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Impact of Impoundment on the Hydrology and Rotifers of the Ikpoba River, Nigeria

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ABSTRACT: An ecological study of the Ikpoba river was carried out to evaluate the impact of impoundment on the rotifer community and water quality. Three stations, 1, 2 and 3 were selected from upstream of the impoundment, the impoundment (reservoir) and its downstream respectively. Among the physical and chemical parameters studied, only the water level, transparency, current velocity and dissolved oxygen were significantly different ($P<0.05$) among the study stations. Fifty rotifer species were collected from the study stretch of which 30, 42 and 18 species occurred at stations 1, 2 and 3 respectively. The families Lecanidae (33.5%) and Brachionidae (15%) were dominant in all the stations. The overall abundance of rotifers at the three stations did not differ significantly ($P > 0.05$). However, impoundment caused a significant increase in the diversity of rotifers in station 2 and a significant reduction in the downstream station 3. Faunal comparisons of the three stations using Jaccard's similarity index showed that stations 1 and 2 were similar, but significantly dissimilar from station 3, confirming significant community changes in the downstream lotic station.

Key words: Ikpoba river; Impoundment; Water quality; Rotifers; Plant diversity.

Introduction

The conversion of a fluviatile ecosystem to a lacustrine one by the impoundment of rivers brings about structural, physical and chemical changes, which profoundly affect the biotic components (1, 2). These changes are products of flooding of terrestrial organic and inorganic materials, introduction of allochthonous matter, followed by their subsequent decomposition and mineralization. Some obvious effects of impoundment on the biota include (a) the replacement of potamoplanktonic species by limnoplanktonic species some of which are introduced into the new lake from pools annexed during flooding; (b) changes in the zooplankton community structure and the establishment of dominance of a few species.

The vast literature on tropical rotifers centred mainly on community composition, distribution and seasonal dynamics (3, 4, 5, 6, 7, 8, 9). The galloping rate of anthrapogenic alteration of our natural environment has led to the current shift of focus from routine ecological descriptions to impact assessment studies and the development of impact prediction models.

The present work is one of a series of reports documenting the impact of impoundment on the water quality and biota of the Ikpoba River. The response of the rotifer communities to impoundment-induced changes along the river continuum is presented in this paper.

Study Site

The study was carried out in a stretch of the Ikpoba river, a fourth order (4°) stream flowing from North to South through Benin City, Southern Nigeria (6°N; 5 8°E). The present study was conducted in a 7km stretch of the river including the impounded portion, downstream of the area previously studied by Ogbeibu and Victor (10). This area is composed of secondary rainforest immensely subjected to deforestation and other anthropogenic activities. The dominant vegetation now comprises rubber (*Hevea brazilensis*); oil palm (*Elaeis guineensis*) and Indian bamboo (*Bambusa*).

Three sampling stations were chosen; the impoundment (station 2), its upstream (station 1) and downstream (station 3). The study area and the main features of these stations have been described (2).

Methods

Sampling for water quality parameters and rotifer fauna was carried out in the three study stations at fortnightly interval between 1200h and 1800h on each sampling day. The sampling period spanned from August to December1997 covering parts of the rainy and dry seasons.

The waterlevel variation was measured at specific points in the study stations using a meter rule. Temperature was measured *in situ* to the nearest 0.1°C with mercury – in – glass thermometer whilea secchi disc was used for the determination of water transparency. The surface float method (11) was used in measuring current velocity. Conductivity and pH were determined in the field using a battery – operated conductivity bridge (model MC-1, Mark V) and a digital pH meter (Cole Palmer, USA). Total alkalinity was determined titrimetrically using 0.01M HCl and methyl-orange indicator, while Dissolved Oxygen and Biochemical Oxygen Demand (BOD_5) were determined titrimetrically using the Azide modification of the Winkler's method (12).

Rotifers were sampled quantitatively by filtering 60 litres of water through a 55µm Hydrobios plankton net and the concentrated sample preserved in 40% buffered formaldehyde. The rotifers were sorted in the laboratory under a Wild M40 stereo microscope, prepared on slides using 100% glycerin, and drawn under an Olympus Universal Vanox Research microscope model 230485 with drawing attachment model MKH 240-790. Keys and references used for the identification of rotifers have been given earlier (13).

Individuals of all identified taxa were counted in a Hydrobios counting chamber. Density was expressed as number of organisms per m^3, using the formula:

$$\text{Density} = \frac{N \times 1000}{\text{Initial volume of water filtered}}$$

where N = number of organisms per sample (14).

