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Hydrobiological studies on Warri River, Nigeria: Part 1. The composition, distribution and diversity of macrobenthic fauna

John O. Olomukoro and Austin B.M. Egborge

Department of Zoology, University of Benin, Benin City, Nigeria

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ABSTRACT: Hydrobiological investigation of macrobenthic fauna of Warri River was carried out for a period of eighteen month from December 1991 to May, 1993 at monthly intervals. Two stations designated along the main river course were sample for macrobenthos. A total of 138 macro-invertebrate taxa comprising 5 was recorded. The most dominant benthic groups were Copepoda, Decapoda, Ephemeroptera, Diptera and Mollusca. Among the species encountered, *naidium bilongata, Naidium breviseta, naidium osborni, nais obtuse, Placobdella monifera, Baetis bicaudatus* and *Vbaetis tricaudatus*, are being recorded for the first time in Nigeria. Of all the assemblage of benthic organisms recorded in this study, species of Hirudinea, odonata and trichoptera were confined to station 1 and Mollusca to station 2, with species richness (d) being higher in the latter station. Positive significant correlations were established between Diptera and crustacean/Odonata/Ephemeroptera and between Trichoptera and Arachnida and Ephemeroptera with odonata; Nematoda with Oligochaeta/Gastropoda.

Application of Sorensen's Quotient (Q/S) indicates great dissimilarity in species composition between the two stations. Seasonal variations in most groups were the same in the two stations with distinct appearances in the dry season and at the end of rainy season months.

Key words: Hydrobiology; Macrobenthic fauna; Abundance; Distribution; Diversity; Warri River.

Introduction

Macrobenthic invertebrates are an integral part of the food cycle of an aquatic environment and unpolluted water will support high diversity of bottom fauna.

Hynes (1972) observed that the aquatic animals, which live on, in or near the substratum of running waters, include representatives of almost every taxonomic group that occurs in freshwater. Egglishaw (1964) experimentally demonstrated the quantitative relationship between bottom fauna and stream riffle and plant detritus. Other researchers in the Temperate Zone have examined the bottom fauna with emphasis on microhabitats of stream insects (Hynes and Coleman, 1968; Mundie, 1971; Scullion and Edwards, 1980; Urk, 1978; Ulfstrand 1968a; Towns, 1978a; Fahy and Murray, 1972 and Choffman, 1973) and difference in abundance due to difference in substrate (Murray, 1936; Pennak and Van Gerpen, 1974; Bishop, 1973 and Wharfe, 1977).

The largest number of invertebrates taxa recorded for a New Zealand stream is fifty, considerably less than for most Northern Hemisphere studies. But the Waitakere River and its tributaries in New Zealand provided 144 taxa (Towns, 1979), a figure comparable with studies on similar sized streams in North America and Europe (Hynes, 1961; Ulfstrand, 1968b; Choffman *et al*., 1971; Fahy, 1975), but less than has been recorded in streams in the humid tropics (Bishop, 1973).

However, outstanding investigations, which deal with the bottom fauna of tropical running waters, have been carried out in a Malayan River (Bishop, 1973; Lim, 1975) and pawnpawn river in Ghana (Hynes, 1975). Other works of interest are those of Fernando (1977) in South-East Asia and Harrison (1958, 1965, 1966), in Western cape Province, South Africa and Zimbabwe. The benthic organisms of some rivers in Nigeria have been studied (Victor and Dickson, 1985; Victor and Ogbeibu, 1985; Olomukoro, 1983; 1996; Egborge and Okoi, 1987).

Investigation of Macrobenthic fauna of Warri River has greatly been neglected and this is the first being carried out in the catchment area. Aspects of Warri River water quality studies that have received full attention include the Chiadocera (Egborge, 1987a); Rotifera (Egborge and Tawari, 1987; Chigbu and Egborge, 1989); Copepoda (Gabriel, 1986; Gabriel and Egborge, 1991) and Fishes (tetsola, 1988; tetsola and Egborge; Agada, 1986).

The present investigation is on the hydrobiological characteristics of macrobenthic fauna of the Warri river from its upper reaches at Agbarho to Aladja brackish water, about 95 km from the Atlantic ocean.

The main objectives of the study are to examine: the composition, spatial distribution and diversity of macrobenthic invertebrate communities of the river.

The study area: Geography

The Warri River (stretches within Long. 5°21-6°20' E and Lat.5°24'N) is one of the most important coastal rivers of the Niger delta of Nigeria. The river is a major tributary of the Forcados River which empties into the Atlantic Ocean (Fig. 1), covering a surface area of about 255 sq. km with a length of about 150 km (NEDECO), 1954). The area has two recognizable annual seasons of variable durations, these are the dry and the rainy seasons (Egborge, 1991). Climate influences in the Niger delta in Nigeria vary from North to South, so that the rainy season lasts for months in Forcados (Close to the Atlantic Ocean) while at Warri it lasts for about 8-10 months (March-November).

At Warri (Fig. 2) the total rainfall recorded in 1992 was 2682.3 mm with peaks of 795.6mm and 758.0 mm of rainfall in May and July respectively. The least rainfall values of 40.7 mm and 27.1 mm were recorded in February and December. In 1993, low period of rainfall was observed in all the month with a peak of 816.5 mm in July.

Monthly variations of relative humidity and atmospheric temperatures were recorded for the period. Generally, lowest value of the former and high atmospheric temperatures characterize the dry season while the reverse is the case in the rainy season.

