THE ROTIFERA FAUNA OF GONGOLA RIVER BASIN, NORTHEAST NIGERIA

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Abstract

This study was undertaken to characterize the taxa composition, distribution pattern and the abundance of rotifers in surface waterbodies in the Gongola basin of Nigeria, West Africa. It was based on the analysis of net zooplankton samples collected from the River Gongola, its flow-through reservoirs, borrow-pit ponds and pools, over the two seasons of one annual cycle. The Rotifera fauna comprised thirty Monogononta species dominated by members of families Brachionidae (43 %) and Lecanidae (23 %). The fauna showed high similarity with those of most other Nigerian inland waterbodies and all the species are either cosmopolitan or cosmotropical in zoogeographical distribution. About one half of the recorded species occurred common to both the lotic and lentic waterbodies while about 40% and 10% were restricted to lotic water and lenthic waters respectively. The most widely distributed and abundant species were *Keratella tropica* and *Brachionus calyciflorus* while the two species restricted to lentic waterbodies were *Asplanchna priodonta* and *Mytilina ventralis*. A number of species showed a definitive pattern of distribution along the horizontal course of the River Gongola. These included *Keratella tropica, K. lenzi, Filinia opoliensis* and *Lecane curvicornis* which increased downstream as opposed to *Lecane bulla* and *Platyias quadricornis* which decreased downstream. Species richness and diversity indices generally increased downstream while species evenness index decreased downstream. Some species varied with the size of lentic waterbodies while others showed potential to serve as indicators of water habitat type. The fauna was qualitatively richer but quantitatively poorer during the rainy season than in the dry season due to the associated effects of rainfall, stream discharge and physico-chemical water quality.

Keywords: Rotifera zooplankton, community structure, distributional pattern, Gongola basin, West Africa.

1. Introduction

Published studies on the zooplankton faunae of Nigerian waters have been devoted mostly to the rotifers (Green, 1960; Egborge, 1972; Egborge and Ogbekene, 1986; Egborge and Tawari, 1987; Egborge, 1991; Akinbuwa and Adeniyi, 1991; Segers *et al.*, 1993; and Onwudinjo and Egborge, 1994). This is probably so because the rotifers have been found, almost invariably, to dominate the zooplankton of all the investigated waterbodies in the country both qualitatively and quantitatively. Rotifers have also been found to portray water quality and/or the trophic status of waterbodies much more than any other zooplankton group (Sladecek, 1983).

Available information on the rotifers of Nigerian waters has been based largely on waterbodies in the southwest and the Niger Delta regions of the country. There is virtually no information on many of the major rivers in the Northern region such as: the Benue, Yobe, Rima, Kaduna, and the Gongola which altogether drain more than one half of the country. River Gongola which is the largest tributary of the Benue River drains a large portion of the recently established oil prospecting blocks of the Benue Trough.

The main objective of this study was to provide a checklist of the rotifera fauna of surface waterbodies in the Gongola River basin and assess the seasonal and spatial variations in the occurrence and abundance of recorded species in the two major habitats, the lotic and lenthic water series in the environment. As a large catchment, the Gongola River basin affords the opportunity to investigate some intrabasin and subbasin variations and differences in the ecology of rotifers in a typical afro-tropical environment.

2. The Study Area

The study area corresponds approximately to the Gongola Basin of Nigeria, one of the twenty geographical regions into which Nigeria is divided (Udo, 1970). It is located in the eastern part of the Nigerian Middle Belt region, covering a surface area of about 62,000 km^2 (i.e. c.a. 6.8% the surface area of Nigeria) roughly between latitudes 09° 27'-11° 44' N and longitudes 009° 55'-012° 22' E (Figure 1).

The Gongola River (after which the basin is named) is the largest right-bank tributary of River Benue and the most important river in the region. The most distal headwater streams of the Gongola River rise east of the Jos plateau and flow into the north-easterly bound trunk river over a distance of about 330 km up to Nafada (or Ngalda). From Nafada, the Gongola River flows southerly over another 310 km to join the Benue River close to the confluence town of Numan. Between Ngalda and the Benue confluence, the left drainage comprises rivers originating from

