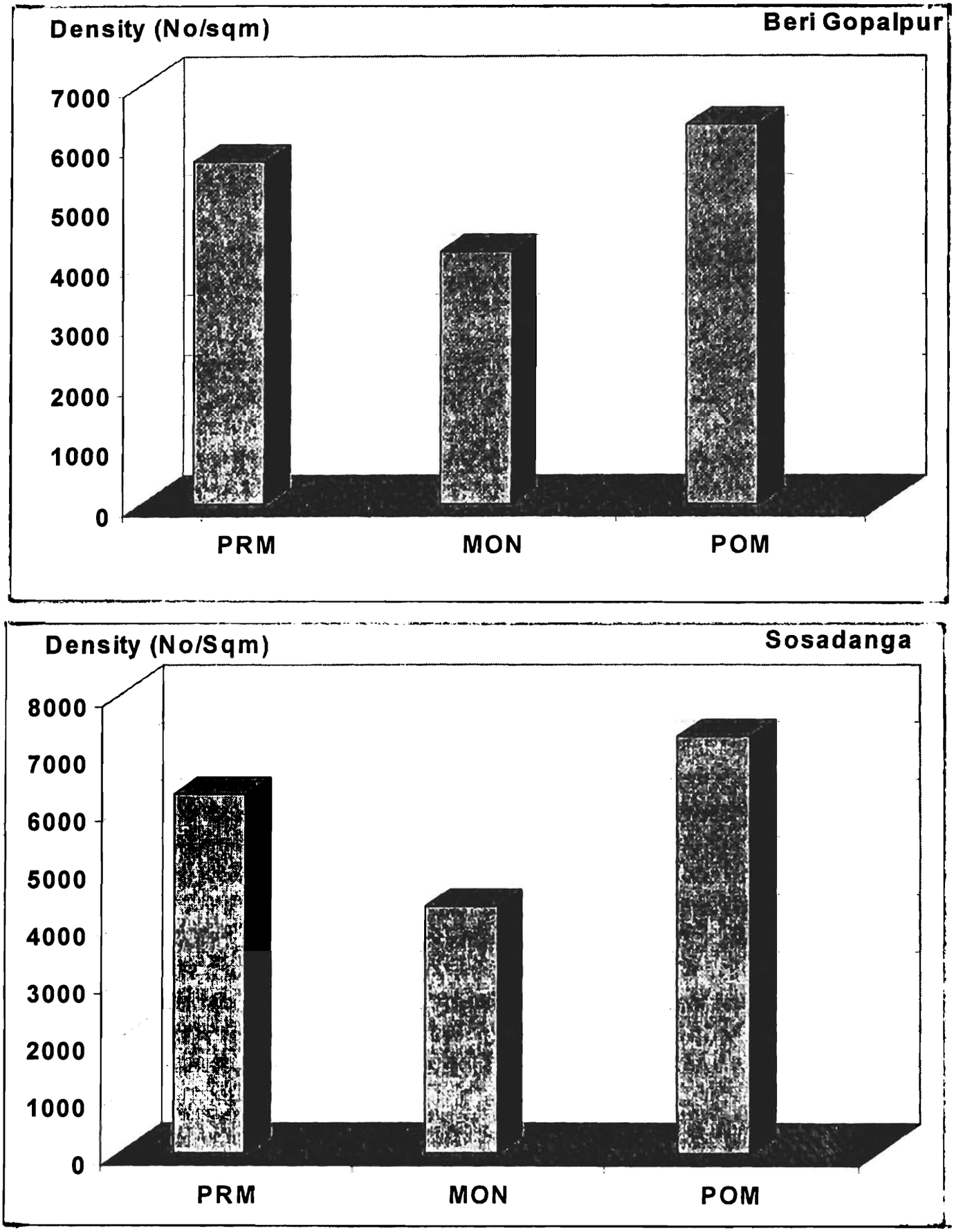


Fig. 6. Mean density of macroinvertebrates in the two ox-bow wetlands during different seasons