Vegetation and land use

The fringing vegetation of the river changes from a fresh water forest at the upper reaches to mangrove swamp and marsh at the lower reached, the outer marginal vegetation are *Raphia Palms* (*Raphia hockerii*)- a popular source of local alcoholic palm wine (tetsola, 1986). Behind this outer marginal vegetation has a dense freshwater swamp forest with timber producing species such as *Alstonia Congensis, Ficus* sp. and *Mitragyna ciliata*. – The entire canopy of the forest is crowded with dense triangles of shrubs and woody climbers (e.g. *Calamitus* sp. and *Aiestotryphyllum secundiflorum*) which are good sources of wood for cane basket and chairs.

Pollution load and demand of Warri river is a daily occurrence through the numerous activities like farming, on and off-shore petroleum processes, timber and sand mill industries, human waste disposal in different part of the warri river catchment area.

Sampling stations and methods

Two sampling stations were visited. Station 1 (upper reaches) is purely freshwater throughout the year. The width of the river here is between 80-100 meters with a depth of 4-7 meters. The dominant macrophytes include *Nymphea sp., cyrtosperma senegaleuse, Lemna sp., Pistia stratiotes, Eichhornia crassipes* (Emergent plants), *ceratophyllum submersum* and *Utricularia sp.* (Submergent plants). The substratum is muddy with clay and covered with much silt.

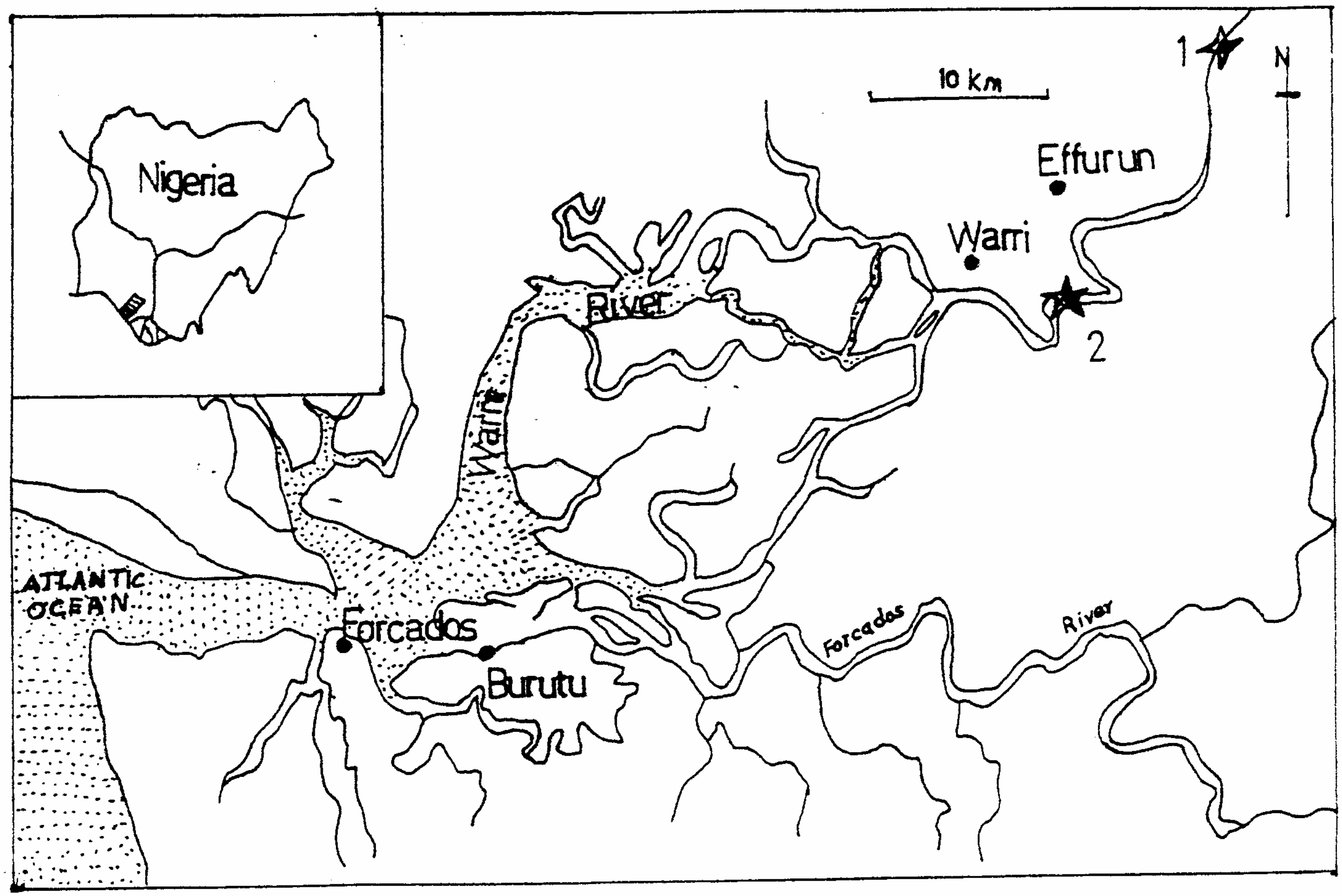

Fig. 1. Map of Warri River showing locations the sampling stations.

