Environmental Impact of Oil Exploration on the Crustacean Zooplankton of Osse River, Southern Nigeria

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Abstract. The impact of crude oil exploration on the crustacean zooplankton of Osse River, Edo State (Nigeria) was investigated at five sites between July 2000 and June 2002. Cladocera accounted for 60.85% of the total number of organisms collected from all the five stations, while Copepoda contributed 39.15%. Chydoridae, the only cladoceran family was represented by 11 taxa of two subfamilies, Aloninae (7) and Chydorinae (4). The overall abundance of Cladocera was significantly different ($P < 0.05$) among the stations. A *posteriori* Duncan Multiple Range (DMR) test showed that the abundance of Cladocera was significantly higher ($P < 0.05$) in 3 stations, whereas, Copepod abundance was significantly higher ($P < 0.05$) in 2 stations. The diversity indices revealed the highest and the lowest taxa richness, while Shannon-Wiener and Evenness indices were higher in 3 stations. The temporal dynamics revealed higher faunal abundance during the dry season.

Keywords: crustacea, zooplankton, fresh water, bio-diversity, oil exploration impact, Nigerian river environment

Introduction

The study of zooplankton of freshwater is the subject of much research because of the importance of these organisms in the food chain of fish and as bio-indicator of anthropogenic impacts and productivity in aquatic ecosystem (Ogbeibu and Omoigberale, 2005; Ogbeibu and Osokpor, 2002; Morgan and Boy, 1982; Kwaitkowski, 1980). Studies of anthropogenic impacts on the aquatic ecosystem using the zooplankton have indicated general decimation of zooplankton population and reduction in the general species richness and diversity (Ohimain *et al.*, 2002, Ogbeibu and Edutie, 2002).

Other important contributions to the ecological study of crustacean zooplankton in Nigeria, include the works of Ogbeibu *et al.* (2001); Imoobe and Egborge (1997); Imoobe and Ogbeibu (1996); Ogbeibu *et al.* (1996); Jeje and Fernando (1986); Egborge (1978, 1972); Bidwell and Clarke (1977); Robinson and Robinson (1971); Imevbore (1965) and Green (1962).

This paper is the third in a series, documenting the impact of exploration activities of Dubri Oil Company on the water quality of the Osse River, providing baseline data on the composition, distribution and temporal dynamics in the crustacean zooplankton.

Study area. The Osse River originates in the Akpata hills in Ekiti State, Nigeria. It flows north-southerly through Ovia North-East local Government area and empties into the Benin river which is one of the four major rivers that drain into the Atlantic Bight of Benin (lat.5°-5 40 °N and log. 5° and 6.30 °E), others being Ramos, Forcados and Escravos river (Fig. 1). Osse river is located on the Benin formation, which is composed of coarse sand, interspersed with lignite and patches of laterite, sand and clay (Wilson and Bain, 1928). Samples were taken from five sampling stations spread upstream to downstream.

Station 1 is located at Ughoton, upstream of the oil company. The vegetation is mostly forest type. The river is flanked by Indian bamboo (*Bambusa* sp.) which provides a canopy for the underlying vegetation. The water surface has a mat of floating macrophytes, *Salvinia* sp., *Nymphaea* sp., *Lemna* sp., and *Eicchornia crassipes* (water hyacinth). The substratum is composed of mainly organic sticky mud.

Station 2 is located about 500 m downstream of station 1. The vegetation consists mainly of secondary forest, made up of trees and tall grasses such as *Pennisetum purpureum*. The floating macrophytes include *Nymphaea lotus* and *E. crassipes*. The muddy substratum is rich in organic matter.

Station 3 is about 500m downstream of station 2. On the left bank of the river is Dubri Oil Company which is engaged in oil exploratory activities. There are very few floating macrophytes. The river at this point is deep, the result of dredging to accommodate barges and tug boats usually anchored on the river. The substratum is a mixture of fine and coarse sand and gravel.