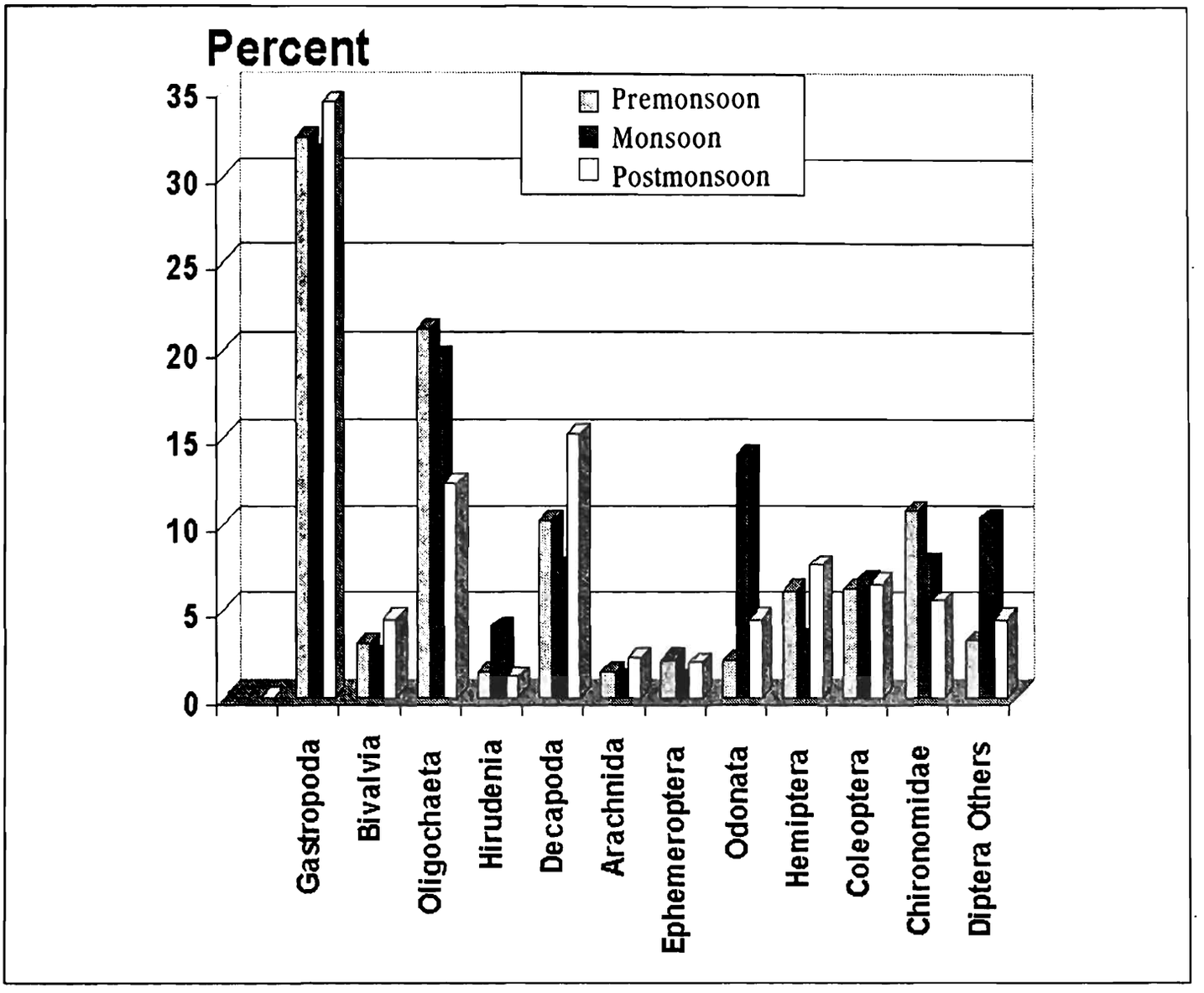


Fig. 7. Seasonal variations in the relative composition of different macro-invertebrate groups

Numerically abundant Taxa : Table 9 lists the numerically abundant taxa of macro-invertebrates. It may be seen that only a few taxa of each group were abundant and contrubuted significantly to numerical density. Out of a total of 78 taxa recorded, only 24 were abundant. This included 5 species of gastropods, 2 species of oligochaetes, one species of arachnids, 1 species of crustacean shrimp, 4 species of Odonata, 6 species of Hemiptera, 5 species of Coleoptera and one species of Diptera : Chironomidae. The gastropod species were by far most abundant.

Diversity Indices : Table 11 shows the mean values of diversity indices of macro-invertebrates in two wetlands during different seasons. Both, species richness and Shannon wiener ($\overline{H}$) indices revealed a high diversity as values were well above the normal range reported for highly divers communities in unpolluted waters.

Table 9. List of Numerically abundant Macro-invertebrate Taxa

GASTROPODA	INSECTA HEMIPTERA
Bellamya bengalensis (Lamarck)	*Anisops bouvieri* Kirkaldy
Gabbia orculla Frauenfeld	*Anisops breddeni* Kirkaldy
Digoniostoma cerameopoma (Benson)	*Ranatra filiformis* Fabricius
Thiara (Melanoides) tuberculata (Muller)	*Diplonychus annulatum* (Fabricius)
Gyraulus convexiousculus (Hutton)	*Limnogonus (L.) nitidus* (Mayr)
Braanchiura sowerbyi Beddard	INSECTA: COLEOPTERA
Limnodrillus hoffmeisteri Claparede	*Hydrocoptus subvittulus* Motschhulsky
ARTHROPODA : ARACHNIDS	*Canthydrus laetabilis* (Walker)
Paradosa spp.	*Guignotus flammulatus* (Sharp)
CRUSTACEA DECAPODA	*Laccophilus anticus* Sharp
Macrobrachium lamarrei (H.M.Edwards)	*Laccophilus confertus* Sharp
INSECTA : ODONATA	*Enochrus esuriens* Motschulsky
Ceriagrion coromandelianum Fabricius	*Amphiops pedestris* Sharp
Pseudagrion microcephalum Rambur	*Berosus indicus* (Fabricius)
Brachythemis contaminata (Fabricius)	DIPTERA : CHIRONOMIDAE
Orthetrum sabina (Drury)	*Chironomus sp. A*

Table 10. Total density (no/cubic meter) and relative composition of relative composition of major groups of macro-invertebrates in the two wetlands

	Beri Gopalpur			**Sosadanga**		
	Pre-monsoon	Mon-soon	Post-monsoon	Pre-monsoon	Mon-soon	Post-monsoon
Total Density(no/m^3)	5710	4105	6315	6250	4305	7250
Relative composition (%)						
Gastropoda	32.2	31.27	34.23	36.15	32.25	38.45
Bivalvia	3.2	2.34	4.5	2.5	3.15	4.55
Oligochaeta	21.2	18.12	12.15	17.5	15.25	10.25
Hirudenia	1.4	4.01	1.2	2	4.65	1.25
Decapoda	10.15	7.35	15.15	14.75	12.65	18.1
Arachnida	1.4	1	2.22	1.2	1.55	1.5
Ephemeroptera	2.21	1	2	1.75	2.75	2.1
Odonata	2.1	14	4.5	3.5	4.7	4.2
Hemiptera	6.1	3.28	7.52	5.55	6.5	6.55
Coleoptera	6.2	6.73	6.53	4.8	5.8	6.3
Chironomidae	10.64	7.64	5.5	7.8	7.2	4.25
Other Diptera	3.2	3.26	4.5	2.5	3.55	2.5

Similarity Analysis : Coefficinet of similarity values for macroinvertebrate fauna of the two wetlands were also significantly high (Table 12).

Table 11. Species diversity indices of phytoplankton, Zooplankton and macro-invertebrates in the two oxbow wetlands.

	Beri Gopalpur			Sosadanga		
	Pre-monsoon	Mon-soon	Post-monsoon	Pre-monsoon	Mon-soon	Post-monsoon
Phytoplankton						
No. of species	27	20	30	28	24	35
Species richness index	3.262	2.595	3.417	3.597	3.582	4.386
Shannon-wiener index ($\bar{H}$)	4.6942	3.8428	4.5633	3.4375	3.2150	4.5210
Zooplankton						
No. of species	44	31	50	40	33	55
Species richness index	6.571	5.112	7.114	5.777	5.087	7.425
Shannon-wiener index ($\bar{H}$)	4.4755	3.8952	4.7116	3.8690	3.2215	4.1042
Macro-invertebrates						
No. of species	66	53	66	68	53	74
Species richness index	8.374	6.758	7.556	8.973	7.685	9.684
Shannon-wiener index ($\bar{H}$)	4.6312	4.6604	4.7015	4.7210	4.4015	4.7885

Table 12. Sorenson's index of similarity of the two ox-bow wetlands.

