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Salinity and the distribution of Cladocera in Warri River, Nigeria

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Abstract

Hydrobiological investigations of the water quality and plankton of Warri River started in 1981, shortly before the commissioning of the Delta Steel Plant on the banks of the river at Aladja. The 150 km of river gradates from pure freshwater through brackish to marine and so provides a suitable habitat for a study of the limits of migration of any group of zooplankton.

The Cladocera of Warri River consists of two bosminids, thirteen chydorids, three daphniids, three macrothricids, one moinid, and two sidids. All except the sidid *Penilia* sp. are well known freshwater forms, which are limited in longitudinal distribution to areas with salinity below 2.5‰.

Penilia sp. found in Warri River were restricted to the truely brackish-water areas with salinity values of 7‰ – 8‰. In this respect they represent the first reported brackish water Cladocera in Africa. They also differ from *Penilia avirostris* Dana found in marine habitats in certain morphological details, and so the Warri River *Penilia* may be a new taxon.

Introduction

The coastal lagoons and tidal rivers of Nigeria have received relatively little hydrobiological attention in the last decade. Many of the investigations in this region have either been fishery oriented (F.A.O., 1965; Bayagbona, *et al.*, 1971; Fagade & Olaniyan, 1972, 1974; Ikusemiju, 1973; Oni, 1973; Powell, 1976; Marcus & Kusemiju, 1984; Nwadiaro, 1985) or oil pollution related (Imevbore, 1979; Adeyemi & Imevbore, 1980; Ekekwe, 1981; Edwards *et al.*, 1983; Ibiebele *et al.*, 1983; RPI, 1985; Ikomi, 1985). These latter studies, which are of short duration and are based on a few specific samples of the consultants, are of little taxonomic significance with regards to the cladoceran fauna of these water bodies.

Indeed, reports on the cladoceran fauna of Nigerian rivers are scanty. To date, the only detailed work has been that of Green (1962) on the Sokoto River in Northern Nigeria. Green described *Alona holdeni* among twenty-nine other cladoceran species. There were in River Sokoto one bosminid, twenty chydorids, two daphniids, four macrothricids, one moinid, and two sidid species (Green, 1962). In River Oshun in Southern Nigeria, Egborge (1972) reported the occurrence of single species each of Bosminidae, Chydoridae, Daphniidae, Moinidae, and Sididae. The low species list of Cladocera in River Oshun was no doubt due to the overwhelming taxonomic problems of the group, particularly of the Chydoridae, which presents the greatest number of species of Cladocera in Nigeria (Rey & Saint-Jean, 1968; Bidwell & Clarke, 1977; Egborge, 1981).

There is in fact no information on the longitudinal variations in the community composition of Cladocera in any of the numerous coastal rivers with atlantic tidal influences in Nigeria. Hence the work reported in this communication attempts to bridge that gap in knowledge and provide some information on salinity and longitudinal distribution

of Cladocera in Warri River.

Identifications of the Cladocera reported here were made in the Zoological Institute, State University of Ghent during a short visit in the Summer of 1982. I am most grateful to both Dr Henri Dumont for help with the identifications and to him and the Director of the Institute for their hospitality.

Geography and sampling stations

The Warri River stretches within latitudes 5°21′ – 6°N and longitudes 5°24′ – 6°21′E. From its source at Utagba-Uno, it meanders past Warri, flowing through the high rain forest belt to Forcados. Here it joins the Forcados River, which is a major confluence of the Atlantic Ocean (Fig. 1). Beyond Warri in the lower reaches of the river, the shore vegetation is typically mangrove swamp with a preponderance of *Rhizophora racemosa* and *Nepah* palms.

Climatic influences in the Niger Delta in Nigeria vary from north to south, so that the rainy season lasts for 11 months in Forcados (close to the Atlantic Ocean), 7–9 months at Warri (about 66 km from Forcados), and 6–7 months at Utagba-Uno. At Warri (Fig. 2) 25 cm and 20 cm of rainfall were respectively recorded at the peak of the rainy sea-