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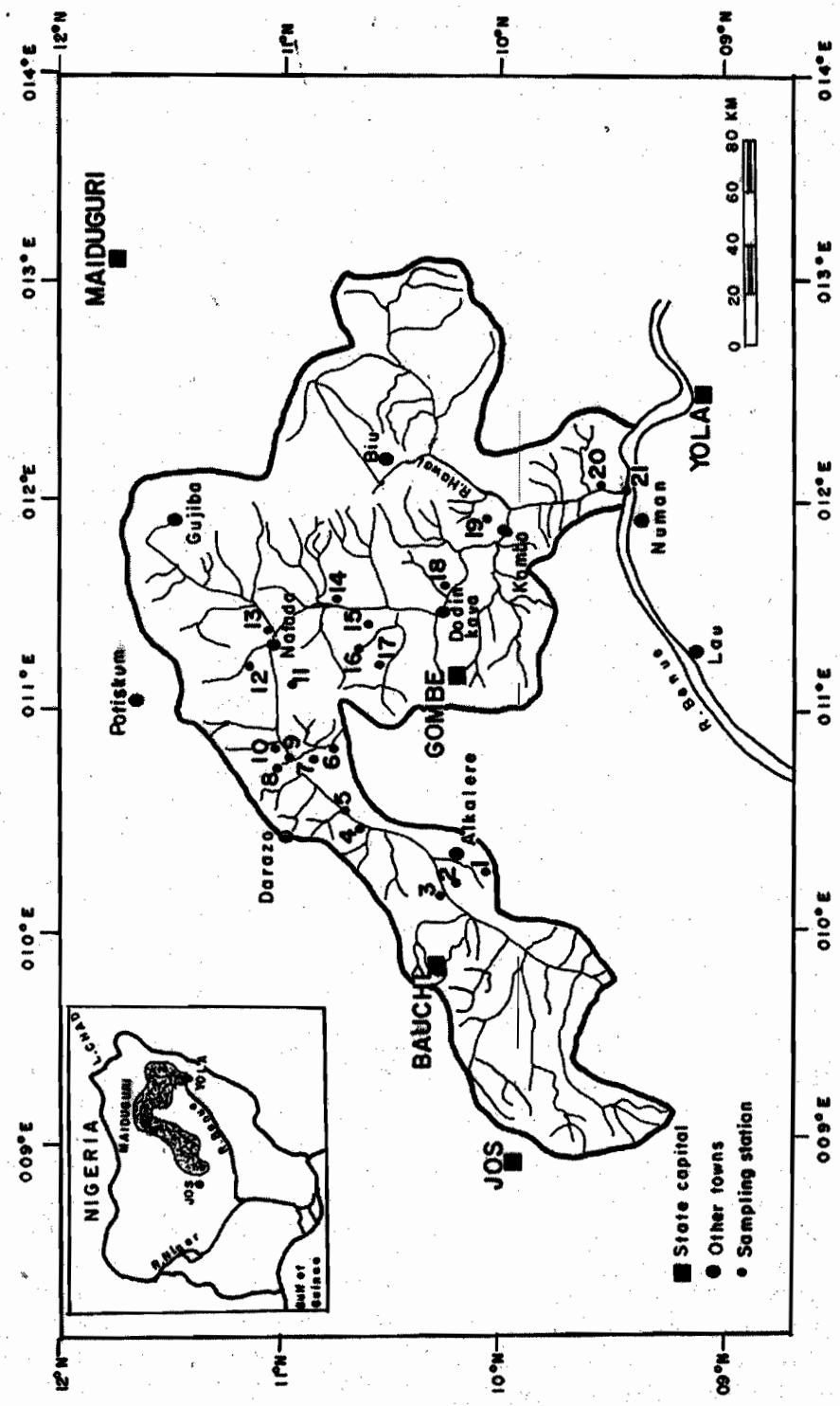


Figure 1: Gongola river basin showing investigated waterbodies and sampling stations.