	Premonsoon	Monsoon	Postmonsoon
Phytoplankton	0.7425	0.7985	0.8158
Zooplankton	0.7012	0.7654	0.8099
Macro-invertebrates	0.7985	0.8015	0.8104

(E) PISCES

Table 13 lists the fishes observed/reported to occur in the two wetlands. Almost all the species listed are common species occurring in the freshwater *beel/boars* of the region. The fish fauna includes both, lentic (ponds/lakes/beels) and lotic (river) elements. Though some estuarine species were also reported to occur, their existence could not be authenticated. A total of 63 species have been listed. Most of the species (28) belonged to family Cyprinidae of the Order Cypriniformes, which were represented by subfamilies Cultrinae (4 species), Hypothalmichthyinae (1species), Rasaborinae (6 species) and Cyprininae (17 species). Only

one more family of the order Cypriniformes *viz.* Cobitidae was represented by single species, *Lepidocephalus guntea.* This was followed by catfishes of the Order Siluriformes which was represented by 5 families *viz.* Bagaridae (3 species), Siluridae (3 species), Schilibeidae (4 species), Claridae (1 species) and Saccobranchidae (1 species). The other important families were Channidae (3 species) and Notopteridae (2 species). Rest of the families were of minor importance and were represented by one or two species.

Out of the 63 species recorded/reported, only a few were of commercial importance and formed sizable fishery. The fingerlings of Indian major carp and exotic species like common carp, silver carp, and grass carp and Tilapia are released periodically for commercial culture. Since both the wetlands have connection with river Icchamati, the occurrence of many more species is a very strong possibility which detailed investigation.

Table 13. Systematic list of fishes occurring in floodplain wetlands (Beels/Baors) of North 24 parganas District, West Bengal.

Species	Local name
Order ANGULIFORME Family ANGUILLIDAE	
1 *Anguilla bengalensis bengalensis* (Gray & Hardw)	Bam
Family OHICHTHIDAE	
2. *Pisodonophis boro* (Hamilton-Buchanan)	
Order CLUPEIFORMES Family CLUPEIDAE	
3. *Gadusia chapra* (Hamilton-Buchanan)	Koira
Order OSTEOGLOSSIFORMES Family NOTOPTERIDAE	
4. *Notopterus chitala* (Hamilton-Buchanan)	Chital
5. *Notopterus notopterus* (Pallas)	Falui
Order CYPRINIFORMES Family CYPRINIDAE Subfamily CULTRINAE	
6. *Chela (Chela) laubuca* (Hamilton-Buchanan)	Beki-chela
7. *Securicula gora* (Hamilton-Buchanan)	Bara-chela
8. *Salmostoma bacaila* (Hamilton-Buchanan)	Gang-chela

Species	Local name
9. *Salmostoma phulo phulo* (Hamilton-Buchanan)	Chela
Subfamily HYPOPHTHALMICHTHYINAE	
10.*Hypophthalmichthys molitrix* (Valenciennes)*	Silver carp
Subfamily : RASBORINAE	
11. *Aspidoparia jaya* (Hamilton-Buchanan)	Chela
12. *Amblypharyngdon mola* (Hamilton-Buchanan)	Chela
13. *Danio (Danio) aequipinnatus* McCLelland	Bashpata
14. *Esomus danricus* (Hamilton-Buchanan)	Dadhikha
15. *Rasbora daniconius saniconius* (Hamilton-Buchanan)	Darkina/Danikoni
16. *Rasbora rasbora* (Hamilton-Buchanan)	Darikana
Subfamily CYPRININAE	
17. *Catla catla* (Hamilton-Buchanan)	Katla
18. *Cirrhinus mrigala,* (Hamilton-Buchanan)	Mrigal
19. *Cirrhinus reab*(Hamilton-Buchanan)	Kharkebata
20. *Cyprinus carpio carpio* (Linnaeus) *	Amrikan rui
21 *Ctenopharyngdon idella* (Valenciennes)*	Gheso rui
22. *Labeo bata* (Hamilton-Buchanan)	Bata
23. *Labeo calbash* (Hamilton-Buchanan)	Kalbasu
24. *Labeo fumbriatus* (Bloch)	
25. *Labeo gonius* (Hamilton-Buchanan)	Goni
26. *Labeo rohita* (Hamilton-Buchanan)	Ruhi
27. *Osteobrama cotio cotio* (Hamilton-Buchanan)	Chanda
28. *Puntius chola* (Hamilton-Buchanan)	Kerundi
29. *Puntius conchonius* (Hamilton-Buchanan)	Kanchan puthi
30. *Puntuus phutunio* (Hamilton-Buchanan)	Phutuni-puthi
31 *Puntuus sarana sarana* (Hamilton-Buchanan)	Swarnaputhi
32. *Puntuus sophore* (Hamilton-Buchanan)	Puthi
33. *Puntuus titco* (Hamilton-Buchanan)	Tita-puthi
Family COBIGIDAE	
34. *Lepidocephalus (L.) guntea* (Hamilton-Buchanan)	Poa
Order SILURIFORMES Family BAGARIDAE	
35. *Mystus bleekeri* (Day)	Tengra
36. *Mystus cavasius* (Day)	Tengra
37. *Mystus tengara* (Hamilton-Buchanan)	Tengra
38. *Mystus vittatus* (Block)	Tengra