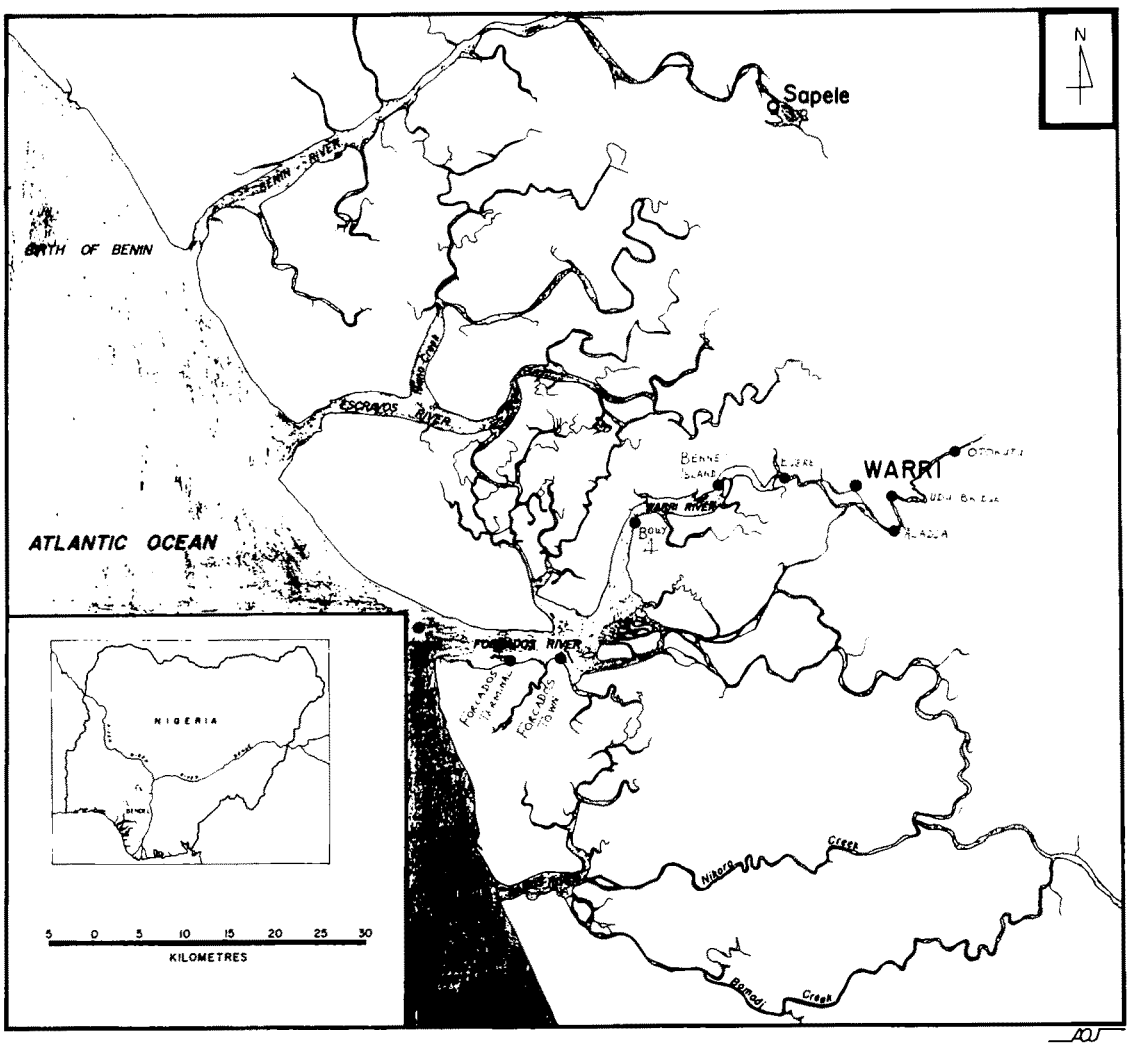

Fig. 1. Location of Warri River in Nigeria (Inset) and sampling stations in 1985.