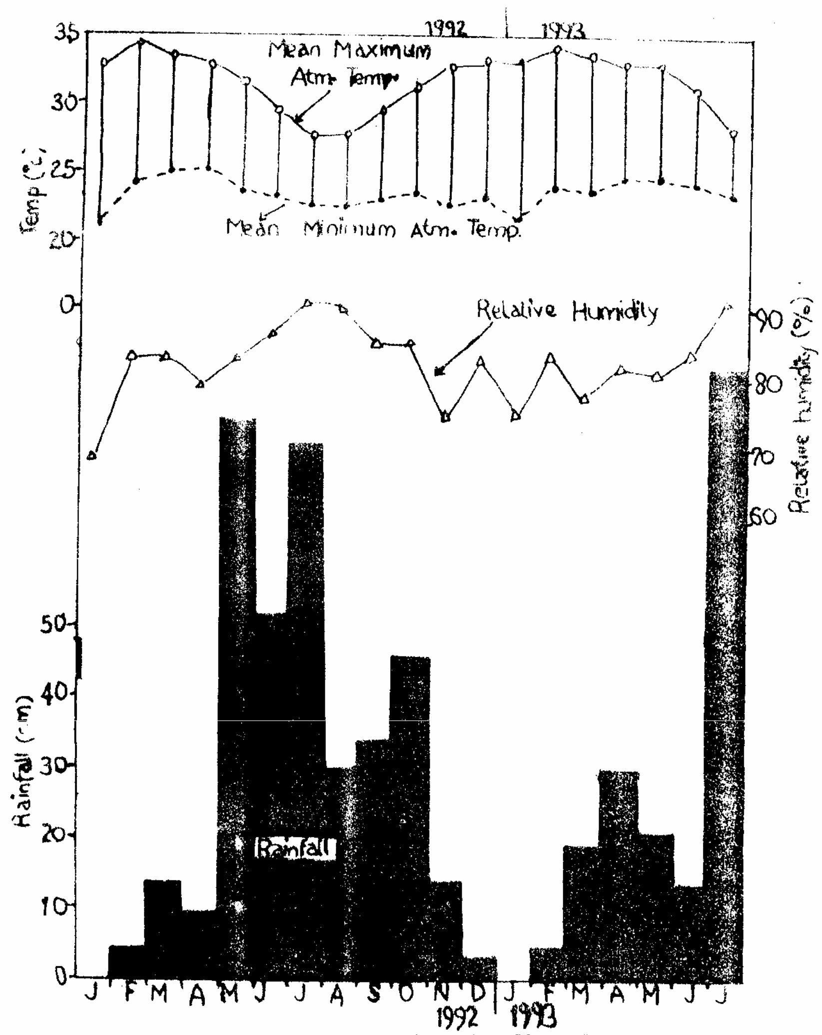

Fig. 2: Seasonal variations in rainfall, relative humidity, minimum and maximum atmospheric temperature in Warri during 1992 and 1993.

Station 2 (lower reaches) consists of fresh brackish and saline water whose extent is not only seasonal but are also dependent on tidal variations (Egborge and Tawari, 1987). Floating aquatic plants include *lemna sp., E. crassipes* and *C. Submersum*. Sandy soils underlain by clay more commonly form the basement, and mangrove swamps with mud deposits rich in organic matter in the top. This station is a recipient of various domestic and industrial wastewater and air-borne particulate matter from quite a number of industries situated along the bank of the river.

Sampling stations were visited monthly over a period of eighteen months (from December, 1991 to May, 1993). Water samples for physico-chemical analyses were collected just below the water surface after temperature of the surface water had been taken with a 76mm immersion Gallenkamp Griffin thermometer, THL-210-050T (0-110°C) graduated at 10°C intervals. pH and conductivity were determined in the laboratory using the HACH-ONE pH and conductivity meters. Turbidity was carried out with the aid of a turbidimeter. Dissolved oxygen and BOD were determined titrimetrically by the method of Mackereth (1963) and manometric method of measurement, using a BSB-controller, model 62OT respectively.

Macrobenthic fauna were sampled from the bottom using an Eckman grab made by Hydro-bios, West Germany, recommended for sand and silt (Hynes, 1961; Elliot, 1977) and a "Kick" technique previously used by Hynes (1961), Egglishaw (1964) and Paterson and Fernando (1970). The contents of each bucket were filtered through Tyle sieves of 1mm, 100µm and 150µm. Macrobenthic organisms retained in the filters were washed, into polypropylene bottles and preserved in 5% formalin. An America optical dissecting microscope, Model 570 was used to sort the Macrobenthic organisms from the light trash, and subsequent counting individual representatives was carried out in the laboratory. The organisms were stored in labelled specimen bottles containing 4% formalin for examination under an Olympus universal vanox research microscope with drawing attachment model MKH-240-790 fixed to it.

Benthic organisms were identified by reference to appropriate keys and works of Ward and Whipple, (1959), Byinkhurst (1966), Pennak (1953), Powell (1977, 1983), Mellanby (1963), Sawyer (1974), Hynes (1970), Olomukoro (1983). Needham and Needham (1962), Macan (1959); Ogbeibu (1991), Pinder and Reiss (1983), Gabriel (1986) and Jeje and Fernando (1986).

Results

Physical and chemical parameters

Table 1 shows the results for the physical and chemical analyses. There was a general increase of water temperature ranging between 26.5 and 32.0°C in stations 1 and 2. The lowest water temperature was recorded in December, in the stations.