Species	Local name
Family SILURIDAE	
39. *Ompak bimaculatus* (Block)	Pabda
40. *Ompak pabda* (Hamilton-Buchanan)	Pabda
41. *Wallago attu* (Schneider)	Pabda
Family SCHILBEIDAE	
Ailia colia (Hamilton-Buchanan)	Kajili
42. *Clupisoma garua* (Hamilton-Buchanan)	Gharua
43. *Eutropiichthys vacha* (Hamilton-Buchanan)	Bacha
44. *Silonia silondia* (Hamilton-Buchanan)	Shiland
Family CLARIIDAE	
45. *Clarius batrachus* (Linnaeus)	Magur
Family SACCOBRANCHIDAE	
46. *Heteropneustes fossilis* (Bloch)	Shinghi
Order ATHERNIFORMES Family BELONIDAE	
47. *Xenthodon cancila* (Hamilton-Buchanan)	Kankli
Order GASTEROSTEIFORMES Family CHANNIDAE	
48. *Channa marulius* (Hamilton-Buchanan)	Saul
49. *Channa striatus* (Hamilton-Buchanan)	Saul
50. *Channa punctatus* (Bloch)	Laata
Order SYMBRANCHIFORMES Family SYMBRANCHIDAE	
51 *Monopterus cuchia* (Hamilton-Buchanan)	Kuchi
Order PERCIFORMES Family CHANDIDAE	
52. *Chanda nama* (Hamilton-Buchanan)	Chanda
53. *Chanda ranga* (Hamilton-Buchanan)	Chanda
Family NANDIDAE	
54. *Nandus nandus* (Hamilton-Buchanan)	Batkoi
55. *Badis badis* (Hamilton-Buchanan)	Nadosh

Species	Local name
Family CICHLIDAE	
56. *Oreochromis mossambica* (Peters)*	Tilapia
Family GOBIIDAE	
57. *Glossogobius giuris giuris* (Hamilton-Buchanan)	Bele
Family ANABANTIDAE	
58. *Anabas testudineus* (Bloch)	Koi
Family BELONTIDAE	
59. *Colisa fasciata* (Schneider)	Kholshey
Order MASTACEMBELIFORMES Family MASTACEMBELIDAE	
60. *Mastacembelus armatus* (Bloch)	Pakal
61 *Mastacembelus panacalas* (Hamilton-Buchanan)	Pakal

* Exotic species

(F) AMPHIBIA

Faunistic survey in and around the two wetlands revealed the common existence of six species of frogs (Family Ranidae). These were *Rana cyanophlyctis* Schneider, *Rana hexadactyla* Lesson, *Rana tigrina* Daudin, *Rana limnocharis* Wiesmann and *Rana crassa* Jerdon. Besides, one species of toad (Family Bufonidae), *Bufo melanogaster* Schneider was also commonly observed.

(G) AVIFAUNA

Since detailed observation on a fauna could not be made, a general list of the marsh and aquatic bird species observed / reported from the freshwater wetlands of the area (North 24 Parganas) has been compiled and shown in Table 14. Only species that occur on the banks /marshes or in water have been taken into consideration. Sixty-four species belonging to five orders in 11 families formed the commonly occurring avifauna. These belonged to all categories *viz.* resident, local migratory and long range migratory. Common resident marsh species belonged to the Families Phalacrocoracidae (cormorant, shags and darters), Ardeidae (herons, egrets and bitterns), Podicipedidae (grebs) and Ciconidae and were represented by 17 species. The abundant species were little cormorant, darter, pond heron, cattle egret, little egret and night heron. The species belonging to the family Anatidae (goose, teal, duck, pochard etc.) were mostly migratory, visiting during postmonsoon months. It was the most diverse family represented by largest number of species (16). They were seen both in water and on the marshy banks near decaying macrophytes. The other smaller marsh birds like

jacanas (Family : Jacanidae), lapwig, plovers, snipes and sandpipers (Family : Charadriidae) also occurred in large numbers during postmonsoon (winter). The water cocks, waterhen, moorhens, water rail and coot etc. (Family: Rallidae) were seen only occasionally in very small numbers. Similarly gulls and terns (family: Laridae) were also not very common and they too were seen in the area during winter months.

Table 14. Systematic list of Birds occurring in floodplain wetlands (beels/baors) of north 24 Parganas District, West Bengal.

Species	Common Name	Local Name
Order PODICIPEDIFORMES Family PODICIPEDIDAE		
1. *Podiceps cristatus* (Linnaeus)	Great Crested Grebe	
2. *Podiceps ruficollis capensis* Salvadori	Little Grebe	Dubri
Order PELECANIFORMES Family PHALACROCORACIDAE		
3. *Phalacrocorax carbo* (Linnaeus)	Large Cormorant	Pan-kawri
4. *Phalacrocorax fuscicollis* Stephens	Indian Shag	Pan-kawri
5. *Phalacrocorax niger* (Vieillot)	Little Cormorant	Pan-kawri
6. *Anhinga rufa melanogaster* Pennant	Darter	Goyar
Order CICONIFORMES Family ARDEIDAE		
7. *Ardea cinerea* Linnacus	Gray Heron	Anjan
8. *Ardea puprpured manilensis* Meyen	Purple Heron	Lal kank
9. *Ardea alba* Linnacus	Large Egret	Bara bak
10. *Ardeola grayii* (Sykes)	Pond Heron	Konch bak
11. *Budulcus ibis coromandus* (Boddaert)	Cattle Egret	Gai bak
12. *Egretta intermedia intermedia* (Wagler)	Medium Egret	Korche bak
13. *Egretta garzetta garzetta* (Linnacus)	Little Egret	Chhota Korchebak
14. *Nycticorax nyciticorax nycticorax* (Linnaeus)	Night Heron	Bachka
15. *Ixobrychus cinnamoneus* (Gmelin)	Chestnut Bittern	Lal bak
16. *Ixobrychus flavicollis flavicollis* (Latham)	Black Bittern	Kalo bak
Family CICONIDAE		
17. *Anastomus oscitans* (Boddaert)	Openbill Stork	Shamukh khol
Order ANSERIFORMES Family ANATIDAE		
18. *Anser anser rubrirostris* Swinhoe	Gray Large Goose	Raj hans