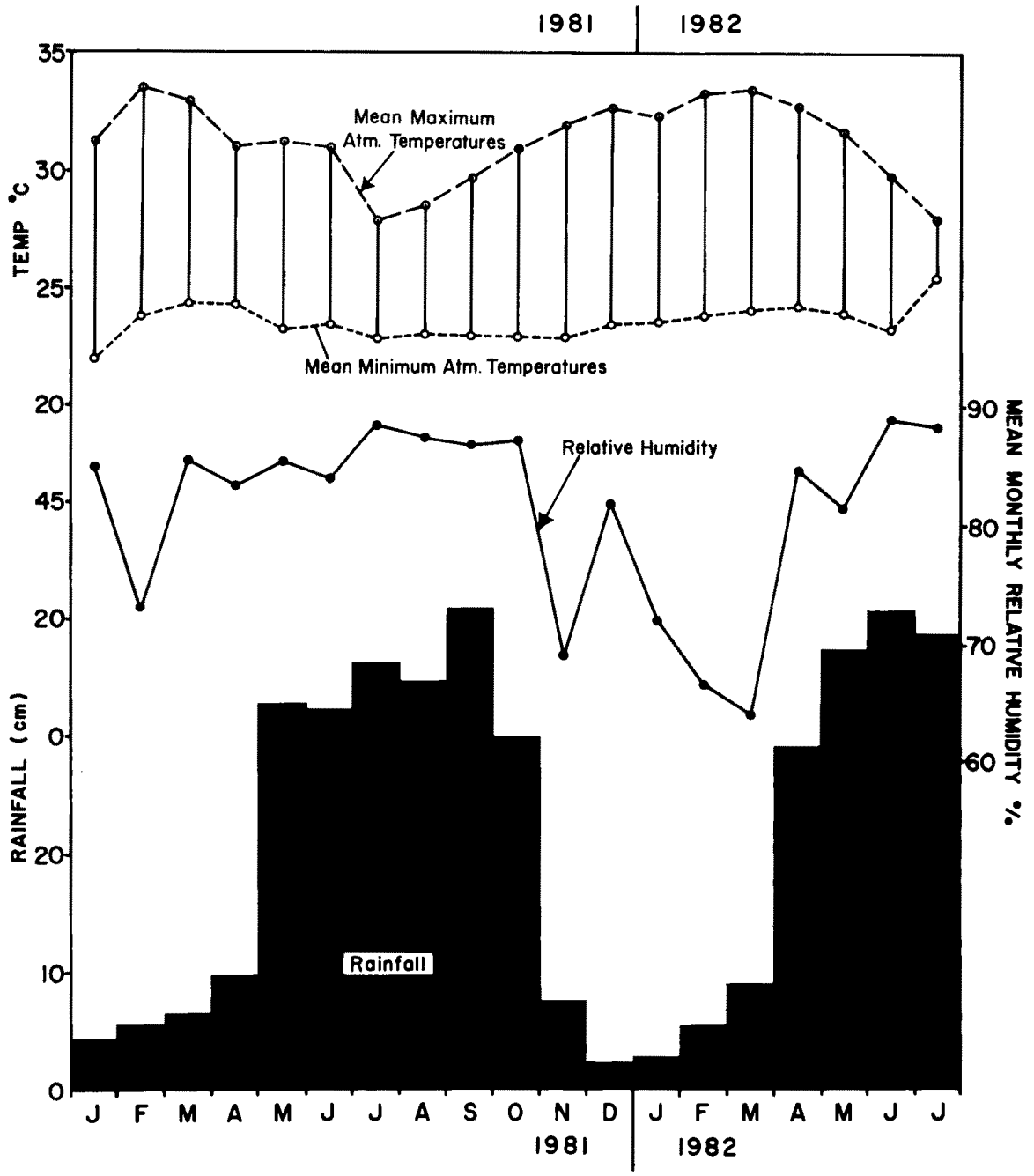

Fig. 2. Seasonal variations in rainfall, relative humidity, minimum and maximum atmospheric temperatures in Warri during 1981 & 1982.

son in September 1981 and June 1982, while less than 10 cm of rainfall was recorded from January to March 1981 and from November 1981 to March 1982. This latter period, with little annual variation, represents the dry season months in Warri. Generally low relative humidity and high atmospheric temperatures characterize the dry season, while the reverse is the case in the rainy season.

Sampling in Warri River started in 1981, and its extent has been dictated by the availability of research funds. Thus from 1981 to 1984, sampling was restricted to the middle 50 km of river, a portion that is predominantly fresh with brackish salinities occurring only from February to April around Warri (Fig. 3). Regular monthly sampling of the lower 77 km of River (Otokutu to Forcados terminal) started from March 1985 to date. The stations sampled during 1981 to 1985 are shown in Table 1, together with their distances from the Atlantic Ocean (South Point) and Forcados terminal.

Table 1. Sampling stations in Warri river and distances from the Atlantic Ocean (south point).

Station	Distance to	
	Forcados Terminal (km)	Atlantic Ocean South point (km)
1981 to 1984		
Udu Bridge	66.5	76.3
Aladja	60.7	70.5
Warri	56.0	65.8
Orugbo Creek	46.0	55.8
Ode Itsekiri	40.2	50.0
1985		
Otokutu	77.0	86.8
Udu Bridge	66.5	76.3
Aladja	60.7	70.5
Warri	56.0	65.8
Ejere	45.5	55.3
Bennet Island	35.0	44.8
Bouy 4	25.7	35.5
Forcados Town	3.4	13.2
Forcados Terminal	0.0	9.8

Sampling periodicity and methods

Sampling times were determined from TIDE TABLES prepared by the Nigerian Navy (1981, 1982, 1983, 1984, 1985). Generally rainy season samples were taken at low tide from Warri towards Forca-