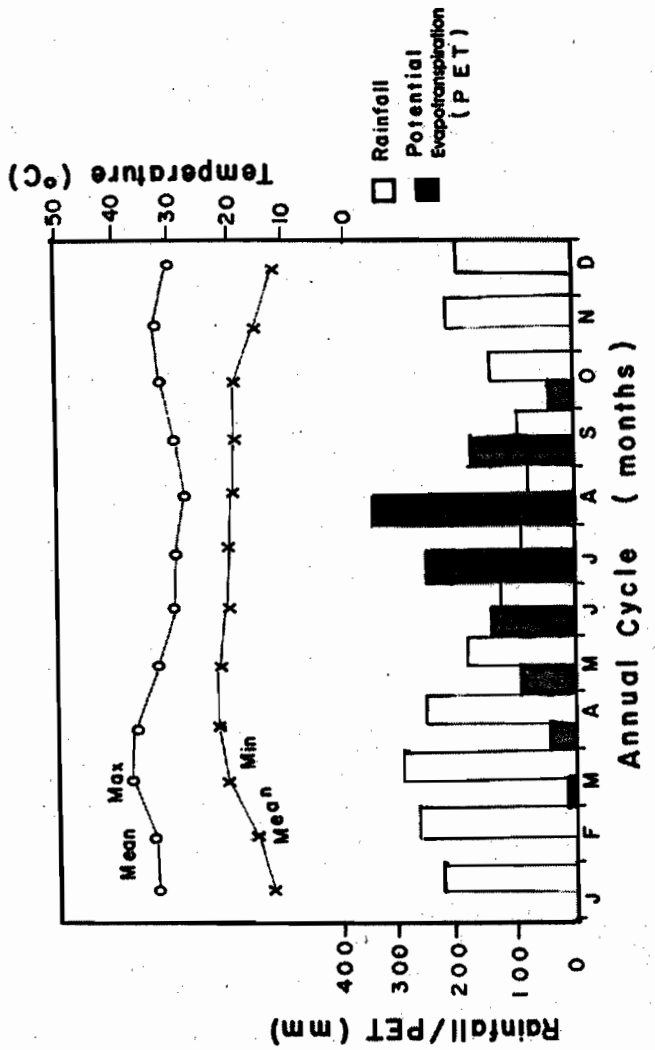


Figure 2: Climate diagram of Yola showing the major meteorological characteristics in the study area.

the Biu plateau (Rivers Panana, Ruhu and Ndivana). The largest tributary, the Hawal River joins the Gongola a few kilometers below Kombo. The right bank drainage could also be subdivided into rivers flowing eastward from the Kerikeri plateau (R. Majuyoru, Difa and Nono) and the rivers flowing north and eastwards from the Longuda plateau - Tangale peak watershed (R. Waja). In various parts of the Gongola valley and along some of its tributaries, the course of the river appears to be completely independent of the surface structure.

The study area falls largely within the moist dry monsoon type of the Hot Equatorial Tropical climate characterized by four humid months. It receives about 750-1000 mm of rainfall distributed over a period of 120-140 days with potential evapotranspiration (PET) of about 2200 mm per annum (Figure 2) (Kowal and Kassam, 1978). Temperatures are generally high and characterized by double peaks (March and November) as well as dual minima (August and December). Wind speeds are generally low. In Yola, about 80% of the annual wind speeds occur in the range of 1-10 knots with easterly winds predominating during the dry season and westerly winds predominating during the rainy season (Ojo, 1977). The highest wind speeds (frequency H" 0.5%) occur as gusts associated with thunderstorms. The region belongs largely to mid-sub arid wooded savanna (Philips, 1959) or the Northern Guinea Savanna zone (Keay, 1959) which is essentially an ***Isoberlinia-Hyparrhenia*** plant association.

3. Materials and Methods

(a) Sampling Programme

A total of twenty sampling stations were established on selected lotic and lenthic waterbodies within the Gongola River basin for plankton collection. Ten of the lotic water stations were located directly on R. Gongola along the trunk stream from the upper reach through to Kiri reservoir, just above its conference with River Benue. The other lotic stations were located on River Geji and Kurungu which are tributaries of River Gongola. The investigated lenthic waterbodies included Dadin Kowa Lake (a flow-through reservoir on Gongola River), Pindiga reservoir, 4 selected ponds and 2 borrow pits. Information on all these waterbodies as well as their site description and grid-coordinates are given in Table 1. The site grid co-ordinates were recorded from a portable Trimble Global Positioning System (GPS) set.

Plankton sampling was carried out during the two seasons of the annual cycle in the study area. The rainy season sampling was carried out in September 1997 while the dry season sampling was carried out in March 1998. As a preliminary survey, sampling was carried out at each station once per season. Twenty litre (20L) volume of water sample was collected directly with a water bottle at each station and strained through a fine-meshed (H" 46μm mesh size) plankton net to a concentrate plankton volume of about 30 ml capacity. The concentrate plankton sample was preserved in 5 % formalin by the addition of appropriate amount of buffered commercial 40% formaldehyde in a suitable plastic specimen bottle with a lid.