Species	Common Name	Local Name
19. *Dendrocygna javanica* (Horsfield)	Lesser Whistling Teal	Saral
20. *Dendrocygna bicolor* (Vieillot)	Large whistling Teal	Bada saral
21. *Tadorna ferruginea* (Pallas)	Brahmni Duck	Chakha chakhi
22. *Anas acuta* Linnaeuus	Pintail	Dig hans
23. *Anas crecca crecca* Linnaeus	Common Teal	Patari hans
24. *Anas platyrhynchos* Linnaeus	Mallard	Neel Sir
25. *Anas strepera strepera* Linnaeus	Gadwall	Ping hans
26. *Anas penelope* Linnaeus	Wigeon	Chhota lal sir
27. *Anas querquedula* Linnaeus	Graganey	Giria hans
28. *Anas clypeata* Linnaeus	Sheveller	Khunte hans
29. *Aythya ferina* (Linnaeus)	Common Pochard	Lal muri
30. *Aythya nyroca* (Culdenstadt)	White-eyed Pochard	Bhuti hans
31. *Aythya fuligula* (Linnaeus)	Tufted Pochard	Baminja hans
32. *Nettapus Coromandelianus Coromandelianus* (Gmelin)	Cotton Teal	Bali hans -
33. *Sarkidiornis melanotos* (Pennant)	Comb duck	Nakta
Family RALLIDAE		
34. *Rallus aquaticus Indicus* Blyth	Water rail	Ambukukkut
35. *Porzana fusca fusca* (Linnaeus)	Rudy Crack	-
36. *Amaurornis phoenicurus chinensis* (Boddaert)	White-breasted waterhen	Dahuk
37. *Gallicrex cinerea* (Gmelin)	Water Cock	Jal Murug
38. *Gallinula chloropus indica* Blyth	Indian Moorhen	Jal murgi
39. *Porphyrio porphyrio poliocephalus* (Latham)	Purple Moorhen	Kam Pakhi
40. *Fulica atra atra* Linnaeus	Coot	Jal kukkut
Order CHARADRIFORMES Family JACANIDAE		
41. *Hydrophasianus chirurgus* (Scopoli)	Pheasant-tailed Jacana	Surdal
42. *Metopidius indicus* (Latham)	Bronzed-winged Jacana	Karatiya
Family CHARADRIIDAE Subfamily CHARADRIINAE		
43. *Vanellus cinereus* (Blyth)	Gray headed Lapwig	-
44. *Vanellus indicus indicus* (Boddaert)	Red Watted Lapwig	Hatiti
45. *Vanellus malabaricus* (Boddaert)	Yellow Watted Lapwig	-
46. *Pluvialis dominica fulva* (Gmelin)	Eastern Golden Plover	Sona batan
47. *Charadrius dubius curonicus* Gmelin	Little ringed plover	
Subfamily SCOLOPACINAE		
48. *Numenius arquata arquata* (Linnaeus)	Eastern Curlew	Sada kastechara
49. *Tringa totanus totanus* (Linnaeus)	Red Shank	Chhoto batan
50. *Tringa stagnatilis* (Bechstein)	Marsh Sanpiper	-

Species	Common Name	Local Name
51 *Tringa nebularia* (Gunner)	Greenshank	Gothra
52. *Tringa ochropus* Linnaeus	Green sandpiper	
53. *Tringa glareola* Linnaeus	Wood Sandpiper	Balu batan
54. *Tringa hypoleucos* Linnaeus	Common snadpiper	
55. *Gallinago stenura* (Bonaparte)	Pintail Snipe	Kada khocha
56. *Gallinago gallinago gallinago* (Linnaeus)	Fantail Snipe	Kada khocha
57. *Scolopax rusticola rusticola* Linnaeus	Woodcock	
58. *Calidris temminckii* (Leisler)	Temmink's Stint	
Family ROSTRATULIDAE		
59. *Rostratula benghalensis benghalensis* (Linnaeus)	Painted Snipe	Baggarji
Family RECURVIROSTRIDAE		
60. *Himantopus himantopus himantopus* (Linnaeus)	Blackwinged Stilt	Lal tingi
Family LARIDAE		
61. *Larus brunnicephalus* Jerdon	Brownheaded gull	
62. *Chlidonias hybrida indica* Stephens	Indian Whiskered Tern	
63. *Gelochelidon nilotica affinis* (Horsfield)	Gullbailed Tern	
64. *Sterna aurantia* J.E. Gray	Indian River Tern	Ganga chiel

DISCUSSION

The floodplain wetlands, representing intermediate conditions between lotic and lentic ecosystems, with considerable variations at micro-ecological levels, serve as unique habitats for the colonization of rich and diverse faunal communities. This is abundantly clear from the large number of taxa of both zooplankton and macro-invertebrates, recorded from the two oxbow wetlands.

The zooplankton communities of the two wetlands were comprised of 76 species belonging mainly to Rotifera and Micro-Crustacea (Cladocera, Copepoda and Ostracoda) with a few protozoan taxa. A general tropical character, as outlined by several earlier workers (Fernando, 1980, Dussart *et al.*, 1984, Sharma and Michael, 1987, Michael and Sharma, 1988, Sharma, 1991a), was very much visible and most of the species recorded were typically associated with this region of the world representing cosmopolitan, cosmotropical, and pantropical elements in the descending order of abundance.

The species richness of Rotifera was highest. A total of 37 species belonging to 15 genera and 12 families were recorded during the period of investigation from the two wetlands. The rich faunal diversity of rotifers in freshwaters of West Bengal has already been documented by Sharma (1999a) who reported the existence of 129 species from

West Bengal. Together with 19 species recorded earlier by Anderson (1889), which could not be collected by him, the list went up to 148. However, the rotifer species recorded from both littoral and limnetic zones of the two floodplain wetlands, which provided ideal conditions for the colonization of rotifers, as also opined by Sharma (1999b), represented only a small fraction of the total number of species reported earlier. It is quite possible that many of the species in his list are either non-planktonic forms or are of rare occurrence, contributing little to zooplankton density and biomass.

The qualitative dominance of rotifers over micro-Crustacea in terms of species richness in the two wetlands is in accordance with general faunal composition of this region as reported earlier (Khan and Sinha, 1999). Such dominance of rotifers in floodplain wetlands has also been reported from different parts of the country including high altitude Kashmir lakes (Khan, 1987, Sanjar and Sharma, 1995). The occurrence of significantly higher number of species belonging to Brachionidae and Lecanidae and the rich species diversity of the genera *Brachionus* and *Lecane* are characteristics of tropical fauna (Green, 1972; Pejler, 1977; Fernando, 1980; Dumont, 1983; Dussart *et al.*, 1984; Sharma 1996, 1999b). However, the common occurrence of many of the *Brachionus* species, classified as acidophilic, in the two highly alkaline oxbow lakes, does not support the views of Sharma (1996, 1999b). Further the wetlands with aquatic macrophytes are known to harbour a very large number of rotifer species. This has been quite evident from the number of species recorded from the two wetlands (26 and 27), which are very close to maximum number reported (Sharma *op. cit.*) to occur in a particular wetland (28 –33).