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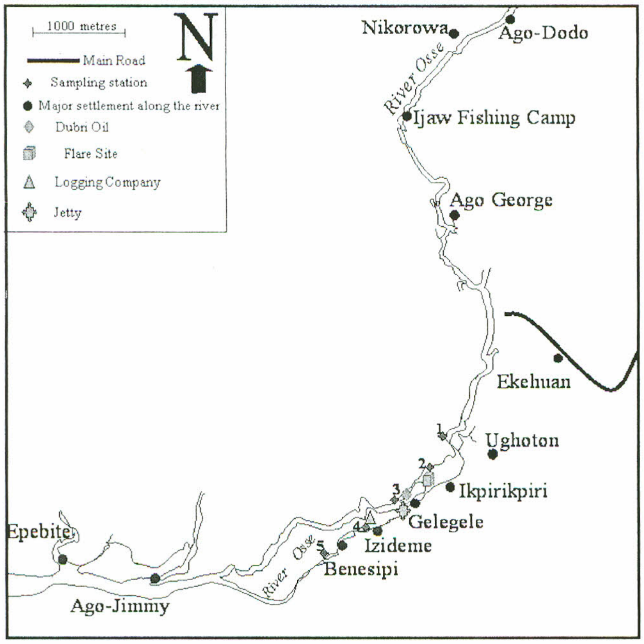

Fig. 1. Location of five sampling stations in southern Nigeria.

Station 4 is located about 500m downstream of station 3. The water surface has a mat of floating macrophytes which include *E.crassipes, Salvinia* sp. and *Nymphaea lotus.* The substratum is composed of decaying pieces of wood, coarse sand and silt.

Station 5 is located about 500m downstream of station 4. A dense mat of floating macrophytes covers the surface of the water including *E. crassipes, Nymphaea* sp. and *Ceratophylllum* sp. The substratum is made up of organic, rich, sticky mud and fine silt.

Materials and Methods

The crustacean zooplankton samples were collected at monthly between July 2000 and June 2002. On each sampling day, samples were collected between 0900 h and 1700 h, starting from station 1 and ending at station 5.

Samples were collected using 55µm Hydrobios plankton net towed by an engine-powered boat driven at low speed for five minutes (Egborge, 1994) and were preserved in 5% formaldehyde (UNESCO, 1974). In the laboratory, crustacean zooplankton were sorted and dissected (where necessary) under a binocular dissecting microscope (American Optical Corporation, model 570), while drawings, counting and identification were done using an Olympus Vanox Research Microscope Model 230485 (Mag. 50-500 x) with an attached drawing tube Model MKH240-790. Identification of specimens for Cladocera and Copepoda was carried out at the University of Benin, Zooplankton Laboratory using relevant literature: (Thorp and Covich, 1991; Williamson, 1991; Jeje and Fernando, 1986; Van de Velde, 1984; Dumont, 1981; Smirnov, 1974; Einsle, 1970; Green, 1962; Onabamiro, 1956; 1952).

The methods used for analyzing the community structure and fauna similarities were according to Ogbeibu and Egborge (1995). The Single Factor Analysis of Variance (ANOVA) was used to test for significant difference in the density of fauna among the stations. Duncan Multiple Range test was conducted to locate the site(s) of significant difference. All appropriate statistical procedures for test of significance and the calculation of diversity and similarity indices were adopted from Magurran (1988), Zar (1984) as well as SPSS 11.0 Windows application.

Results and Discussion

A summary of some physical and chemical parameters of the study stations is given in Table 1. All factors with the exception of air temperature were not significantly different ($P > 0.05$) among all the stations. The values of air temperature of station 3 were significantly higher ($P < 0.05$) than those of other stations, which were not different ($P > 0.05$) from each other.