(b) Sample Analysis

In the laboratory the 30 ml concentrate plankton samples were further treated with a few drops of Lugol solution and allowed adequate time (H" 1 week) for all plankton to settle to the bottom of the specimen bottle. For analysis, this was further reduced to a final concentrate volume of about 5 ml by carefully decanting off enough of the top supernatant portion. About 1 ml of the final concentrate volume was examined at a time in an improvised plankton counting chamber (Damann, 1950) under a compound light microscope (Baush and Lomb model). Measurements of taxonomic features of observed plankters were made using a calibrated ocular micrometer at the appropriate magnifications of the microscope (mostly at the scanning and low power). From such measurements and diagnosis scaled drawings of the recorded plankters were made. Identifications of the plankters were made using a wide range of references (Donner 1956; Ward and Whipple, 1959; Green, 1960; Wulfert, 1965; Pontin, 1978; De Ridder, 1981; Egborge and Chigbu, 1988; and Akinbuwa and Adeniyi, 1991). Plankton abundance was based on enumeration of specimens from the whole 5ml final concentrate sample and expressed as number of rotifera organisms per cubic meter volume of the original water sample (Schwoerbel, 1970; Wetzel and Likens, 2000).

(c) Data Analysis

The variation in habitat and seasonal abundance of rotifera species were summarised using descriptive statistics. The various indices of community structure (species richness, diversity indices, and evenness indices) were all calculated in accordance with the procedures of Ludwig and Reynolds (1988). The relationships between the different investigated habitat types (based on rotifera abundance) were established using cluster analysis (farthest-neighbour method or total linkage method) according to Hedges (1971). The degree of similarity between the rotifer fauna of R. Gongola and those of other Nigerian waterbodies was compared by means of Sorensen Index (Sorensen, 1948). Sorensen Index (S) was calculated according to the following equation:

Table 1: Locations and site descriptions of the investigated waterbodies in Gongola River basin

	Sampling Station Location		Grid Co-ordinates		Approx. altitude (m)
Ref. no*	Waterbody	(Village/Town)	Latitude (N)	Longitude (E)	
1	Pond	Gwaram	10^0 12' 00"	10^0 17' 27.3"	NA
2	Pool	Gwaram	10^0 15' 16.4"	10^0 17' 27.3"	NA
3	R. Gongola	Dindima	10^0 14' 20.4"	10^0 08' 44.5"	480
4	R. Gongola	Hashidu	10^0 38' 49.4"	10^0 53' 49.4"	NA
5	R. Gongola	Bawa	10^0 41' 41.6"	10^0 29' 58"	335
6	Spring pool	Basher	10^0 49' 16.9"	10^0 45' 59.2"	NA
7	Reservoir	Pindiga	10^0 59' 25.9"	10^0 57' 59.1"	540
8	Pond	Mabani**	10^0 59' 21.0"	10^0 49' 57"	321
9	R. Gongola	Dewu	11^0 01' 23"	10^0 50' 53"	NA
10	R. Gongola	Lube	11^0 03' 00.4"	10^0 52' 33.4"	277
11	Borrow pit	Wuro/Baparu	10^0 56' 47"	11^0 22' 15"	385
12	R. Gongola	Gube	11^0 05' 10"	11^0 22' 16"	201
13	R. Gongola	Ngalda	11^0 05' 39.1"	11^0 22' 10.3"	308
14	R. Gongola	Ashaka	10^0 53' 54.5"	11^0 31' 39"	180
15	D. Kowa lake	Damagara	10^0 311' 41.5"	11^0 26' 35.5"	300
16	R. Kurungu	Kurungu	10^0 31' 41.5"	11^0 19' 14.8"	270
17	R. Geji Bauchi	Geji-Bauchi	10^0 30' 18.1"	11^0 19' 50.7"	240
18	R. Gongola	Dadin Kowa	10^0 17' 57.7"	11^0 30' 51.3"	180
19	Borrow pit	Tumu	10^0 00' 04.8"	11^0 59' 59.9"	450
20	R. Gongola	Kirri Dam	9^0 37' 00.0"	12^0 03' 0"	

D = Dadin; NA= Not Available; * = As applicable to Fig. 1; ** = Mabani - Alagamo

$$S = \left(\frac{2c}{a+b}\right) x100$$

where:

c = number of species common to both waterbodies
a = number of species in Gongola River basin
b = number of species of comparable waterbody

4. Results

(a) Taxa Composition

The rotifera fauna of the Gongola River basin comprised thirty species (including two subspecies) belonging to fifteen genera in nine of the families of the two orders (Ploima and Flosculariacea) of the class Eurotatoria. An outline classification of the fauna is presented in Table 2. Apart from *Testudinella patina* (Testudinellidae: Flosculariacea) all the recorded species belong to the Order Ploima of the subclass Monogononta. The families Colurellidae, Mytilinidae, Synchaetidae and Testudinallidae were represented by one species each while Euchlanidae and Trichocercidae were represented by three species each. The families Brachionidae and Lecanidae were represented by thirteen and seven species/subspecies respectively. The dominant genera were *Brachionus* (7 spp.) *Lecane* (6 spp.), and *Keratella* (3 spp.).