Like rotifers, the diversity of cladoceran in the two oxbow lakes was also comparatively high. The twenty-four species belonging to 16 genera and 6 families represented nearly 42% of the total cladoceran species (57) known from West Bengal (Venkataraman, 1999). The high species richness of the two wetlands was mainly contributed by littoral chydorids, which was undoubtedly due to abundance of macrophytes. The diversity and abundance of littoral chydorids are known to be governed mainly by macrophytes (Whiteside and Harmsworth , 1967; Freyer, 1968; Quade, 1969). Not only chydorids but several species belonging to other limnetic families also occurred in littoral macrophytes where they seem to be well adapted and there appeared to be no truly limnetic species. The high species diversity of Chydoridae in the two wetlands supports the view of earlier workers that such dominance is the characteristics of tropical water bodies (Green 1962, Mamril and Fernando 1978, Dumont 1980, Dumont *et al.* 1981, Sharma and Michael 1987, Sharma, 1991b, Egborge *et al.* 1994, Sinha and Khan, 2000). Like most of the tropical wetlands, the occurrence of large–sized cladoceran, particularly those belonging to genus *Daphnia*, was very much restricted to both the wetlands. Several workers (Fernando 1980a, Kerfoot and Lynch 1987, Fernando *et al.*, 1987) have discussed factors responsible for such scarcity in considerable details.

Qualitatively, the copepods were represented by only a few species in both wetlands but quantitatively their contribution was highest. Only 8 species, 4 of Calanoid and 4 of Cyclopoid were recorded. Out of these only *Heliodiptomus contortus* occurred throughout

the year in both wetlands. Among the other 3 species, *H. vidvus* was recorded only from Beri Gopalpur and *H. cinctus* only from Sosadanda and these were next to *H. contotus*. *Arctodiaptomus keifari* was of rare occurrence and was collected in small numbers from Beri Gopalpur. Similarly among Cyclopoids, *Mesocyclops leuckarti* was the most abundant species occurring throughout the year in both wetlands followed by *Microcyclops varicans*. The other two species occurred only in Beri Gopalpur. Generally the number of species of copepod occurring in an ecosystem is never very large, either in temperate or tropical freshwaters.

It is evident from the studies that the diversity of zooplankton in the floodplain wetlands of the country is considerably rich. However, there has been some confusion in the reports of some earlier workers regarding the occurrence and abundance of various zooplankton species. CIFRI (2000) states the occurrence of *Daphnia galeata and Daphnia. longiuris* in the beels of West Bengal, which have yet not been reported from the country. The report further states that *Brachionus, Keretella* and *Moina* dominated in south Bengal beels and nauplius, *Diaptomus*, and *Cyclops* dominated in North Bengal beels" The former list belongs to Rotifera (*Brachionus* and *Keratella*) and Cladocera (*Moina*) and latter belongs to Copepoda. It is not clear what the authors wanted to convey because there appears no geographical barrier between various beels of the two sides studied by them.

The density of zooplankton in both the wetlands was quite high and it was always dominated by copepods, which inspite of their very restricted species diversity, contributed maximum to the density and biomass, almost throughout the year. Their numerical contribution varied between 40 and 50%. This was mainly contributed by the two most dominant species viz. *Heliodaptomus contortus* and cyclopoid *Mesocylops leuckarti*. The copepodites of these two species were present in large numbers throughout the year. The dominance of copepods in different types of wetlands of this region has already been reported (Khan and Sinha, *loc. cit.*).

As indicated by several earlier workers (Anderson 1971, 1974, Patalas 1972) that in a zooplankton community, only few commonly occurring and abundant species contribute maximum to density and biomass. Anderson (1974) found that such numerically abundant species contributed 27% of the community in 340 lakes and ponds of Canada. Yousuf *et al.* (1986) found that 35.5% of total community were contributed by only four species in some freshwater lakes and ponds of Kashmir. During present study too, both wetlands were characterized by a set of few numerically abundant species that controlled the bulk of zooplankton density.

The macroinvertebrate diversity of both wetlands was considerably high and as many as 78 taxa were recorded during the period of study. These were broadly divisible into two main categories - 1) macrophytes associated and 2) benthic. The rich diversity of macroinvertebrates in both wetlands can be related to the growth of abundant and diverse macrophytes as most of the animals belonging to entomofauna, carcinofana, aracnofauna

and malacofauna take shelter under these plants, both in free living and attached conditions. The significance of macrophytes in the distribution and abundance of freshwater macro-invertebrate fauna has been well-realised (Pieczynska and Ozimek, 1976) and it has been stated that diverse flora are responsible for greater faunal assemblage and the establishment of stable communities, especially of insects (Boyd, 1971). More than 100 species of macrophytic plants have been reported to occur in the freshwater wetlands of West Bengal (Deb, 1976). However, during present studies only 31 taxa were recorded. It is quite possible that a thorough floral taxonomic study may reveal several more taxa. From the list it is quite visible that the macrophytes of both the wetlands were similar qualitatively and therefore, the associated macroinvertebrate fauna were also similar. However, Sosadanga harboured slightly larger number of taxa, (27 in postmonsoon) as compared to Beri Gopalpur (25 in postmonsoon).