Turbidity unit ranged between 4.0 unit and 11.0 unit, and was consistent during the first and last six months of the sampling period. The hydrogen-ion (pH) at the surface water ranged from 5.1 – 7.30 at station 1 and 6.25 – 7.80 at station 2. The coefficients of variation for the stations were 28.5% (station 1) and 5.6% (station 2), being higher in the former than the latter.

Conductivity and dissolved oxygen values decreased downstream in most of the months, although they were markedly higher in the dry season and lowest in the wet season.

BOD_5 values ranged between 2.0 and 10.5mg1^{-1} throughout the period at both stations. BOD_5 value was highest at the beginning of the wet season and lowest in the month of September.

Taxonomic checklist, distribution and abundance (NO.M^{-2})

A total of 138 macro-invertebrates taxa comprising of 5 species of nematoda, 14 species of Oligochaeta, 4 species of Polychaeta, 3 species of Hirudinea, 4 species of Cladocera, 12 species of Cyclopoida, 1 specie of Harpacticoida, 10 species of Decapoda, 1 specie of Amphipoda, 9 species of odonata and 14 species of Ephemeroptera were recorded. Others include 1 specie of each of plecoptera, Lepidoptera and nemiptera, 5 species of Coleoptera, 9 speciues of trichoptera, 6 species of Arachnida, 25 species of Diptera and 13 species of Mollusca.

Comparison of the relative percentage composition of the benthic groups in stations 1 and 2 (Table 3) revealed that all the organisms except polychaetes, amphipoda, decapods and gastropods were higher in station 1 than station 2. At the former station, copepoda had the highest record of 39.6% and lowest (0.8) was recorded for odonata. At the lower reaches (station 2) of the river, gastropoda was dominant among the benthic groups with a record of 49.7%, ephemeroptera had the least record of 0.03%.

Table 1: Summary of some physical and chemical parameters at the study stations of Warri River. December, 1991 – May, 1993.

Parameter		Station 1			Station 2			
	n	**Mean±SE**	**Min-Max**	**%CV**	**Mean±SE**	**Min-Max**	**%CV**	**Statistical significance**
Temperature °C	18	28±0.21	26.5-30.0	3.2	29.3±0.27	27.5-32.0	3.8	Accept Ho:
Conductivity	18	39.2±4.68	18.10-90.80	50.70	445.4±131.21	35.4-2200.0	124.9	*P>0.05
Turbidity	18	6.00±0.48	4.0-11.0	33.8	6.91±1.16	5.0-30.0	38.4	Reject Ho:
pH	18	5.78±0.39	5.1-7.30	28.5	6.99±0.93	6.25-7.80	5.6	P<0.05
Dissolved Oxygen	18	5.65±0.19	4.28-7.42	14.1	5.23±0.14	3.97-6.21	11.2	Reject Ho:
BOD	18	3.23±0.36	2.0-6.0	47.7	7.13±0.68	6.1-10.5	40.21	P<0.01

*Temperature and Turbidity.

Seasonal changes in the population density of benthic organisms

In the two stations, the dominant macro-invertebrate organisms were the Nematoda, Oligochata, Crustacea, Ephemeroptera, Diptera and Mollusca (Fig. 3). In station 1, copepoda were dominant in all the months from January, 1992 to May, 1993, with a peak recorded in February 1992. The decline of Decapoda and Ephemeroptera was observed from April to October, 1992 and April to July, 1992 respectively. The former increased in November and December, 1992 but declined again in the same period in 1993. The appearances of Nematoda and Oligochaeta were pronounced between the months of March and July, 1992 and 1993.

The two groups of organisms had their peak in May 1993. A sharp decrease in abundance is observed as from August, 1992 after the rains. No record of mollusca was made in this station.

In station 2, irregular fluctuations of Nematoda, Oligochaeta and decapoda were observed throughout the period of studies, with each having a peak in November, 1992, April, 1992 and November 1992 respectively. Copepoda had two peaks of abundance in April and October, 1992; with a sharp decrease in May to August, 1992. The dry season appears to be the favourably period for the copepoda rapid increase.

Mullusca were dominant generally from December, 1991 to September, 1992 and January to May, 1993; with a major peak in February, 1992.

Diversity

Fig. 4 shows the species richness (d) belonging to the studied station on each sampling month. The observed species richness was high for most months in the two stations with a tendency to be lower in the months of April 1992 at station 1 and October 1992 at station 2. But species richness was more elevated in January, 1993 in both stations of the eighteen months of sampling, species diversity with species richness index of over 4.00 was recorded in fourteen (14) months at station 1, while station 2 had a record of the same index in only three months of sampling. Again, this shows that the former station had higher number of taxa recorded at every sampling visit than the later.