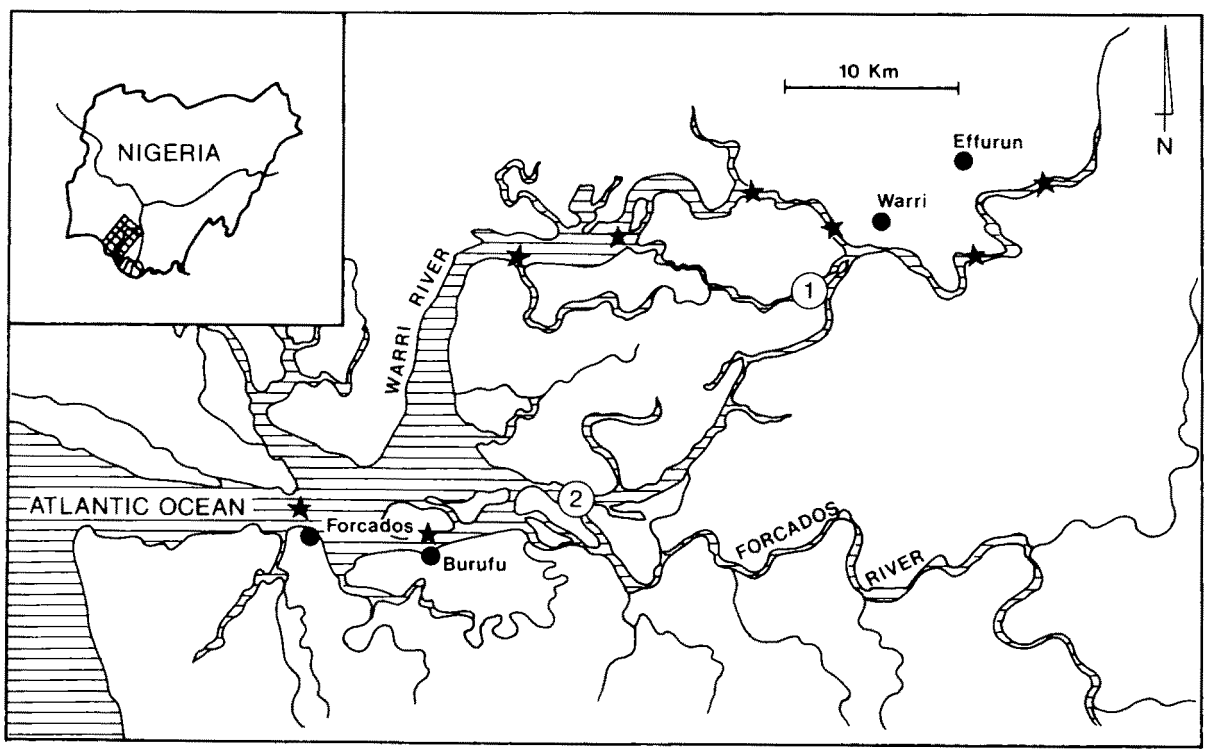

Fig. 3. Part of Warri River showing sampling stations in 1981/1982.

dos, and dry season samples were taken at high tide in a reversed direction. This is a deliberate effort to get minimum and maximum river conditions in any one year.

On each sampling day, quantitative plankton samples were collected by towing two HYDRO-BIOS 55 μm and 100 μm mesh nets at low speed for 10 minutes. Plankton samples were preserved in 4% formalin.

Salinity values were obtained on the spot using an Oceanographic salinity measuring bridge type MC5 manufactured by Electronics Instruments Limited, Surrey, England. Salinity values below the limit of resolution with the measuring bridge (2‰) were obtained by the titrimetric method of Harvey (1969). The titrations were done on a magnetic stirrer.

Results and discussion

The Cladocera:

The Cladocera of Warri River consists of 24 species in six families. These are:

FAMILY BOSMINIDAE

Bosmina longirostris (O. F. Müller, 1785)
Bosminopsis deitersi Richard, 1897.

FAMILY CHYDORIDAE

Alona alonopsoides Brehm, 1933
Alona diaphana King, 1853.
Alona eximia Kiser, 1948.
Alona holdeni Green, 1952.
Alona karua King, 1853.
Alona pulchella King, 1853.
Alona quadrangularis (O. F. Müller, 1785)
Alona rectangula Sars, 1862.
Chydorus sphaericus (O. F. Müller, 1785)
Ephemeroporus sp.
Kurzia longirostris (Daday, 1898)
Leydigia ciliata Gauthier, 1939.
Pleuroxus laevis Sars, 1862.

FAMILY DAPHNIIDAE

Ceriodaphnia cornuta Sars, 1885.
Ceriodaphnia rigaudi Richard
Scapholeberis kingi Sars, 1903.

FAMILY MACROTHRICIDAE

Ilyocryptus spinifer Herrick, 1882.
Macrothrix laticornis (Jurine, 1820)
Macrothrix spinosa King, 1853

FAMILY MOINIDAE

Moina micrura Kurz, 1874.

FAMILY SIDIDAE

Diaphanosoma excisum Sars, 1885.
Penilia sp.

With the exception of *Bosmina longirostris* and *Penilia* sp. the remaining Cladocera in Warri River have been listed from rivers and lakes in Nigeria (Green, 1962; Egborge, 1972, 1981). On-going research in Nigeria suggests that *Bosmina longirostris* is common in freshwater ponds and rivers with slightly acidic pH values. These ponds and rivers are associated with the swamps of the Niger Delta. In Lake Bangweulu and the Luapula River Basin in Central and East Africa, *Bosmina longirostris* was found in lakes, rivers, and ponds with pH values of 5.7–8.1 (Kořinek, 1984).

Penilia, described by Dana (1852), is recognizable by the 2-segmented rami of the antenna (Fig. 4). According to Korovchinsky (in Smirnov Timms, 1983), the head of the female of *P. avirostris* has two ventral rostral projections (absent in the male), and the posterodorsal part of the shell has a deep depression. The Woods Hole Massachusetts, *P. avirostris* Dana also show two ventral projections, one of which is the well developed antennule (better developed in the males) and the deep postero-dorsal depression (Lochhead, 1954). All the specimens seen in Warri River samples have a birdlike pointed 'beak' or rostral projection and a prominent cervical sinus in addition to the postdorsal depression. In addition, the postero-ventral projection of the shell is relatively longer and not as pointed as the Woods Hole specimens. One point of agreement of the Warri River specimens and the descriptions of Korovchinsky (1983) and Lochhead, (1954) is the very long terminal claws