The community structure was analysed using the Shannon-Wiener general diversity (H') and Evenness (E) indices using the computer BASIC programme SPDIVERS.BAS for diversity indices (15). Differences in diversity at the stations were tested for significance using Hutchinson's t-test (16). Kruskal-Wallis test was performed to detect significant differences in the abundance of taxa at the three stations. If significant HC (Kruskal-Wallis statistic) values ($P < 0.05$) were obtained, a *posteriori* multiple comparison test was performed to determine the location of significant difference. Faunal similarities between pairs of stations were examined using Jaccard's coefficients (15, 17).

Results

(a) Physical and Chemical Conditions

The results of physical and chemical conditions of the study stations are summarized in Table 1. Water temperature was not significantly different ($P > 0.05$) among the stations. However, Analysis of Variance

Table 1: Summary of the Physico-chemical properties of the study stations, Ikpoba River, August – December, 1994 (n = number of samples).

Properties	STATION 1				STATION 2				STATION 3				ANOVA	
	n	Mean ± S.E	Min.	Max.	n	Mean ± S.E	Min	Max.	n	Mean ± S.E	Min.	Max.	F. value	Probability
Physical														
Air Temperature ^{0}C)	10	29.1 ± 0.46	26.0	31.0	10	27.6 ±0.99	24.5	33.0	8	29.2 ±0.95	24.0	32.0	1.209	P>0.05
Water Temperature (^{0}C)	10	23.3 ±0.52	20.0	26.0	10	23.9 ±0.59	22.0	27.0	8	24.1±0.48	22.0	26.0	0.321	P>0.05
Water level (m)	10	1.58 ±0.06	1.15	1.80	10	1.02 ±0.00	0.79	1.30	8	1.996 ±0.09	1.64	2.35	46.07*	P<0.01
Current Velocity (cm/s)	10	40.1 ±1.9	33	50	10	0	0	0	8	54 ±4.8	33	78	113.27*	P<0.01
Transparency (m)	10	1.03 ±0.04	0.88	1.15	10	0.56 ±0.03	0.50	0.74	8	1.03 ±0.05	0.88	1.26	57.91*	P<0.01
Chemical														
Hydrogen-ion conc. (pH)	10	6.86 ±0.18	5.92	7.81	10	6.60 ±0.16	5.64	7.40	8	6.74 ±0.23	5.50	7.89	0.54	P>0.05
Total Alkalinity (mgl^{-1} $CaCO_3$)	10	9.08 ±0.79	5.3	12.3	10	8.98 ±0.01	3.3	12.3	8	8.01 ±1.07	3.5	12.3	0.3567	P>0.05
Conductivity (μScm^{-1})	10	19.62 ±0.06	16.0	22.0	10	22.5 ±0.13	16.8	29.0	8	19.0 ±0.11	15.0	23.4	3.27	P>0.05
Dissolved Oxygen (mgl^{-1})	10	13.6 ±0.43	12.1	16.8	10	5.1 ±0.46	2.6	7.1	8	14 ±0.57	12.9	17.3	91.35*	P<0.01
Dissolved Oxygen (% Saturation)	10	161.88±4.83	143.7	198.9	10	60.18 ±5.45	51.4	83.3	8	173.29 ±6.51	153.8	208.8		
BOD_5 (mgl^{-1} O_2)	10	3.85 ±0.86	1.3	9.7	10	3.77 ±0.46	0.9	5.4	8	3.3 ±0.68	1.1	12.4	0.18	P>0.05

The results of Analysis of Variance (ANOVA) computed for each factor and the statistical significance is indicated; * Indicates significant difference.

revealed a significant difference ($P < 0.05$) in the current velocity, transparency and dissolved oxygen in the study stations. A *posteriori* comparison using Duncan's Multiple Range test showed station 2 to be the cause of the significant difference observed. The upstream control station did not differ from the downstream station in terms of the measured physical and chemical conditions.

(b) Rotifer Community

Distribution and Density

Fifty species of rotifer were identified from all stations (Table 2). Station 2 had the highest number of species (42) while stations 1 and 3 had 30 and 18 species respectively. Although the overall density of rotifers was highest (2,958 individuals per m^3) in station 2, analysis of variance did not reveal any significant difference ($P > 0.05$) among the study stations. Howevcer, the major taxonomic groupos showed varied responses in the three stations (Fig. 1).

Asplanchnidae contributed 6.4% to the total density of rotifers. It was represented by only onespecies *Asplanchina priodonta*, which had the highest density in station 1 and the lowest in station 3. Nine species of Brachionidae were recorded. They include *Anuraeopsis racensis, Berzins, Beauchampiella eudactylota gosse, brachionus calyciflorus Pallas, B. caudatus Borris and Daday, B. patulus Wulfert, Keratella cochlearis cochlearis gosse, K. tropica Apstein, Platyias leloupiGillard and P. quadricornis Ehrenberg*. This family contributed 15% to the total rotiferdensity. Only *Anuraeopsis* and *Beuchampiella* were collected in station 3 which had the lowest density. *Colurellidae* had only two species *Colurella colurus Ehrenberg* and *Colurella* sp., which were collected, in stations 1 and 2; they constituted only 3.6% of the population. *Epiphanidae* was represented by *Proales* sp. (1.4%) which never occurred in station 3. The two species of *Euchlanidae Dipleuchlanis propatula* Gosse and *Euchlanis* sp. recorded in this study contributed only 6.1%, with the highest density in station 2. Only *Ascomorpha* sp. represented the family Gastropalidae. It constituted 5.0% and showed wide distribution.