Because of the abundant macrophytes, the macro-invertebrate diversity of the freshwater of this region in general is very high. De and Sengupta (1988) recorded 23 species of only Coleoptera belonging to 4 families - Dytiscidae, Gyrinidae, Halipidae and Hydrophilidae from a floodplain wetland of North 24 Parganas district (Borti beel). CIFRI (2000) reported 43 species belonging to Mollusca, Insecta and Annelida from the beels of West Bengal. From some wetlands of eastern Bihar, Roy *et al.* (1988) recorded 71 species belonging only to insects. However, highest number of taxa was reported by Mukherjee *et al.* (2000), who listed a total of 104 taxa only from 2 urban manmade lakes and a sewage-fed fish culture pond of Calcutta. Contrary to this, Singh and Roy (1991) reported the occurrence of only 30 species from Kawar Lake, a floodplain wetland of Bihar.Qualitatively the aquatic and semi-aquatic insects as a whole were the dominant component of macroinvertebrate fauna of both wetlands and contributed maximum to the diversity. The Coleoptera was represented by highest number of species, followed by Hemiptera. These two groups are fully aquatic and pass their almost entire life in water. Many coleopteran and hemipteran species are predaceous / carnivorous and feed upon larvae and adults of other insects, shrimps, fishes etc. and therefore, play very sigificant role in the trophic dynamics of the ecosystem. The insects of the Order Odonata, Diptera and Ephemeroptera are aquatic only in their immature stages and adults are aerial. The qualitative dominance of Coleoptera and Hemiptrea over other groups in the freshwater of this region has been well documented (Roy *et al.* 1988; Pal *et al.*, 2000). The ephimeropterans, which are generally inhabitant of cleaner, slightly acidic water of higher altitudes, were represented by a single species.

Molluscs were only second to insect in the order of species diversity. The gastropods occurred both on macrophytes and on bottom soil and appeared to most successfully adapted to all zones of freshwater wetlands in tropics. Niche segregation was evident in case of certain gastropod species. While the larger sized individuals of the common and abundant species *Bellamya and Thiara* were littoral benthic, the smaller size individuals were found to attach with macrophytes, particularly free floating ones. Similarly, *Lymnaea* species occurred attached to floating leaves of *Lemna* and *Pistia* etc. Both the species of bivalves were truly benthic, found buried in the bottom soil.

From the studies, three clear patterns of macroinvertebrate species diversity were apparent. First all the shrimp, arachnids and Insecta species, except some dipterans were typical component of nekton or neuston communities found closely associated with macrophytes, second almost all the species of gastropods, oligochaetes and chironomids were *eurotrophic,* i.e. which live both on bottom sediments and on hydrophytes (Kornijow and Gulati, 1992) and third, the variety of species exclusively associated with bottom sediment were limited to a few gastropods, bivalves leaches and crabs.

Like zooplankton, the numerical density of macroinvertebrates of the two wetlands was also considerably high because of very favourable conditions of food supply and shelter. The density was higher in Sosadanga than Beri Gopalpur, prabably due to comparatively denser macrophyte strands. The numerical density of macro-invertebrates varied considerably from wetland to wetland. CIFIRI (2000) reported that the density of weed associated fauna and benthos in West Bengal beels varies from 53/m^2 to 2832/m^2 and from 90 to 13,238/ m^2 respectively. In urban lakes of Calcutta, Mukherji *et al.* (2000) reported the variation in density between 2128/m^2 and 5158/m^2. During present investigations the relative composition was dominated by gastropods which contributed nearly one third (32.2-38.4%) of the total macro-invertebrate density. In both wetlands this was followed by oligochaetes, chironomids and decapod crustacean. These four groups together subscribed nearly 78% in Beri Gopalpur and 71% in Sosadanga. Contrary to the present observations Mukherji *et al. (op. cit)* found very high contribution of gastropods (between 48 and 58%) and oligochaetes (between 40 and 60%). The comparatively lower contribution of both gastropods and oligochaetes in the two wetlands studied may be due to their unpolluted as well as productive condition as greater dominance of molluscs is an indicative of unproductive character of the ecosystem (Sinha and Jha, 1997). One of the most important features of these wetlands observed was the higher (7.35%-15.15%) contribution of the crustaceans (shrimps and crabs). The contribution of Entomofauna (excluding the dipteran) in both wetlands was also significant. Mukherji *et al. (op. cit.)* found very little contribution of both crustacean and insect (excluding Diptera). In their studies, the crustacean contribution varied between 0.35% and 1.80% and insects (excluding Diptera) contributed less than 1%. This substantial difference might be due to the entirely different nature of the two sets of wetlands.

The bulk of both, macrophyte associated as well as benthic macro-invertebrate densities was contributed by only a few species of each group and remaining species occurred in small numbers or appeared for limited duration of certain period of the year. Such numerically abundant species play the main role in the production dynamics of the ecosystem. The comparatively lesser contribution of both oligochaetes and chironmids in the two wetlands are definitely indicative of lesser degree of their eutrophy.

While a number of workers have reported that plants do not support specific faunal associations (Rook, 1984; Schramn *et al.*, 1987 and Korinjow, 1989), Kornijow and Gulati (1992) observed that species diversity and abundance of animal communities inhabiting the different plant species differed markedly. A preliminary analysis of the habitat preference during present investigations revealed no significant preference of any plant species by any

group of macro-invertebrates. The high faunal diversity of the two wetlands was clearly visible from the values of various diversity indices. It has been reported that the Shannon-Wiener diversity index above 3 reflects cleaner water conditions. The values in the two wetlands throughout the year were above 3 both for zooplankton and macro-benthos.

As compared to 63 species of fishes recorded during present investigation, Nandi *et al.* (1993) reported 76 species from wetlands of North and South 24 Parganas but their list included several estuarine species like 3 species of mullet, *Liza,* several species of family Gobiidae including mudskippers, *Therapon jarbua* (Forskal), *Lates calcalifer* (Bloch) and *Scatophagus argus* (Linnaeus) etc, which generally do not occur in floodplain wetlands. CIFRI (2000) reported 42 common species from several floodplain wetlands but the list was not exhaustive. Similarly, Chakraborty (1997) also reported 63 similar common species of fishes from eastern India, particularly West Bengal. Although the list of freshwater fishes reported from West Bengal is a very large one which lists the occurrence of 172 species, It appears that the species recorded during the present investigation are of common occurrence in floodplain wetlands.

The list of common wetland avifauna presented here also tallies well with the earlier records. Compared to the present list of 64 species, Nandi *et al. (op. cit.)* reported the existence of 72 species of birds from wetlands of this region. However, they included several species, which are only distantly related to wetlands, like kingfishers (Family Alcedinidae), eagles and kites (Family Accipitridae), falcon (Family Falconidae) owls (Family Strigidae) and warblers (Family Muscicapidae). These species have not been considered here as the list is confined only to true wetland birds.