Checklist of Crustacean Zooplankton species

Phylum	Arthropoda
Class	Crustacea
Subclass	Branchiopoda
Order	Cladocera
Family	Chydoridae Stebbing, 1990
Subfamily	Aloninae Frey, 1967
Genus	*Alona* Baird, 1843
	Alona costata Sars, 1862
	Alona eximia Kiser, 1948
	Alona gutata Sars, 1862
	Alona rectangula Sars, 1862
	Camptocercus australis Sars, 1896
	Disparalona rostrata Koch, 1841
	Euryalona orientalis Daday, 1898
Subfamily	Chydorinae Stebbing, 1902
	Alonella excisa excisa Fisher, 1854
	Chydorus sphaericus O.F Muller, 1785
	Oxyurella singalensis Daday, 1898
	Pleuroxus hamatus Baird, 1879
Subclass	Copepoda
Order	Cyclopoida
Family	Cyclopidae
Subfamily	Eucyclopinae Kiefer, 1927
	Ectocyclops sp. Koch, 1839
	Eucyclops agiloides Sars, 1909
	Mesocyclops sp. Kiefer, 1928
	Thermocyclops sp. Sars, 1901
Subfamily	Cyclopinae
	Microcyclops varicans Sars, 1862

Table 1. Physical and chemical conditions of the study stations

Parameters (n=24)	Min	Max	Mean ± SE	Statistical significance
Station 1				
Air temperature	26.10	31.20	29.13 ± 0.34	*P<0.05
Water temperature	25.20	29.10	27.30 ± 0.26	P>0.05
pH	5.76	7.91	6.96 ± 0.11	P>0.05
Dissolved oxygen	4.40	7.80	6.43 ± 0.18	P>0.05
B.O.D.	1.60	4.20	3.23 ± 0.15	P>0.05
Conductivity	11.00	123	33.48 ± 6.98	P>0.05
Alkalinity	20.00	75.0	50.65 ± 3.01	P>0.05
Nitrate	0.04	0.61	0.25 ± 0.03	P>0.05
Phosphate	0.28	2.88	1.61 ± 0.13	P>0.05
Station 2				
Air temperature	26.00	31.20	29.18 ± 0.34	*P<0.05
Water temperature	25.30	29.00	26.29 ± 1.09	P>0.05
pH	6.02	7.84	7.03 ± 0.11	P>0.05
Dissolved oxygen	4.80	8.20	6.44 ± 0.17	P>0.05
B.O.D.	1.60	4.10	2.83 ± 0.14	P>0.05
Conductivity	13.0	180.0	40.03 ± 7.33	P>0.05
Alkalinity	17.50	100.00	48.71 ± 3.79	P>0.05
Nitrate	0.09	0.73	0.31 ± 0.04	P>0.05
Phosphate	0.72	3.06	1.73 ± 0.12	P>0.05
Station 3				
Air temperature	27.00	33.70	31.35 ± 0.38	*P<0.05
Water temperature	25.50	29.30	27.42 ± 0.25	P>0.05
pH	5.80	7.83	7.01 ± 0.10	P>0.05
Dissolved oxygen	5.40	8.80	6.39 ± 0.15	P>0.05
B.O.D.	1.20	4.80	2.93 ± 0.13	P>0.05
Conductivity	16.00	208.0	50.92 ± 8.81	P>0.05
Alkalinity	21.00	90.00	49.96 ± 3.35	P>0.05
Nitrate	0.06	0.73	0.33 ± 0.04	P>0.05
Phosphate	0.15	2.60	1.66 ± 0.12	P>0.05
Station 4				
Air temperature	26.80	31.30	29.28 ± 0.32	*P<0.05
Water temperature	25.70	29.10	27.27 ± 0.26	P>0.05
pH	6.09	7.70	6.92 ± 0.08	P>0.05
Dissolved oxygen	5.20	11.60	6.76 ± 0.28	P>0.05
B.O.D.	0.8	4.8	2.65 ± 0.17	P>0.05
Conductivity	10.00	130.00	43.73 ± 7.03	P>0.05
Alkalinity	17.5	80.00	47.94 ± 3.85	P>0.05
Nitrate	0.06	0.69	0.34 ± 0.04	P>0.05
Phosphate	0.43	3.10	1.79 ± 0.13	P>0.05
Station 5				
Air temperature	26.20	31.20	29.20 ± 0.30	*P<0.05
Water temperature	25.50	29.30	27.26 ± 0.26	P>0.05
pH	5.55	7.73	6.83 ± 0.11	P>0.05
Dissolved oxygen	5.40	7.80	6.50 ± 0.15	P>0.05
B.O.D.	1.60	5.60	3.17 ± 0.18	P>0.05
Conductivity	14.00	110.00	48.86 ± 6.50	P>0.05
Alkalinity	19.20	95.00	45.92 ± 3.80	P>0.05
Nitrate	0.10	1.14	0.39 ± 0.05	P>0.05
Phosphate	0.40	3.52	1.73 ± 0.13	P>0.05