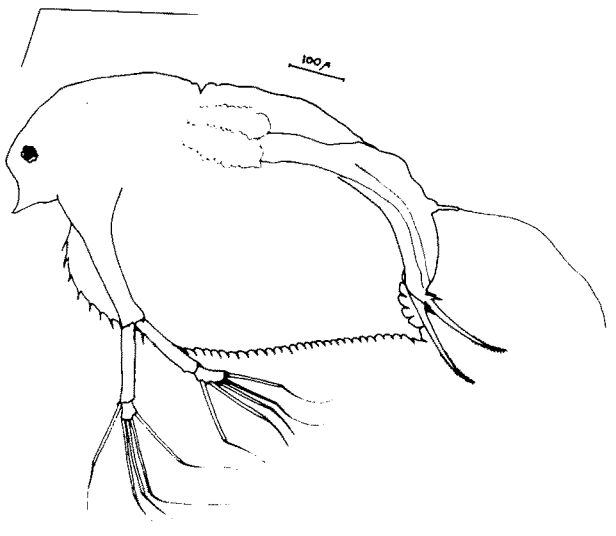

Fig. 4. Penilia sp. from Warri River, Nigeria.

of the postabdomen, each with a pair of basal spines. The Warri River specimens have the following dimensions:

Body length	=	0.80 mm
Body height	=	0.50 mm
Carapace length	=	0.61 mm
Terminal claw	=	0.21 mm

From all indications, the Warri River specimens are probably not *Penilia avirostris* Dana. They also are certainly not *P. orientalis* Dana, *P. pacifica* Kramer, or *P. schmackeri*. Richard. The specific identification of the Warri River *Penilia* can be made only after detailed examination of more specimens and reference to the drawings and descriptions (Dana, 1852a, b; Kramer, 1895; Zernov, 1908; Calman, 1908; Behning, 1927; Steuer, 1933a, b; Dakin & Colefax, 1940; Dolgopolskaya, 1958; Markina, 1975).

Longitudinal distribution of Salinity

The seasonal variations in salinity from Udu Bridge to Ode-Itsekiri Community Farm during 1981/82 is shown in Fig. 5. Salinity varied from 0.02‰ at Udu Bridge to 2.35‰ at Orugbo Creek. At all five stations, the peak period of salinity was April 1982, when salinities were 0.32‰, 1.30‰, 2.05‰, 2.35‰ and 1.15‰ at Udu Bridge, Aladja, Warri, Orugbo Creek and Ode-Itsekiri Community Farm, respectively. The seasonality in the fluctuations in salinity are apparent, with higher salinity values in the dry season months and lower values in the rainy season months. The salinity peak recorded in all stations in April is out of phase with the pattern of rainfall. This is because of the well known time lag between the onset of the rains and the time it takes runoff water to get into the river systems in Nigeria.

The generally lower salinity values at Ode-Itsekiri Community Farm is the result of dilution of the river waters by masses of freshwater from the

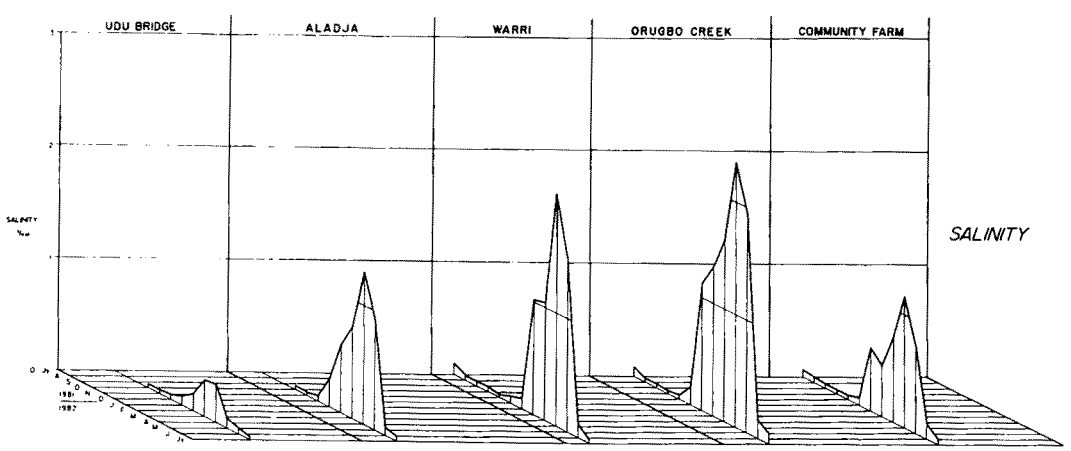

Fig. 5. Qualigrams showing the seasonal variations in the longitudinal distribution of salinity in five sampling stations in Warri River in 1981/1982.

numerous tributaries in this region. Thus, in any one year at any station from Udu Bridge to Ode-Itsekiri the Cladocera are subjected to salinity fluctuations of 0.02 to 2.35‰.