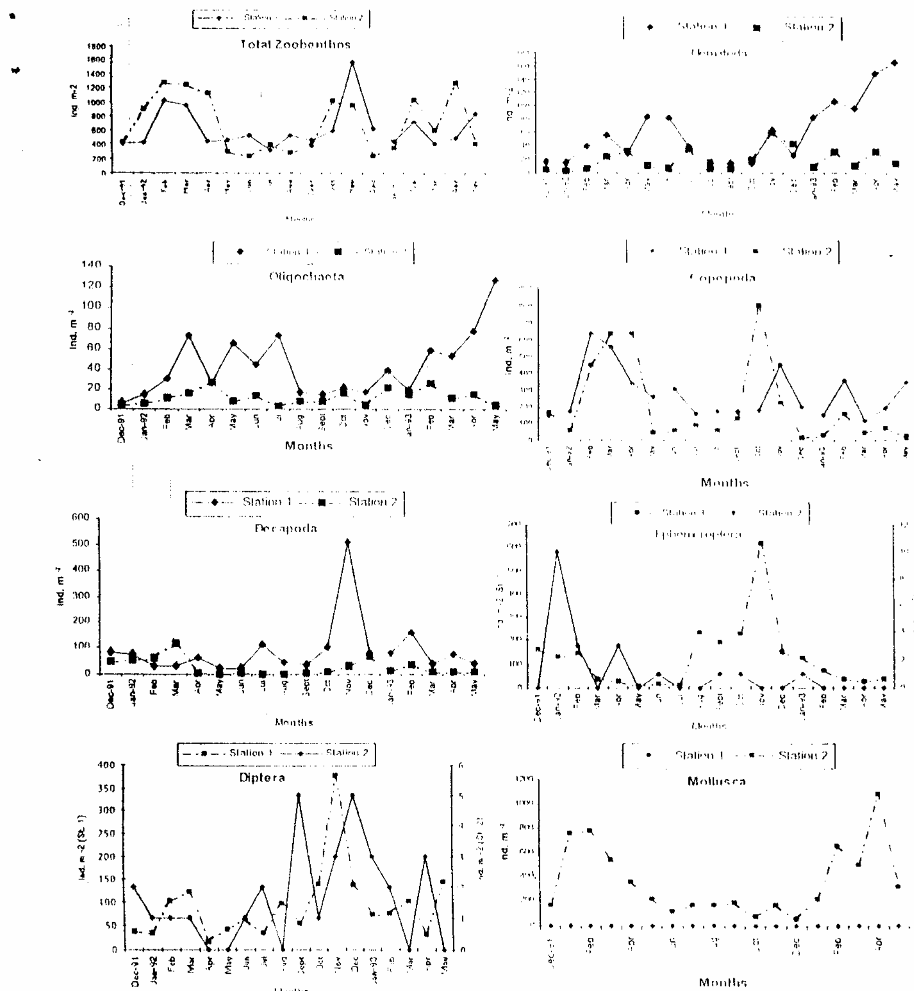

Fig. 3: Macroinvertebrate densities for total invertebrates and eight dominant taxa from December 1991 to May 1993.

Table 2: Composition, abundance and distribution of macro-fauna in Warri River, 1991 – 1993. + = Rare (< 10 indiv.); ++ = Commom (> 10 indiv.); +++ = Dominant (> 100 indiv.); ++++ = Abundant (> 500 indiv.)

TAXA	Sation 1 (Upper Reaches)	Station 2 (Lower Reaches)
PHYLUM NEMATODA		
CLASS: SECERNENTA		
Order: Diplogasteridae		
Diplogaster sp.*	++	+
Order: Enoplida		
Family: Dorylaimidae		
Dorylaimus sp. 1	++	+
Dorylaimus sp. 2	+	+
Order: Chromadorida		
Family: Plectidae		
Rhabdolaimus sp.	+++	++
Rhabdatid sp.	+	
PHYLUM ANNELIDA		
CLASS: OLIGOCHAETA		
Order: Pleslopora		
Family: Aeolosomatidae		
Aelosoma sp.	+	
Family: Naidiade		
Aulophorus furcatus, Muller 1773	+	+
Aulophorus vagus, Leidy	+	+
Chaetogaster diphanus, Gruith	++	
Nadium bilongata, Chen*	+	
Nadium breviseta, Bourne*	+	
Nadium osborni, Walton*	+	+
Nais communis	+	+
*Nais obtusa**	++	+
*Nais simplex**	+	+
Nais sp.	+	+
Ophidonais sp.	+	
*New record in Nigeria		
Pristina sp.	++	+
Stylaria fossularis, Leidy 1852	++	+

Table 2 (Contd)

TAXA	Sation 1 (Upper Reaches)	Station 2 (Lower Reaches)
CLASS POLYCHAETA		
Lycastoides alticola		
Lycastopsi sp.		+
Namanereis hawaiiensis, Johnson 1903		+
Nereis sp.		+
CLASS HIRUDINEA		
Order: Rhynchobdellida		
Family: Glossiphonia		
Placobdella monifera, Moore 1912	+	
Order: Arynchobdellida		
Family: Hirudidae		
Haemopsis mamorata, say 1824	+	
Haemopsis sp.	+	
*New record in Nigeria		
PHYLUM ARTHROPODA		
CLASS: CRUSTACEA		
SUBCLASS: BRANCHIOPODA		
Order: Cladocera		
Family: Chydoridae		
Subfamily: Chydorinae Stebbing 1902		
Ephemeroporus barrosi Richard 1894	++	+
Pleuroxus laevis Sars, 1865	++	+
Subfamily: Aloninae Frey, 1967		
Euryalona orientalis Daday, 1898	++	
Family: Sididae Sars, 1865		
Laptonopsis sp.	+	
SUBCLASS: COPEPODA		
Order: Cyclopoda		
Cyclops bicolor	+	+
Ectocyclops phaleratus	+	+
Eucyclops agiloides	++	++
Halicyclops kondiensis	++	++
Halicyclops sp.	+	+

Table 2 (Contd.)