* = significantly different means (P<0.05).

A total of 7134, individuals were collected which belonged to sixteen taxa (Table 2). All the taxa were well represented in the five stations. Cladocera accounted for 60.85% of the total number of individuals while Copepoda contributed 39.15%. Among the cladocerans, the family Chydoridae was the only group encountered. It was represented by 11 taxa from two subfamilies, Aloninae (7) and Chydorinae (4). Abundance was highest (12.72%) at station 5 and lowest (4.9%) at station 4. The most important taxa were *Chydorus sphaericus, Oxyurella singalensis, Alona exima* and *A. rectangular.* The overall abundance of Cladocera was significantly different (P < 0.05) among the stations. A posteriori Duncan's multiple range (DMR) test showed that the abundance was significantly higher (P < 0.05) in stations 1, 2 and 5 than in the other stations (3 and 4) which were not significantly different (P > 0.05) from each other.

Copepoda contributed 39.15% to the total density. The family Cyclopoidae was the only group encountered in this study. The most dominant and widely distributed species were *Mesocyclops* sp., *Thermocyclops* sp. and *Microcyclops varicans. Mesocyclops* and *Thermocyclops* recorded the highest density at station 1, while *M. varicans* and *Mesocyclops* sp. dominated the Cyclopoidae at station 5. A test of significance using Duncan Multiple Range (DMR) revealed that the means of stations 1 and 2, which were not significanty different from each other (P> 0.05), were significantly higher (P< 0.05) than those of other stations.

Temporal dynamics. The Crustacean zooplankton varied greatly in their relative abundance temporally (Fig. 2a, 2b). In all stations, higher densities were encountered during the dry season (October to March) than during the rainy season. The density of Cladocera at station 1 was the highest between October 2000-March 2001 and October 2001-January 2002 while the minimum densities were obtained in June 2001. The same trend was observed in stations 2, 3, 4 and 5 with a peak in December 2000 and minimum in June 2001. The density was generally low in stations 3 and 4 throughout the study period (Fig. 2a).

Among the Copepoda, the trend in all the study stations was the same. There was an irregular rise in the population of Copepoda from July, 2000 with a peak in November, 2000. A second peak and maximum was attained in October 2001. The least density was attained in June 2001 in stations 1 and 2 and May-June 2002 for stations 3, 4 and 5 (Fig. 2b).

Biological indices. The diversity indices calculated for the five stations are summarized in Table 3. The taxa richness (d) was highest in station 3 followed by stations 4, 2 and 5 while, the lowest value was recorded in station 1. Shannon

Table 2. Taxa composition, abundance and distribution of Crustacean zooplankton in Osse river