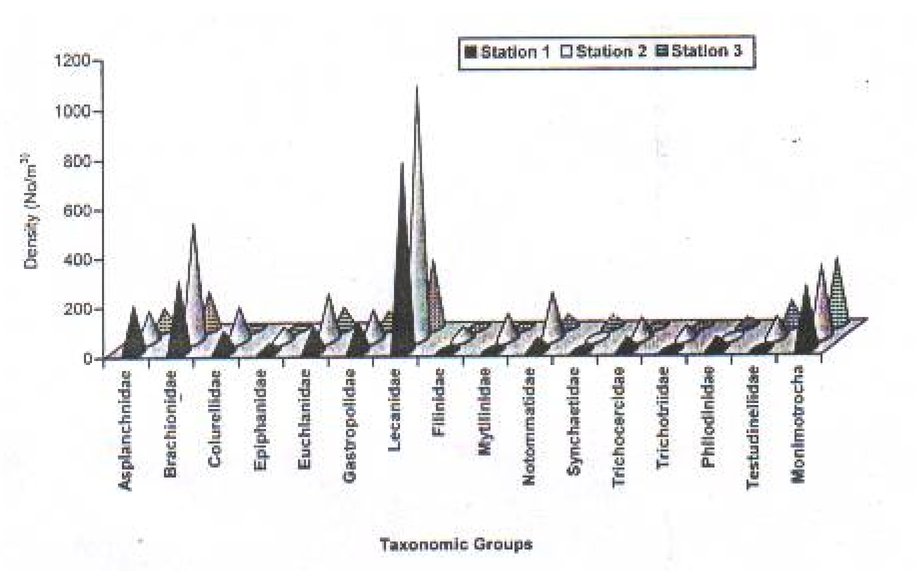

Fig. 1: Spatial variation in the density of major taxonomic groups pf rotifers in the study area

Table 2: the distribution of zooplankton taxa and individuals (individuals/1001) in the study stations.

Taxa	Stations					
	1		2		3	
	No. of Taxa	No. of Individ.	No. of Taxa	No. of Individ.	No. of Taxa	No. of Individ.
Asplanchidae	1	187	1	119	1	85
Brachonidae	5	289	6	476	2	153
Coluellidae	2	85	2	136		
Epiphanidae	1	34	1	51		
Euchanidae	1	102	2	187	2	85
Gastropolidae	1	119	1	119	1	68
Lecanidae	11	765	13	1020	5	27
Filinidae			1	51		
Mytilinidae			2	102		
Notommatidae	1	51	3	187	1	51
Synchaetidae					1	51
Trichocercidae	1	51	2	85		
Trichtriidae			1	51		
Philodiidae	1	51			1	34
Testudinellidae	1	17	2	85	1	102
Monimotroch	4	255	5	289	4	272
Total	30	2006	42	2958	1	1173
Taxa richness (d)		1.447		1.627		1.273
Shannon--Wiener Diversity (H')		1.973		2.168		2.077
Evenness (E)		0.794		0.821		0.901

Lecanidae was the dominant family comprising 33.5% of the total rotifer density Its density was highest in station 2. The fourteen species recorded here were *Lecane acronychal*, Haver and Murray; *L. crepida,L. curvicomis*, Murray; *L. leontina*, Turner; *L. Ludwigi, L. Luna*, Harring and Myers; *L. lunaris*, Ehrenberg; *L. petica*, Haring and Myers; *L. Ungulata*, Gosse; *Monostyla bulla bulla*, Gosse; *M. bulla, styrax*, Myers; *M. Lunaris, M. quadridentata* Ehrenberg and *Monostyla* sp. *Filina longiseta* Ehrenberg, the only representative of Finidae occurred in low numbers in station 2 only. Among the Mytilinidae, only *Mytilina ventralis* Ehrenberg was recorded and occurred only in station 2. Notommatidae contributed 4.7% to the total population. It was represented by *Monomatta* sp., *Dorria* sp., *Taphrocampa* sp. and *Pedipatia* sp., with the highest density also in station 2. Synchaetidae had only one species, *Polyarthra vulgaris* Carlin which occurred in station 3 only. The two species *Trichocerca similes* Wierzejski and *Trichocerca longiseta* representing Trichoceridae occurred in stations 1 and 2 but disappeared in station 3. 1*Macrochaetus collinsi* Gosse (Trichotridae), occurred only in station 3. Philodinidae was represented by *Rotaria neptuna* Ehrenberg which occurred sparingly in stations 1 and 3. Tesrudinellidae was only 3.3% of the total fauna. It was represented by *Horaella* spp. which dominated in station 2 but were absent in station

3. Many unidentified species were grouped under the order Monimotrocha. They made up 13.3% of the total density and showed wide distribution in all the stations.