Altogether 28 of the 30 recorded species/subspecies were from the lotic (i.e. running) waterbodies as opposed to only 18 species recorded from the lenthic (static) waterbodies of the Gongola basin. The only two species not recorded from the lotic waters were *Asplanchna priodonta* and *Mytilina ventralis*. On the other hand, of the six recorded *Lecane* species, only two of them, *Lecane luna,* and *Lecane curvicornis* occurred in the lenthic waters (the others were restricted to lotic waters). Figure 3 highlights the habitat and seasonal differences in the taxa composition of the fauna. About 53% of the recorded species occurred common to both lotic and lenthic waters while 40% (i.e. 12 of the 30 species) were restricted only to the lotic waters (Groups E and F of Figure 3). Whereas *Keratella cochlearis* and *Beauchampiella eudactylota* were recorded only in the dry season, five species (*Argonotholca foliacea, Lepadella ovalis, Polyarthra vulgaris, Testudinella patina,* and *Dipleuchlanis propatula*) were restricted to the rainy season. Among the species that were common to both lotic and the lenthic water series, most of them occurred more frequently in the rainy season.

(b) Distribution Pattern, Abundance and Community Structure

The number of species recorded per station per sampling varied both with habitat type and season. On the average, more species were recorded per sampling per station for the lenthic waters (mean =

Table 2: Species checklist and outline classification of the rotifer fauna of the Gongola River basin

Category	Taxon
Phylum	Rotifera
Class	Eurotatoria
Subclass	Monogononta
Order	Ploima
Family	Asplanchnidae
	Asplanchna priodonta Gosse
Family	Brachionidae
	Anuraeopsis racenensis
	Argonotholca foliacea (Ehrenberg)
	Brachionus angularis Gosse
	B. calyciflorus Pallas
	B. caudatus Barrois and Daday
	B. falcatus Zacharias
	B. quadridentatus Hermann
	B. rubens Hudson and Goose
	B. urceolaris O.F. Muller
	Keratella cochlearis Goose
	K. lenzi Hauer
	K. tropica (Apstein)
	Platyias quadriconis (Ehrenberg)
Family	Colurellidae
	Lepadella ovalis (O.F. Muller)
Family:	Euchlanidae
	Dipleuchlanis propatula (Gosse)
	Beauchampiella eudactylota Gosse
Family:	Lecanidae
	Lecane (Monostyla) bulla Gosse
	L. (Monostyla) bulla styrax Myers
	L. (Monostyla) quadridentatus Ehrenberg
	Lecane (Lecane) curvicornis Murray
	L. (Lecane) hornemanni Ehrenberg
	L. (Lecane) luna Turner
	L. (Lecane) luna presumpta Altistrom
Family:	Mytilinidae
	Mytilina ventralis (Ehrenberg)
Family:	Synchaetidae
	Polyarthra vulgaris Carlin
Family	Trichocercidae
	Trichocerca chattoni Beauchamp
	T. ruttneri Donner
	T. similis Wirzejski
Order	Flosculariacea
Family	Testudinellidae
	Testudinella patina (Hermann)