	Station 1	Station 2	Station 3	Station 4	Station 5
Phylum: Arthropoda					
Class: Crustacea					
Order: Cladocera					
Family: Chydoridae					
Alona costata Sars	43	23	34	22	58
A.exima Kiser	138	164	84	83	138
A.gutata Sars	49	29	18	33	76
A.rectangula Sars	147	232	78	46	184
Alonella excisa excisa Fisher	38	59	31	46	78
Camptocercus australis Sars	58	44	21	16	32
Chydorus sphaericus Muller	245	187	110	81	185
Disparalona rostrata Koch	67	21	24	18	53
Euryalona orientalis Daday	97	77	68	38	136
Oxyurella singalensis Daday	105	123	70	52	101
Pleuroxus hamatus Baied	83	106	53	20	149
Subclass: Copepoda					
Order: Cyclopoida					
Family: Cyclopoidae					
Ectocyclops sp. Koch	212	89	18	103	88
Eucyclops agiloides Sars	63	110	55	73	102
Mesocyclops sp. Kiefer	263	132	115	97	125
Microcyclops varicans Sars	102	150	20	100	140
Thermocyclops sp. sars	229	159	64	89	65

diversity (H') was significantly higher ($P < 0.05$) in stations 3, 4 and 5 than in stations 1 and 2 which were not different from each other. The Evenness Index (E) was higher in station 5 than in other stations.

The crustacean zooplankton encountered in this study appears to be frequent inhabitants of tropical rivers. This is not surprising since the colonization of streams to a great extent depends on animals with wide distributional capacities (Green, 1979). The invertebrate communities of lotic ecosystems are a conservative 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).

Eleven species of Cladocera and 5 species of Copepoda, reported in this study, support the fact that flowing water is a poor habitat for zooplankton (Dudgeon, 1995; Idris and Fernando, 1981). This report is similar to an earlier study on a stretch of Osse River (Ogbeibu *et al.*, 2001) which recorded 16 species of Cladocera and 6 species of Copepoda. Other studies on lotic ecosystems have also implicated the poor diversity of tropical crustacean zooplankton. Bidwell and Clark (1977) recorded 24 and 9 species of Cladocera and Copepoda, respectively, from Lake Kainji; Burgis (1973), reported 7 cladoceran species from Lake George, Uganda and Ogbeibu *et al.* (1996), reported 25 cladoceran and 9 Copepod species from a temporary pond in southern Nigeria. The Cladocerans are more diverse than the Copepods in this study. Tropical waters are known for their paucity of copepod species (Robinson and Robinson, 1971) but have high biomass and numerical dominance of few species (Burgis, 1973). The Cladocerans were dominated by the Chydoridae which were well represented in all the sampling stations. High abundance and species richness of the Chydoridae is characteristic of tropical freshwater zooplankton (Imoobe and Egborge, 1997; Dumont, 1981; Mamaril and Fernando, 1978; Green, 1962). Like most tropical freshwaters, the dominant Cladocerans of

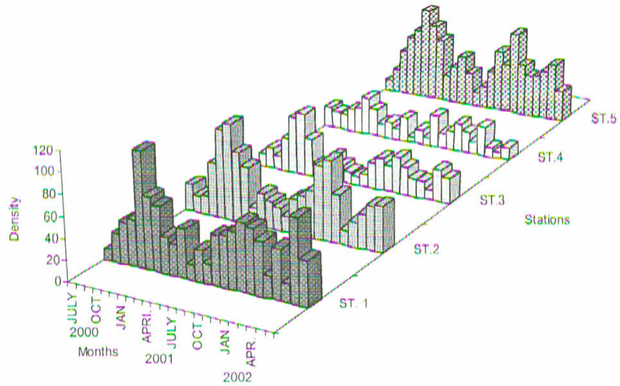

Fig. 2a. Temporal variation of Cladocera in the study stations.

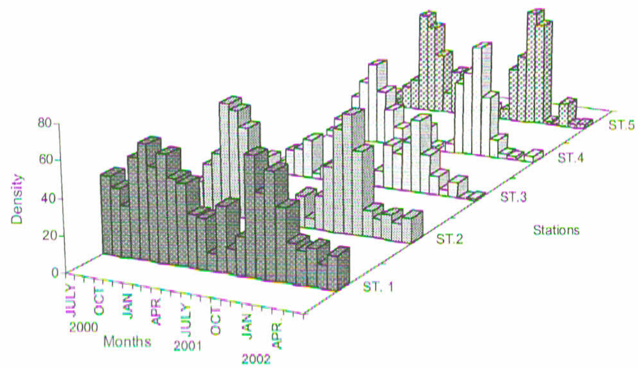

Fig. 2b. Temporal variation of Copepoda in the study stations.