TAXA	**Sation 1 (Upper Reaches)**	**Station 2 (Lower Reaches)**
Macrocyclops sp.	+	++
Mesocyclops leuckarti (Ogunu)	++	++
Mesocyclops salina	++	++
Mesocyclops sp.	++	++
Metacyclops minutus	++	++
Microcyclops varicans	+	++
Thermcyclops sp.	+	++
Order: Harpacticoida		
Bryocamptus sp.	+	++
SUBCLASS: OSTRACODA		
(Several species unidentified)		
SUBCLASS: MALACOSTRACA		
Order: Decapoda		
Family: Atyidae		
Caridina Africana Kinsley, 1882	++	
Caridina gabonensis Roux, 1927	++	
Family: Desmocaridae		
Desmocaris bislineata	+	
Desmocaris tripinosa Auruvillius	+	+
Family: Eurhynchydae		
Euryhynchina edintonae Powell	+	+
Family: Apheidae		
Potamalpheops monody (Sollaud)	++	++++
Family: Palaemonidae		
Leander tenuicormis (Say)	+	+
Family: Gecarcinidae		
Cardiosoma sp.		+
Family: Grapsidae		
Sesarma alberti Rathbun		++
Order amphipoda		
Gammarid sp.		+
CLASS ARACHNIDA		

Table 2 (Contd.)

TAXA	Sation 1 (Upper Reaches)	Station 2 (Lower Reaches)
SUBCLASS: ACARI		
Order: Hydrachnellae		
Family: Arrenuridae	+	
Arrenurus sp.	+	
Hydrarachna sp.		
Family: Hygrobatidae		
Hygrobates sp.	++	
Hygrobatid type B	+	
Mediopsis sp.	+	+
Megapus sp.	+	+
CLASS INSECTA		
SUBCLASS: PTERIGOTA		
ORDER: PLECOPTERA		
Family: Perlidae		
Neoperla sp. Needham	+	
Order: Ephermeroptera		
Family: Baetidae		
Baelis sp. Leach	+	
Baetis bicadatus	+	
Baetis tricadatus	+	
Callibaetis sp.	+++	
Centroptilum sp.	+++	
Cloeon cylindroculum	+++	
Cloeon simplex	++	
Cloeon bellum	+	
Cloeon sp.	++	
Heptagenia sp.	+	
Pseudocloeon sp.	+	
Family: Ephemeridae		
Ephemeralla ignita	+	
*New Record in Nigeria		

Table 2 (Contd.)

TAXA	Sation 1 (Upper Reaches)	Station 2 (Lower Reaches)
Family: Leptophlebiidae		
Adenophleblodes sp. Ulmer	+	
Family: Trichorythidae		
Dicercornyzon sp. Demoulin	+	
Order: Odonata		
SUBORDER: ANISOPTERA		
Family: Gomphidae		
Gomphid sp.	+	
Gomphid Type C	+	
Family: Libellulidae		
Libellulla sp.	+	+
Orthemis sp.	+	
Plathemis sp.	+	
SUBORDER: ZYGOPTERA		
Family: Coenagriidae		
Coenagrion sp.	+	
Coenagrion scitulum Rambur	+	
Enallagma sp. Chapenthier	+	
Hesperagrion heterodoxum Seleys	+	
Family: Lestidae		
Lestes sp. Kirby	+	
Order: Hemiptera		
Family: Naucoridae		
Pelocoris femoratus	+	
Order: Lepidoptera		
Family: Pyralididae		
Nymphula sp.	+	
Order: Trichoptera		
Family: Hydroptilidae		
Agraylea sp. Curtis	+	
Hydroptila sp.	++	
Oxyethira sp.	+	

Table 2 (Contd.)

TAXA	Sation 1 (Upper Reaches)	Station 2 (Lower Reaches)
Family: Limnephilidae		
Leptocella sp. Banks	++	
Family: Polycentropidae		
Polycentropus sp.	+	
Order: Coleoptera		
Family: Hydrophilidae		
Hydrophilus sp. Geoffrey	+	
Family: Dytiscidae		
Deronecles sp.	+	
Dytiscus marginalis	+	
Laccophilus sp.	+	
Family: Chysomelidae		
Donacia sp.		+
Order: Diptera		
Family: Ceratopogonidae		
Alluaudomyia needhami	+	
Forcipomyia sp.	+	
Palpomyia sp. Meigen 1818	+	+
Palpomyia tibialis	+	
Stilobezzia antennalis	+	
Family: Chironomidae		
Subfamily: Chironomidae		
Chironomus fractilobus		+
Cryptochironomus sp. Kieffer 1918	+	
Polypedilum sp. Kieffer 1913	+	
Pseudochironomus sp.		+
Tanytarsus sp. 1 Wulp 1874		++
Tanytarsus sp. 2		+
Tanytarsus sp. 3		+
Subfamily: Orthocladiinae		
Cardiocladius sp. Kieffer 1912	+	+
Corynoneura sp. Winaertz 1846	++	+

Table 2 (Contd.)