Distribution of Cladocera in 1981/82

The seasonal variations in the relative importance of Cladocera and Copepoda in four stations of Warri River shown in Fig. 6 reveal that importance of Cladocera decreases with nearness to the Atlantic ocean. Cladocera were relatively more important than Copepoda at Udu Bridge (76 km), where in April 1982 at the peak fo the dry season they accounted for 80% of the adult crustacean plankton population. It was only at this station that the few specimens of *Scapholeberis kingi* and *Alona alonopsoides were found. At Warri (66 km) the Cladocera accounted for only 6% of the adult crustacean plankton population in April 1982. Although the only cladoceran present in Orugbo Creek at this time when salinity was 2.35‰* was *Diaphanosoma excisum,* its presence could be due to the proximity of the Community Farm (Ode-Itsekiri), from where there is an influx of freshwaters from inland tributaries of the Niger Delta swamps. In the dry season month of April, freshwater influx can only be through the advent of low tides or direct precipitation. The relative importance of Cladocera at Ode-Itsekiri was generally low with the exception of July 1981 and February 1982, when they had higher relative values than the Copepoda.

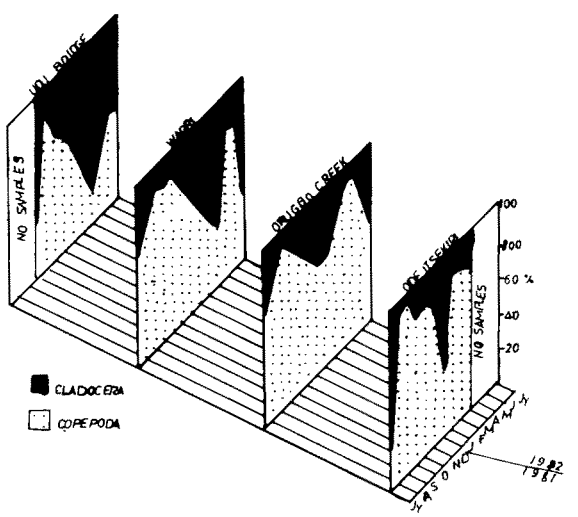

Fig. 6. Seasonal variations in the relative importance of Cladocera and Copepoda in four stations of Warri River.

Distribution of Cladocera in 1985

Figure 7 shows that *Bosmina longirostris, Bosminopsis deitersi, Moina micrura, Ephemeroporus* sp., and *Diaphanosoma excisum* were commonly seen in samples taken from stations where salinities were prodominantly below 1‰. All five cladocerans were thus limited to Otokutu and Udu bridge in March, and their range increased as salinity decreased from May to July from Otokutu to Bouy 4. In July when the low salinity zone was most extensive, the only cladoceran in Bouy 4 (S=1.8‰) was the sidid *Diaphanosoma excisum.* It would appear then that this cladoceran does venture into areas of the river with salinities of 1.8–2.4‰ (as seen in Orugbo Creek). On the other hand, *Bosmina longirostris* seems to have a salinity limit of 1.7‰, which was the salinity value at Udu Bridge in April 1985.

Penilia sp. was first seen in Warri River at Ejere in April, when the salinity was 7.1‰. During this period it was not seen in samples taken in the other stations from Bennet Island to Forcados Terminal, where higher salinities occured. Its second appearance was at Forcados Terminal in July, when the salinity decreased to 7.2‰ as a result of the high precipitation and runoff in this rainy season month. The appearance of *Penilia* sp. therefore was not only sporadic but was restricted to areas of the river where salinities were between 7‰ and 8‰.

The sporadic and discontinuous distribution of *Penilia* is well known (Lochhead, 1954) and seems explainable in terms of the distribution of resting eggs. Available literature shows that *Penilia* has been found mainly in open coastal waters with salinities of 32‰–49‰. Lochhead (1954) found it in Rio de Janeiro harbour in South America, and it has been seen frequently in Australia (Dakin & Colefax, 1940; Sheard, 1949; Kott, 1955, 1957; Markina, 1975). This, therefore, appears to be the first report of the occurrence of *Penilia* in the inland brackish waters of Africa. From the distribution of *Penilia* and other Cladocera in Warri River, the longitudinal zonation of the river is apparent with regards to the limits of distribution. Predominantly freshwater Cladocera are found