Diversity

The diversity (H^1) values for stations 1, 2 and 3 were 1,97, 2.17 and 2.08 respectively. There were not significantly different ($P > 0.05$). Faunal similarities computed using Jaccard's coefficient revealed high similarity between stations 1 and 2; stations 1 and 3 and 2 and 3 were significantly dissimilar.

Discussion

The physical and chemical conditions in any water body have considerable bearing on the life of lotic organisms (18). These parameters may act singly or in combination and the response they elicit may differ from species to species and perhaps from stream to stream. In this study, the low transparency recorded at station 2, the impoundment, was probably due to the continued accumulation of silt in the bed of the reservoir which are easily suspend on the slightest agitation, thus increasing the turbidity and lowering the transparency. The growth of macrophytes within the impoundment also interferes with the transparency. The significantly low level of dissolved oxygen recorded within the impoundment cannot be dissociated from the active decomposition of organic matter trapped within the impoundment, which increased the oxygen demand. The absence of flow and turbulence that characterize lentic waters does not encourage constant oxygenation (13).

The 50 rotifer species recorded in this study represents 26.3% of the 190 species that have been reported in Nigerian waters (19). However, the species reported are typical of tropical rotifer assemblage. Although the varieties of rotifers in the Ikpoba River compares favourably with what obtaine in other systems. An earlier work on the reservoir rotifers of the Ikpoba River documented the dominance of Lecanidae (33%) and Brachionidae (17%). Thepresent study reported 33.5% of Lecanindae and 15% of Brachionidae, confirming the dominance of Lecanidae. In the Sokoto River, Green (20) listed 41 rotifer species dominated by Brachionidae (29.3%) and Lecanidae (17.1%). Egborge and Tawari (5) also reported the dominance of Brachionidae in the Benin River. A striking feature revealed in the present study is the shift in the order of dominance as the habitat changes from lotic to locustrine ecosystem. According to Ruttner-Kolisko (21), tropical lakes are characterized by a predominance of *Brachionus* spp. (Brachionidae). Although the work of Satory (4) in South African artificial impoundments supports this view, reports on Nigerian rotifers have shown the dominance of Lecanidae in lacustrine habitats (6,9) and the dominance of Brachionidae in lotic systems (5, 20). An intra-system comparison of the Ikpoba River rotifer community revealed an emergence of new varieties within the impoundment that were previously absent in its upstream and downstream. The response of rotifers to the presence of the dam varied from species to species. *Asplanchna* sp. and the philodinid *Rotaria neptuna* were the only species found to dominate the upstream lotic section; the other species either occurred exclusively or increased in density within the impoundment. Wetzel (22) associated high population density of rotifers with the presence of submerged macrophytes, since about 75% of the known species occur in the littoral areas of lakes and ponds (23). Thus the distribution and abundance of rotifers are influenced by the presence of submerged macrophytes and the flow velocity of the water. Impoundment therefore favoured high density and diversity of rotifers. The absence of most species of *Brachionus* from station 3 can be associated with the more acidic water in that station. Pejler (24) recorded the genus *brachionus* in waters of pH > 6.6 and slightly alkaline waters. Inputs from the surrounding factories in station 3 might have resulted in the lowered pH of the water.

Computations of rotifer diversity in the study stationsshowed that station 2 had the highest diversity. The overall diversity of any community is the product of all dynamic spatial and temporal changes affecting the community and a measure of ecosystem stability (25). The rotifer community within the impoundment is therefore considered more stable and ecologically robust than in the upstream and downstream stations. The observed diversity and stability within the reservoir are a result of a combination of the following interacting factors: (a) high nutrient supply as allochthonous production increased following surface run-off inputs; (b) the presence of decaying phytoplankton and bacteria on which most species thrive (21); (c) differences in species adaptive behaviour which probably kept most species in the littoral and macrophyte zone of the reservoir and (d) reduced flow velocity which favours the development of rotifer communities. Egborge and Chigbu (6) predicted the observations in this study when they noted that the forming of impoundment might influence the fauna when the reservoir finally stabilizes. The rich development of plankton observed in this study partly explains the higher fisheries potential of most artificial impoundments in tropical Africa. It must be cautioned here that both the positive and negative impacts of impoundments must be weighed through comprehensive environmental impact assessment (EIA) studies before the construction of dams.

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