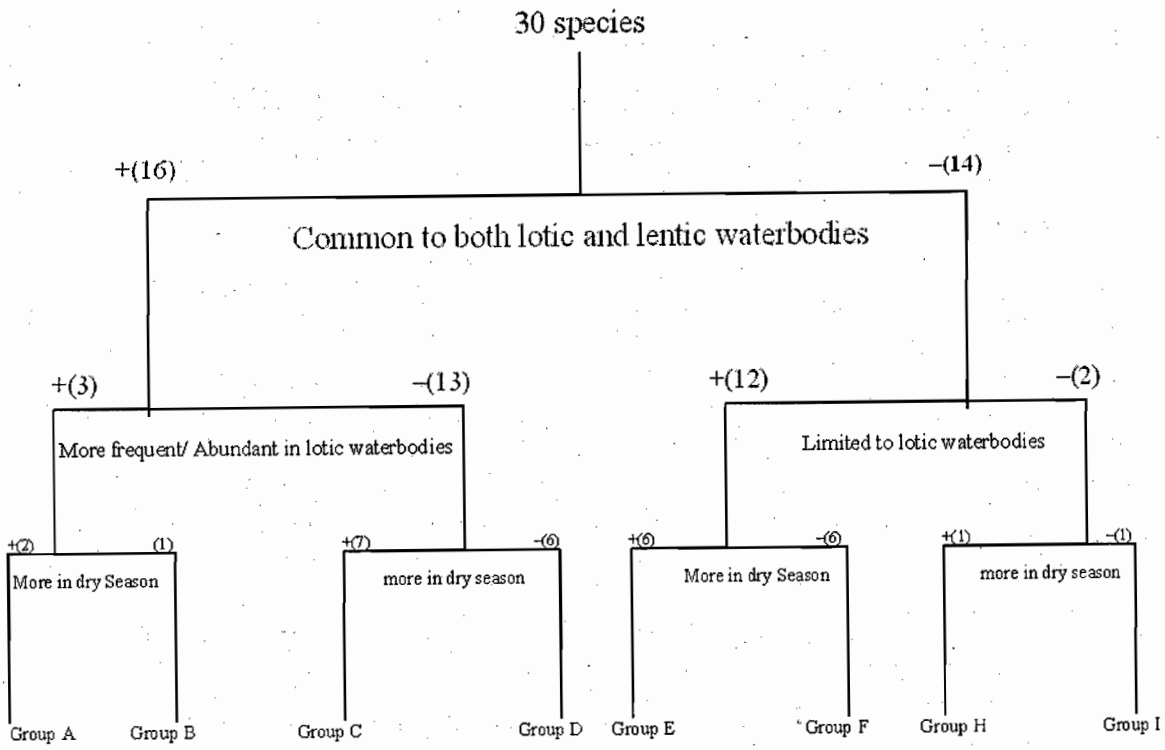
Table 3: Habitat and seasonal variations in the abundance (organism.m^{-3}) of rotifer species in Gongola River basin

	Lotic water series				Lentic water series			
	Rainy season		Dry season		Rainy season		Dry season	
Taxon	Max	Mean ± SE	Max	Mean ± SE	Max	Mean ± SE	Max	Mean ± SE
Asplanchna priodonta	ND	ND	ND	ND	ND	ND	3,800	1270 ± 512
Anuraeopsis racenensis	100	17 ± 11	ND	ND	ND	ND	ND	ND
Argonotholca foliacea	100	8 ± 8	ND	ND	ND	ND	ND	ND
Brachionus angularis	ND	ND	300	50 ± 46	6,500	1,083 ± 989	ND	ND
B. calyciflorus	5,000	470 ± 400	2,000	350 ± 300	2,400	1,017 ± 404	4,700	3,466 ± 324
B. caudatus	1100	91 ± 88	700	184 ± 71	300	50 ± 45	ND	ND
B. falcatus	100	8 ± 8	100	33 ± 14	4,300	750 ± 649	100	66 ± 27
B. quadridentatus	400	50 ± 32	100	17 ± 15	11,500	2,450 ± 1,705	ND	ND
B. rubens	100	8 ± 8	300	134 ± 55	100	17 ± 15	ND	ND
B. urceolaris	ND	ND	100	17 ± 15	200	33 ± 30	1,400	500 ± 178
Keratella cochlearis	ND	ND	100	17 ± 15	N	ND	800	450 ± 143
K. tropica	4,400	509 ± 366	500	217 ± 79	4,200	917 ± 608	21,300	8,070 ± 3,850
K. lenzi	100	8 ± 8	7,900	77 ± 870	100	50 ± 20	100	34 ± 14
Platyias quadricornis	200	150 ± 14	2,200	367 ± 330	400	117 ± 68	ND	ND
Lepadella ovalis	100	8 ± 8	ND	ND	ND	ND	ND	ND
Dipleuchlanis propatula	200	17 ± 16	ND	ND	2,600	433 ± 395	ND	ND
Beauchampiella eudactylota	ND	ND	100	17 ± 15	ND	ND	ND	ND
Filinia opoliensis	400	45 ± 26	300	100 ± 46	2,900	600 ± 423	100	33 ± 19
Lecane (M) bulla	100	8 ± 8	800	150 ± 118	ND	ND	ND	ND
L. (M) bulla styrax	100	8 ± 8	100	33 ± 19	ND	ND	ND	ND
L. (L) curvicornis	500	67 ± 40	1,400	267 ± 200	100	33 ± 19	ND	ND
L. (L) hornemanni	ND	ND	100	17 ± 15	ND	ND	ND	ND
L. (L) luna	ND	ND	1,000	200 ± 145	200	66 ± 38	100	33 ± 19
L. (L) luna presumpta	ND	ND	200	33± 30	ND	ND	ND	ND
Mytilina ventralis	ND	ND	ND	ND	100	17 ± 15	ND	ND
Polyarthra vulgaris	200	17 ± 16	ND	ND	ND	ND	ND	ND
Testudinella patina	100	17 ± 11	ND	ND	ND	ND	ND	ND
Trichocerca ruttneri	200	17 ± 16	100	17 ± 15	ND	ND	ND	ND
T. similis	ND	ND	100	17 ± 15	ND	ND	ND	ND
T. chattoni	200	25 ± 17	700	117 ± 105	200	50 ± 31	ND	ND