the river were *Chydorus sphaericus, Alona rectangular, A. exima* and *Oxyurella singalensis*. Species of Cladocera encountered in this study appear to have preference for sites with rich organic substratum and macrophytes, a condition characteristic of stations 1, 2 and 5 where the most abundance of Cladocera was encountered. Dominance of Chydoridae can also be explained by the fact that they are benthic while some other groups are less inclined to be completely benthic (Fernando, 1980).

Copepoda comprised of cosmopolitan and tropical species. The number of species recorded in this study is comparable to the species composition in some other Nigerian water bodies. Egborge (1972), recorded four species from Oshun River and six from Lake Asejire, Imevbore (1965) recorded 6 from Eleiyele Reservoir, Ibadan while, Ogbeibu *et al.* (2001) recorded 6 species from the Ovia River. These were however lower than the 21 species reported by Gabriel (1986) for Warri River. Large number of species recorded in these systems can be explained by their coastal nature, having a mixture of marine, brackish and freshwater forms. Cyclopoida were the only Copepods encountered in this study. This observation is

Table 3. Diversity of Crustacean zooplankton in the study stations of Osse River, 2000-2002

Parameters	Stations 1	2	3	4	5
No. of taxa	16	16	16	16	16
No. of individuals	1939	1705	863	917	1710
Taxon richness (d)	1.982	2.016	2.219	2.199	2.015
General diversity (H)	2.595	2.598	2.605	2.62	2.682
Evenness (E)	0.837	0.84	0.845	0.858	0.913

similar to the findings of Burgis (1973) in her study of the zooplankton of Lake George, Uganda. Cyclopoids are known to be dominant in the freshwater environment (Jeje and Fernando, 1986; Bidwell and Clarke, 1977). The dominance of Cyclopoids; represented mainly by *Mesocyclops* sp., *Thermocyclops* sp and *Microcyclops varicans* in this study agrees with earlier findings. However, Ogbeibu and Egborge (1995) on the contrary, reported dominance of Calanoida over Cyclopoida in temporary freshwater ponds in Okomu Forest Reserve, while Morgan and Boy (1982) reported only Calanoida in some temporary freshwater ponds in North-west Africa. This is further corroborated by Fernando (1980), who reported the presence of Calanoida in temporary waters and their rarity in rivers.

A strong disparity in the spatial distribution of crustacean zooplankton was observed in this study. The macrophyte-rich stations 1, 2 and 5 harboured more species and had the highest abundance, when compared with the impacted stations 3 and 4. Idris and Fernando (1981) and Ogbeibu *et al.* (1996) earlier reported positive association between Cladocerans and macrophytes. In this study, there was a distinct seasonality of crustacean zooplankton; crustacean maxima corresponded with the periods of early dry season. Similar phenomenon was observed by Liao *et al.* (1989) who reported more Cladocera and Copepoda during dry season in Pearl River in tropical Asia. Similar findings have been reported by Etta (1974), Robinson and Robinson (1971), Proszynska (1966) and Burgis (1971, 1973) in Ibadan University Fish Pond (Nigeria), Lakes Chad (Nigeria), Volta (Ghana) and George (Uganda), respectively.

However, maximum crustacean zooplankton was reported in the rainy season by Ogbeibu *et al.* (2001), Imoobe and Egborge (1997) and Imevbore (1967). All these confirm the belief of Damas (1964) that plankton maxima in the tropics may occur at any period of the year depending on the predominant set of physical, chemical and biological conditions of the particular ecosystem.

It is clear that the species composition of the Osse river is highly cosmopolitan and all the species are common in the limnetic tropical Africa. Low abundance of species in stations 3 and 4 when compared to stations 1, 2 and 5 further supports the negative impact of the activities of crude oil exploitation activities on the fauna of aquatic ecosystem.

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