From the foregoing accounts it is clear that faunal diversity of the two wetlands studied was quite rich and compared well with the fauna recorded from this region. Not only diversity but their densities were also significantly moderate exhibiting their non polluted natural status. These waterbodies are excellent habitat for a variety of fauna and flora.

Floodplain wetlands also play very important role in socio-economic condition of the region as almost all the beels and baors are used for commercial fishery. Besides the natural immigration of fish seed from rivers during monsoon, fingerlings are also released periodically by fishermen. However, the per capita yield is very low. This is due to very improper management of the wetlands. It is high time that attempt should be made to properly conserve their biodiversity on one hand and increase productivity in terms of fish and fodder on the other hand.

SUMMARY

Floodplain wetlands, defined as low lying areas bordering large rivers, which are seasonally inundated by over-spills from the main river channel, are integral component of Ganga and Brahamputra river basin and constitute important freshwater resources of the states of

Bihar, West Bengal and Assam. Such wetlands play vital role not only in the recruitment of fish population in the reverine ecosystem but also support a rich floral and faunal diversity of macrophytes, plankton, benthos and macrophytes associated macro-invertebrate communities. In the state of West Bengal, where they are commonly known as *beel/jheel* (closed, lake-like) and *baors* (oxbow lakes), such wetlands occur in abundance mainly in the districts of Murshidabad, Nadia and North 24 Parganas along the tributaries/distributories of main river Ganga *viz.* Icchamati, Bhagirathi and Jalangi.

Detailed studies were carried out on the general physico-chemical conditions of water, and soil, phytoplankton, macrophytes, zooplankton, macrophytes associated and benthic macro-invertebrates, fish, amphibia and avifauna of two large oxbow wetlands, situated in the Bongaon Sub-Division of the district of North 24 Parganas, along the river Icchamati.

Both wetlands were considerably infested with a variety of macrophytes. Altogether 31 taxa belonging to 12 families under three main categories, *viz.,* floating, submerged and emergent were recorded. The entire littoral zone of both wetlands was covered with thick growth of macrophytes throughout the year.

A total of 43 taxa of phytoplankton belonging mainly to families Myxophyceae (7 taxa), Chlorophyceae (17 taxa) and Bacillariophyceae (12 taxa) occurrd in the two wetlands during the period of the study. Besides, families Charraphyceae, Chrysophyceae, Dinophyceae and Euglenophyceae were also represented by one or two taxa each. The density varied between 1510 Cell l^{-1} and 485 Cell l^{-1} in Beri Gopalpur and between 1115 Cell l^{-1} and 3325 Cell l^{-1} in Sosadanga, being lowest during monsoon and highest in post monsoon. The composition was mostly dominated by green algae which contributed 36.5 to 46.5%, followed by blue green algae.

The zooplankton community was comprised of 76 species belonging mainly to Rotifera and Micro-Crustacea (Cladocera, Copepoda, and Ostracoda) with a few protozoan taxa. A general tropical character was very much visible and most of the species recorded were typically associated with this region of the world representing cosmopolitan: cosmotropical: pantropical elements in the descending order of abundance. The species richness of Rotifera was highest followed by Cladocera. Lowest species diversity was exhibited by copepods. Not much difference in the species richness of two wetlands was noticed. The densities of both the wetlands were quite moderate almost throughout the year with pronounced seasonal variations. The mean seasonal density varied 425 l^{-1} from 980 l^{-1} and 440 l^{-1}-1250 l^{-1} in Beri Gopalpur and Sosadanga respectively, highest in post monsoon and lowest in monsoon. The relative density was always dominated by Copepods (40.3-50.4%), followed by Rotifers (28.0 - 35.2%) and Cladoceran (16.4 -27.3%). Out of 76 species of Zooplankton recorded from the two wetlands, only 18 species (8 of Rotifera, 7 of Cladocera and 3 of Copepoda) were numerically abundant and contributed substantially to total zooplankton density.

The macroinvertebrate diversity of both wetlands was considerably high and as many

as 78 taxa belonging to Oligochaeta, Hirudenia, Gastropoda, Bivalvia, Ephemeroptera, Odonata, Hemiptera, Coleoptera, Diptera, Hydroacrina and Decapod crustacea. These were broadly divisible into two main categories - (1) macrophytes associated and (2) benthic. The rich diversity of macroinvertebrates, in both wetlands can be related to the growth of abundant and diverse macrophytes as most of the animals belonging to entomofauna, carcinofauna, aracnofauna and malacofauna take shelter under these plants, both in free living and attached conditions. Qualitatively, the aquatic and semi-aquatic insects as a whole were the dominant component of macroinvertebrate fauna of both wetlands and contributed maximum to the species diversity. Molluscs were second only to insects in the order of diversity. The gastropods occurred both on macrophytes and on bottom and adopted most successfully to all zones. Three clear patterns of macroinvertebrate species diversity were apparent. First, all the shrimp, arachnid and insect species, except some dipteran, were typical component of necton or neuston communities found closely associated with macrophytes, second, almost all the species of gastropods, oligochaetes and chironomids were *eurotrophic, i.e.* which live both on bottom sediments and on hydrophytes and third, the variety of species exclusively associated with bottom sediment was limited to a few gastropods, bivalves, leaches and crabs. Like zooplankton, the numerical density of macroinvertebrates of the two wetlands was also considerably high and varied between 4105/m^3 and 5710/m^3 in Beri Gopalpur and between 4305/m^3 and 7250/m^3 in Sosadanga. Only a few taxa of each group were abundant and contributed significantly to numerical density.

The high faunal diversity of the two wetlands was clearly visible from the values of various diversity indices. The values of Shannon-Weiner diversity index ($\bar{H}$) in the two wetlands throughout the year were above 3, both for zooplankton and macro-benthos. The Shannon-Weiner diversity index ($\bar{H}$) above 3 reflects cleaner water conditions.

The common fish fauna of the floodplain wetlands of this region comprised of 63 species. Amphibians were represented by 5 common species of frog and one species of toad. The list of common wetland avifauna included 64 species.

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