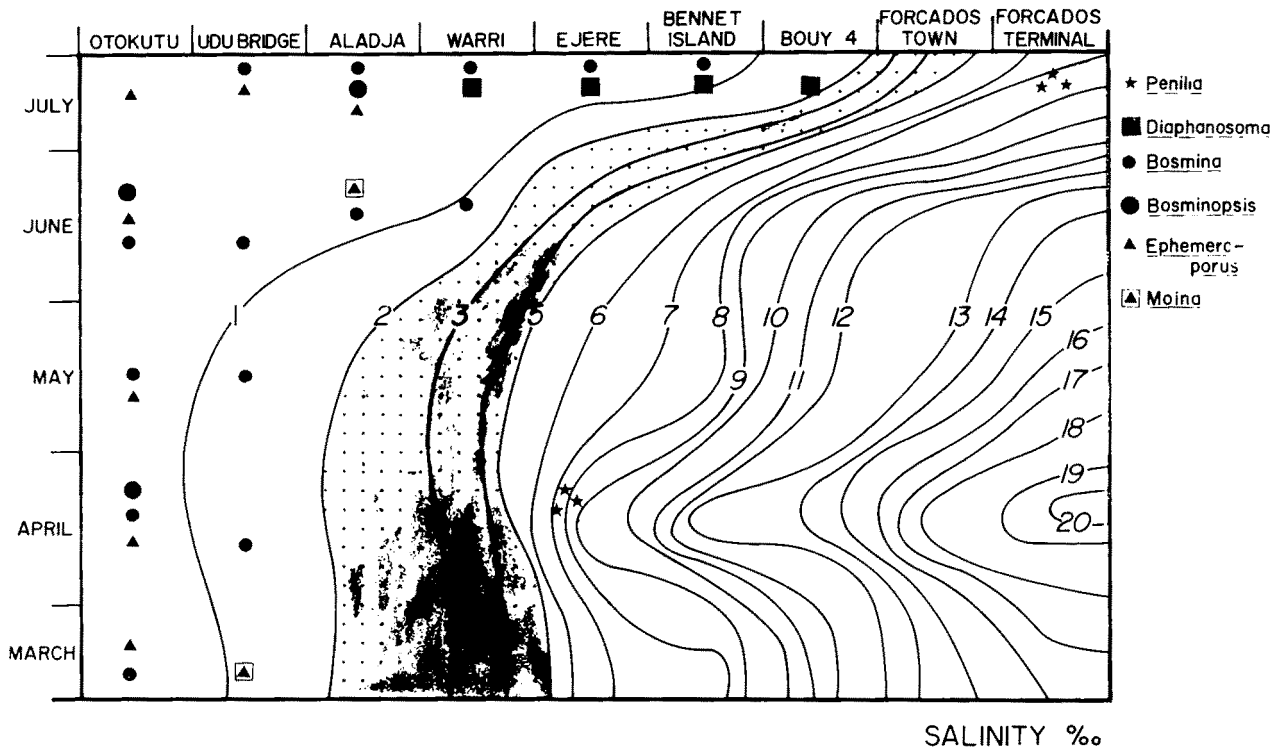

Fig. 7. Isohalines and distribution of Cladocera in the lower 77 km of Warri River.

where salinities are lower than 2‰/3‰, while brackish-water Cladocera are found where salinities are higher than 7‰. The region between these two limits is a NO CLADOCERA ZONE. The extent and position of this 'no cladocera zone' is seasonal and might also depend on tidal variations.

References

Adeyemi, S. A. & A. M. A. Imevbore, 1980. The effect of petroleum spillage and off shore mining activities on water quality. Proc. 1st. National Conf. on water pollution and pesticide residue in food. Fed. Ministry of Water Resources Publication. 45–60.

Bayagbona, E. L., V. O. A. Sagua & M. A. Afinowi, 1971. A survey of the shrimp resources of Nigeria. J. Mar. Biol. II (2): 179–189.

Behning, A. L., 1927. Ueber *Penilia schmackeri* aus dem Schwarzen Meer. In 'Collected papers dedicated to N. M. Knipovich'. Moscow pp. 345–350.

Bidwell, A. & N. V. Clarke, 1977. The invertebrate fauna of Lake Kainji, Nigeria. Nigerian Field 42(3): 104–110.

Calman, W. T., 1908. Notes on a small collection of plankton from New Zealand. Annals and Magazine of Natural History Series 8(1): 232–241.

Dakin, W. J. & A. N. Colefax, 1940. Plankton of the Australian coastal waters off New South Wales. Part 1. Monograph No. 1 Department of Zoology, University of Sydney.

Dana, J., 1852a. Conspectus Crustaceorum in orbis terrarum circumnavigatione C. Wilkes classe Republicae foederata duce collectorum. Proceedings of the American Academy of Arts and Sciences 2: 47.

Dana, J., 1952b. United States Exploring Expedition during the years 1838–42 under Charles Wilkes. Vol. 13: Crustacea Part II. Sherman, Philadelphia.

Dolgopolskaya, M. A., 1958. The Marine Cladocera of the Black Sea. Trudy Sevastopolskaya Biologicheskaya Stantsiya 10: 27–75.

Edwards, A. W. A., K. Ikusemiju, J. Alo & O. F. Kamson, 1983. Funiwa 5 oil well blow-out: recovery of mangrove areas and sandy beaches: Final Report for NNPC. Lagos, Nigeria.

Egborge, A. B. M., 1972. A preliminary check list of zooplankton organisms of the River Oshun in the Western State of Nigeria. Nig. J. Sci., 6: 67–71.

Egborge, A. B. M., 1981. The composition, seasonal variation, and distribution of Zooplankton in Lake Asejire, Nigeria. Rev. Zool. Afr. 95(1): 136–180.

Ekekwe, E., 1981. The Funiwa 5 oil well blow out. Proc. International Seminar on the Petroleum Industry and Nigerian Environment. Thomopolos Environmental Pollution consultant in Co-operation with NNPC Publication. 64–68.

Fagade, S. O. & C. I. O. Olaniyan, 1972. The biology of the West African shad *Ethmalosa fimbriate* (Bowditch) in the La-

gos Lagoon, Nigeria. J. Fish. Biol. 4: 519–534.

Fagade, S. O. & C. I. O. Olaniyan, 1974. Seasonal distribution of the fish fauna of the Lagos Lagoon. Bull. de IFAN. T. XXXVI. Ser. A(1). 244–252.