TAXA	**Sation 1 (Upper Reaches)**	**Station 2 (Lower Reaches)**
Cricotopus sp. 1 Wulp 1874	++	
Procladius sp.	+	+
Subfamily: Tanypodinae		
Tanypus sp. Miegen 1803	++++	+
Clinotanpus maculatus	++	+
Pentaneura (Ablabesmyia) sp.	+	+
Family: Psychodidae		
Antocha sp.		+
Psychoda sp.	+	
Family: Culicidae		
Subfamily: Culicinae		
Culex sp. 1		+
Culex sp. 2	+	
Culicid Type E		+
PHYLUM MOLLUSCA		
CLASS: GASTROPODA		
SUBCLASS: PROBOSBRANCHIA		
Order: Mesogastropoda		
Family: Neritdae		
Neritima glabrata Lamarck		+++
Nerita senegalensis		++
Family: Hydrobiidae		
Hydrobia sp. Hartmann		+++
Hydrobia guyenoti Binder		++++
Hydrobia lineate Binder		+++
Potamopyrgus sp. Stimpson		++
Potamopyrgus ciliatus Gould		++++
Family: Planorbidae		
Biomphalaria sp.		++
CLASS LAMELLIBRANCHIA		
Family: Patellidae		
Patella sp.		+
Family: Ancylidae		
Macoma cumana		+
Sphaerium corneum		+

Table 3: Relative percentage composition of the benthic organisms in the two stations.

Group	Relative % representation in station	
	STATION 1	**STATION 2**
Nematoda	8.1	2.8
Oligochaeta	6.8	1.7
Polychaeta	-	0.4
Copepoda	39.6	30.5
Decapoda	3.0	11.2
Decapoda (Crabs)	-	1.3
Ephemeroptera	18.4	0.03
Diptera	16.4	0.88
Odonata	0.8	-
Caddis larvae	1.5	-
Arachnids	1.9	-
Gastropoda	-	49.7

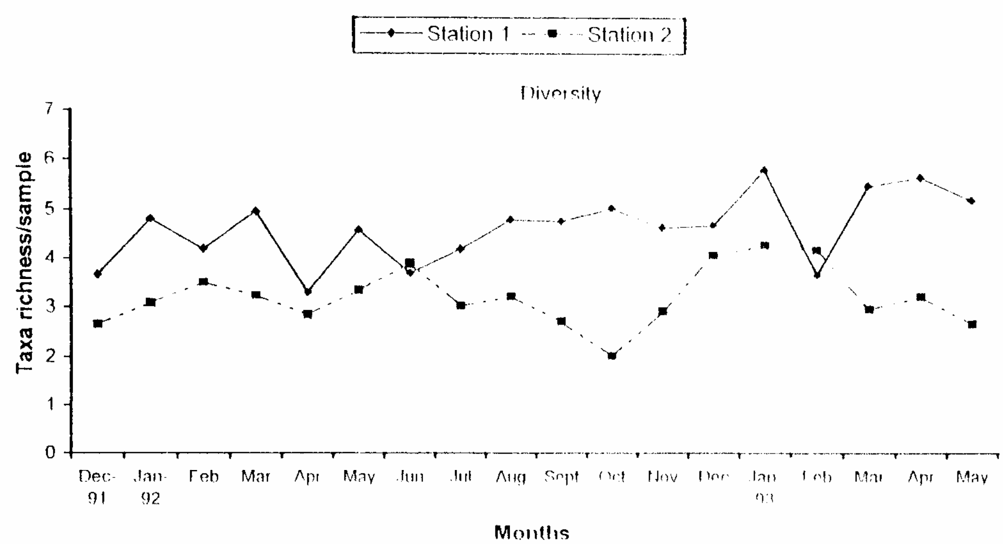

Fig. 4: Taxa richness per sampling visit in the two stations

Discussion

The qualitative nature of the macrobenthic fauna of Warri River appear to be unique in its community structure. In all, 138 taxa were identified from the sample collected from the stations, and the community structure was dominated by various benthic invertebrate groups of the animals recorded in this river are widely distributed elsewhere in Africa. This is not surprising since the colonization of streams to a great estent depends on animals with wide distributional capacities, (Green, 1979). Such common taxa include the Ephemeroptera, Chiromidae, Oligochaeta, Libellulidae and Dytiscidae. Species of decapod such as *Caridina Africa, C. gabonensis, Desmocaris trispinosa* and *potamalpheops monody* are widespread in West Africa and also in other African countries (Powell, 1978). Few of the Diptera such as the ceratopogonid, *Palpomyia sp., Forcipomyia sp., Stilobezzia, antennalis* and *polypedilum sp*. were known with certainty only from the Holarctic region. However, *Naidium bilongata, N. breviseta, N. osborni, Nais obtuse, Haemopsis marmorata, Namanereis hawaiiensis, Lycastoides alticola, Baetis bicaudatus* and *B. tricaudatus*, appear to be first records for Nigeria. The invertebrate community of lotic ecosystem is a conservation assemblage of types that recur in similar biotopes regardless of geographical location. Similar environmental niches harbour analogous taxa, often of the same family or generic group, wherever such habitats are found (Bishop, 1973).