SE = Standard error; ND = Not detected

Table 4: Habitat and seasonal variations in the community structure of rotifers from Gongola River basin

Community structure	Lotic (Running) water series						Lentic (Static) water series					
	Rainy season			Dry season			Rainy season			Dry season		
	Range	Median	Mean ± SE	Range	Median	Mean ± SE	Range	Median	Mean ± SE	Range	Median	Mean ± SE
Species richness												
Species number (S)	0-7	3	3.25±0.90	2-9	7	6.33±1.15	0-9	7	6.2±1.2	0 – 7	6	6±1.0
Margalef index (R_1)	0-0.92	0.381	0.36±0.12	0.22-1.12	0.79	0.72±0.14	0-0.93	0.73	0.63±0.12	0.52– 0.72	0.6	0.6±0.04
Menhinik index (R_2)	0-0.26	0.16	0.16±0.03	0.10-0.25	0.20	0.17±0.02	0-0.14	0.11	0.11±0.02	0.04– 0.11	0.07	0.07±0.01
Diversity												
Shannon's index (H^1)	0-1.53	0.76	0.69±0.20	0.54-1.68	1.54	1.32±0.21	0-1.67	1.13	0.89±0.22	0.91– 1.24	1.10	1.10±0.07
Simpson's index (N)	0-1.00	0.57	0.57±0.12	0.20-.50	0.37	0.32±0.04	0-0.83	0.48	0.43±0.11	0.34– 0.52	0.43	0.43±0.04
Evenness/ Equitability												
Pielon index (E_1)	0-1.00	0.75	0.57±0.16	0.28-1.00	0.86	0.73±0.09	0-0.75	0.53	0.44±0.10	0.57– 0.95	0.76	0.76±0.08
Sheldon index (E_2)	0-1.25	0.75	0.63±0.16	0.24-1.00	0.76	0.65±0.10	0-0.57	0.39	0.34±0.18	0.50– 0.90	0.70	0.70±0.08
Modified Hill Index (E_5)	0.38-1.22	1.00	0.89±0.10	0.37-1.00	0.74	0.73±0.08	0-0.593	0.47	0.41±0.08	0.62-0.79	0.70	0.70±0.04



Group A
Brachionus caudatus
B. rubens

Group B
Lecane curvicornis

Group C
*Keratella cochlearis**
B. calyciflorus
B. falcatus
K. lenzi
L. luna
B. urceolaris
B. angularis

Group D
*Dipleuclanis propatula***
K. tropica
Filinia opoliensis
B. quadridentatus
Platyias quadricornis
Trichocerca chattoni

Group E
*Beauchampiella eudactylota**
L. bulla
L. bulla styrax
L. luna presumpta
L. hornemanni
Trichocerca similis

Group F
Anuraeopsis racenensis
T. ruttneri
*Argonotholca foliacea***
*Lepadella ovalis***
*Polyarthra vulgaris***
*Testudinella patina***

Group H
Asplanchna priodonta

Group I
Mytilina ventralis

* Restricted to dry season.
**Restricted to rainy season.

Figure 3: Outline classification of spatial and season distribution of rotifers in Gongola basin.

six species) than for the lotic stations (mean = four species). The number was generally higher in the dry season than in the rainy season. This was particularly pronounced in the lotic waters for which the dry season average species record per station was double that of the rainy season.

Figure 4 shows that the total recorded species at any point along the River Gongola trunk stream exhibited significant direct correlation ($p < 0.01$) with catchment area as well as stream length. Thus, cumulative species richness generally increased from the headwaters through middle reach to the lower reach of the river.

The most widely distributed species were *Keratella tropica, Brachionus calyciflorus,* and *Filinia opoliensis* with overall occurrence frequency of 56 %, 52 % and 44 % respectively. Five of the species had occurrence frequency in the range of 20-40 % (*Brachionus falcatus, B. quadridentatus, Keratella lenzi, Lecane luna,* and *Lecane curvicornis*) while the other species were characterized by occurrence frequency ≤ 20%. Virtually all the lotic water restricted species belonged to the latter category.