Food and Agricultural Organisation of the United Nations (FAO), 1965: Investigation of the possibility of brackish water fish culture in the Niger Delta. Nigeria. Report No. 1973. 52 pp.

Green, J., 1962. Zooplankton of the River Sokoto. The Crustacea. Proc. Zool. Soc. Lond. 138: 415–453.

Harvey, H. W., 1969. The Chemistry and Fertility of Sea Waters. Cambridge University Press. 240 pp.

Ibiebele, D. D., C. R. Powell, P. M. Shou, M. Isoun, M. Murday & M. D. Selema, 1983. Establishment of baseline data for complete monitoring of petroleum related aquatic pollution in Nigeria. Proc. Seminar on Petroleum Industry and the Nigerian environment. Port-Harcourt.

Ikomi, R. B., 1985. The fauna of Kulama Creek in the Niger Delta. M.Sc. thesis, University of Lagos, Lagos, Nigeria. 100 pp.

Ikusemiju, K., 1973. A study of the catfishes of Lekki Lagoon with particular reference to Chrysichthys walkeri (Bagridae). Ph.D. Thesis. University of Lagos, Nigeria.

Imevbore, A. M. A., 1979. The impact of oil production on the biota of the Niger Delta. Proc. Seminar on the Petroleum Industry and the Environment of the Niger Delta. Fed. Ministry of Housing and Environment Publication: 87–102.

Kořinek, V., 1984. Hydrobiological survey of the Lake Bangweulu Luapula River Basin. Cladocrea. Vol. XIII (2): Cercle Hydrobiologique de Bruxelles. 117 p.

Korovchinsky, N. M., 1983. Genus *Penilia* Dana 1852: in 'Revision of the Australian Cladocera' Eds. Smirnov, N. N. & B. V. Timms. Records of the Australian Museum (1983), Suppl. 1: 12–13.

Kott, P., 1955. The zooplankton of Lake Macquarie 1953–54. Australian Journal of Marine and Freshwater Research 6: 429–442.

Kott, P., 1957. Zooplankton of East Australian Waters, 1953–54. C. S. I. R. O. Australian Division of Fisheries and Oceanography Report No. 14.

Kramer, A., 1895. On the most frequent pelagic Copepoda and Cladocera of the Mauraki Gulf. Transactions and Proceedings of the New Zealand Institute, new series 10, 27: 214–223.

Lochhead, J. H., 1954. On the distribution of a marine cladoceran, *Penilia avirostris* Dana (Crustacea, Branchiopoda), with a note on its reported bioluminescence. Biological Bulletin 107: 92–105.

Marcus, O. & K. Kusemiju, 1984. Some aspects of the reproductive biology of the clupeid *Ilisha africana* (Bloch) of the Lagos Coast, Nigeria. J. Fish. Biol. 25: 679–689.

Markina, N. P., 1975. Planktonic communities in the Great Australian Bight. Hydrobiological Journal 11: 13–18.

Nigerian navy, 1981, 1982, 1983, 1984, 1985. Tide Tables. Tidal predictions for Lagos, Escravos Bar, Forcados Bar, Bonny Town and Calabar for the year 1981, 1982, 1983, 1984, 1985 (respectively). 37 pp.

Nwadiaro, C. S., 1985. The distribution and food habits of the dwarf African cichlid *Pelvicachromis pulcher* in the River Sombreiro. Nigeria Hydrobiol. 121: 157–164.

Oni, A., 1973. Seasonal variation in abundance of mullet fry in the Lagos Harbour mouth. Occasional Paper No. 21. Federal Department of Fisheries, Lagos, Nigeria.

Powell, C. B., 1976. The habitat and inland limit of *Alpheopis mondi* Sollaud. a freshwater alpheid (Decapoda Caridea) from West Africa. Crustaceana (Leiden) 31(3): 314–316.

Research planning institute (RPI), 1985. Environmental baseline studies for the establishment of control criteria and standards against petroleum related pollution in Nigeria Draft Final Report. RPI/R/84/4/15–7.

Rey, J. & L. Saint-Jean, 1968. Les Cladocères (Crustaces, Branchiopodes) du Tchad, Cah. O.R.S.T.O.M. Ser Hydrobiol., 11(3–4): 79–118.

Sheard, K., 1949. Plankton characteristics of the Cronulla onshore station, New South Wales, 1943–46. CSIRO (Australia) Bulletin 246:1–23.

Smirnov, N. N., and B. V. Timms, 1983. Revision of the Australian Cladocera. Records of the Australian Museum, Suppl. 1. 130 pp.

Steuer, A., 1933a. Zur Fauna des Canal di Leme bei Rorigno. Thalassia 1(4): 1–44.

Steuer, A., 1933b. Die 'Arten' der Cladocerengattung *Penilia* Dana. Mitt zool. Mus. Berlin 19: 80–83.

Zernov, S. A., 1908. *Penilia schmackeri* Richard (Cladocera) in the Black Sea. Yearbook of the Zoological Museum of the Academy of Sciences 13: 500–502. (In Russian).