A comparison of the community structure of the present Warri river catchment area with those of temperate streams reveals that the number of taxa recorded in this study is quite high and similar to those of temperate regions in all respect (Fahy and Murray, 1972; Town, 1978a, 1979). Fahy (1975) while investigating a small stream in Western Ireland reported 100 taxa, a figure relatively lower than that of the present study. But Towns (1978a) reported 144 taxa from the Waitakere system in which Diptera comprised twenty-four species. The diversity of invertebrate communities in tropical streams is known to be higher than that of the temperate streams (Bishop, 1973). In Nigeria, although few macrobenthic organisms of some river in Nigeria have been studied, taxa recorded from such studies are precisely very low (Victor and Dickson, 1985; Victor and Ogbeibu, 1985; Olomukoro (1983). A total of 55 taxa was recorded on some biotopes of Ikpoda river (Victor and Ogbeibu, 1985) and Olomukoro (1983) recorded 33 taxa in a tributary of it. The low number of taxa reported in these studies is probably due to the inadequacy of taxonomic information on the streams benthos of Nigeria. This may also account for the low diversity in these streams and therefore should be given due consideration while comparing temperate streams. It has been observed that the high abundance or standing crop of Benthic invertebrates in any aquatic ecosystem does not simultaneously mean greater species diversity in the system. Fahy (1975) on the invertebrate community of a small stream in Western Ireland, found approximately 60,000 invertebrates comprising 100 taxa that were listed. By comparison thirty-four species of trichoptera (Towns, 1978a; Ulstrand. 1968a), twenty-two species Ephemeropetra (Ulfstrand, 1968a) and fifty-five species of Chironomidae (Fahy and Marray, 1972); twenty-five species Plecopterans were recorded in a single study in most European rivers. Whereas fewer species of Trichoptera (7) and Plecoptera (1) were respectively recorded here.

Few of the benthic organisms have some specialized distributional pattern as exhibited by Polychaeta, Trichoptera, Odonata, Coleoptera, Amphipoda and Mollusca. The first benthic organisms were restricted to the upstream stations 1 where the water is fresh throughout the year. While Amphipoda and Mollusca were restricted to the fresh/brackish waters of station 2. It is difficult to ascertain whether the occurrence of these species in the river are influenced by a particular factor.

All the species of Polycheta recorded during the study were confined to station 2. The restriction of Polycheta to this station is expected. They are deposit feeders and live in mud. Polycheta are also known to be tolerant to silting and velocity of flow than most groups of benthic organisms (Bishop, 1973). Their occurrence may be governed by niche preference and feeding habit.

All the species of Polychaeta recorded during the study were confined to station 2. The restriction of Polychaeta to this station is expected. They are deposit feeders and live in mud. Polychaeta are also known to be tolerant to silting and velocity of flow than most groups of benthic organisms (Bishops, 1973). Their occurrence may be governed by niche preference and feeding habit.

The trichopteran larvae (or caddisfly larvae) were significantly restricted to the upstream station 1. Current is an important factor controlling the distribution of net-spinning forms. Trichopteran are known to utilise specific currents and dynamic pressure to maintain efficiency in their seston sieving devices

(Carisson, 1967; Edington, 1968). Besides, the caddishfly larvae are highly tolerant to organically polluted rivers or streams with BODs of more than 5.0 ppm as occasionally observed in the down stream station 2. All this probably explains the distribution of this group in station 1 whereas their occurrence in the down stream station is lacking.

The distributional pattern of Odonata and coleopteran larvae was similar to that of trichoptera nymphs. Their occurrence in the upstream station 1 probably shows their complete dependence on current flow for feeding respiratory requirements.

All molluscan species recorded in this study were restricted to the downstream station 2. Four species, *Hydrobia lineata, Hydrobia guyenoti, Tympanotonus fuscatus radula* var. and *Tympanonus fuscatus fuscatus* were present in this station. The first two species are the two dominant species among the molluscan organisms recorded in the station, and they are known to be prevalent in blackish waters, streams or lakes whose surface waters are less acid than pH 6.2 (Pennak, 1953). This may not be the only limiting factors in the distribution of mollusca in this river.

The seasonal variations in the population density of the dominant group of benthic invertebrates in the stations revealed that the Nematoda, Crustacea, Oligochaeta, Diptera and Mollusca were abundant all the year round. The attainment of maxima of crustacea, Oligochaeta, Nematoda and Mollusca occurred only in the dry season (that is from January to May) than in the rainy season period. The high density of the Ephemeroptera and Diptera was observed to prevail at the end of the rainy season (between September and February). This pattern of seasonal variation was also exhibited by Arachnida, Odonata, Trichoptera and Coleoptera whose appearance was more significant than abundant in August to October and became scarce in the rest months.

Hydrobiological investigations revealed the positive correlation of Arachnida high turbidity (in the rainy season). Of all the macro-invertebrate organisms recorded, Mollusca had positive significant correlations with conductivity, turbidity, total solids and total hardness. These factors may have determined the restriction of Mollusca to the fresh/brackish water of station 2. Among the benthos, positive significant correlations were established between Diptera and Crustacea/Odonata/Arachnida/Ephemeroptera. Ephemeroptera was also significant with Odonata while Odonata with Crustacea. Although the feeding relationships in these organisms have not been experimentally determined, grazing may be an important factor in the seasonal variations and interrelationship of Warri River Macrobenthos.

Diversity between the two stations is quite significant. Application of Sorensen's quotient (Q/S) indicates great dissimilarity in species composition between the stations.

Species richness was observed to decline at the on set of rainy season. This probably could be attributed to some environmental factors such as impact of run off from the surrounding land and its attendance problem on the bank roof of the receiving water body. This is known to increase the suspended solids load on the river bed and consequently reducing or blanketing breeding sites of macro-invertebrates and some in the process are completely wiped out of existence particularly the sessile forms.

In conclusion, long term limnological investigations with emphasis on water quality monitoring programme, detail systematics and ecology of the macrobenthos should be initiated on Nigeria water bodies to unveil the critical factors influencing the ecology of macrobenthic fauna.

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