Table 3 provides detailed information on the habitat and seasonal abundance of the respective plankters per station per sampling. The abundance of individual plankters varied over a wide range of 0-

Table 5: Horizontal variations in relative abundance and community indices of rotifers in the River Gongola

Parameter	Upper Reach (station 4)	Middle Reach (station 18)	Lower Reach (station 20)
Taxon			
Keratella tropica	-	++	+++
K. lenzi	-	+	+++
Filinia opoliensis	-	+	++
Lecane curvicornis	+	++	+++
L. bulla	++	+	-
Platyias quadricornis	+++	+	-
Taxa indices			
Margalef index	0.40	0.51	0.59
Shannon's index	1.00	1.05	1.15
Simpson index	0.33	0.35	0.41
Hill's evenness	1.17	0.71	0.66
Species richness	3	7	5

- = Absent; + = Common; ++ = Abundant; +++ = Very abundant

Table 6: Habitat variation in the relative abundance and community structure of rotifers in lentic waterbodies in Gongola River basin

Parameter	Seasonal pond (station 1)	Borrow pit (station 11)	Dadin Kowa Reservoir (station 15)
Taxon			
Brachionus quadridentatus	+	+	++
Keratella tropica	+++	++	+
Brachionus calyciflorus	+++	+++	+
B. falcatus	+++	+	-
Filinia opliensis	++	+	-
Platyias quadricornis	+	+	-
Lecane (L.) *luna*	+	-	-
Taxa indices			
Margalef index	0.80	0.93	0.66
Shannon's index	1.67	1.23	0.95
Simpson's index	0.22	0.42	0.57
Hill's evenness	0.59	0.57	0.48
Species richness	9	9	6

- = Absent; + = Common; ++ = Abundant; +++ = Very abundant

Table 7: Similarity between the rotifer fauna of the River Gongola basin compared with those of some other waterbodies in Nigeria.

Water body	State of location	Reference source	No of rotifera species	Similarity with R. Gongola (%)
R. Warri	Delta	Egborge, 1994	58	92.0
R. Sokoto	Sokoto	Green, 1960	41	73.1
R. Ikpoba	Edo	Egborge and Chigbu, 1988	46	65.2
R. Osun	Osun	Egborge, 1972	27	62.9
Badagry Creek	Lagos	Egborge, 1991	51	58.8
R. Benin	Edo	Onwudinjo and Egborge, 1994	50	48.0
Lake Kainji	Niger	Bidwell and Clarke, 1977	35	75.7
Opa Reservoir	Osun	Akinbuwa and Adeniyi, 1991	61	59.6
Eleyele Reservoir	Oyo	Imevbore, 1965	17	51.6
Shiroro Lake	Niger	Ovie and Adeniji, 1994	19	48.5
Asa Lake	Kwara	Ovie and Adeniji, 1995	43	43.1
Erinle Lake	Osun	Akinbuwa, 1999	117	41.7

* = Based on Sorensen's index (Sorensen, 1948); ** = Badagry Creek- Lagos Harbour

21,300 organisms.M^{-3} (ca. 0-21 organisms.L^{-1}). For the two water series, dry season mean abundance was double that of the rainy season. For instance the mean (± standard error) abundance for the typical lotic water in the rainy season was 1,408±621 organisms.M^{-3} as opposed to 3240±1130 organisms.M^{-3} in the dry season. On the other hand, the mean station abundance for lentic waterbodies during the rainy season was 7,683±2,180 organisms.M^{-3} as opposed to 13,033±5,290 organisms.M^{-3} in the dry season. The most frequently occurring species were also among the most abundant species, viz: *Keratella tropica* (mean range = 217±79-8,070±3,850 organisms.M^{-3}), *Brachionus calyciflorus* (470±400-3,466±324 organisms.M^{-3}), *Asplanchna priodonta* (0-1270±512 organisms.M^{-3}), and *K. lenzi* (8±8-767±870 organisms.M^{-3}). Tables 4-6 also show that species richness and the various indices of the community structure of the rotifer assemblage exhibited both habitat and seasonal variations. Diversity in rotifer assemblage was generally higher in lenthic water series than in the lotic water series; it was also higher during the dry season than in the rainy season. Species evenness or equitability followed essentially the pattern exhibited for species diversity for both habitats and seasons. Table 5 provides evidence that a number of rotifer species showed definitive pattern of occurrence along the horizontal course of the Gongola River. Whereas *Lecane bulla* and *Platyias quadricornis* were restricted to the upper and middle courses, *Keratella tropica, K. lenzi* and *Filinia opoliensis* were absent from the upper reach but increased in

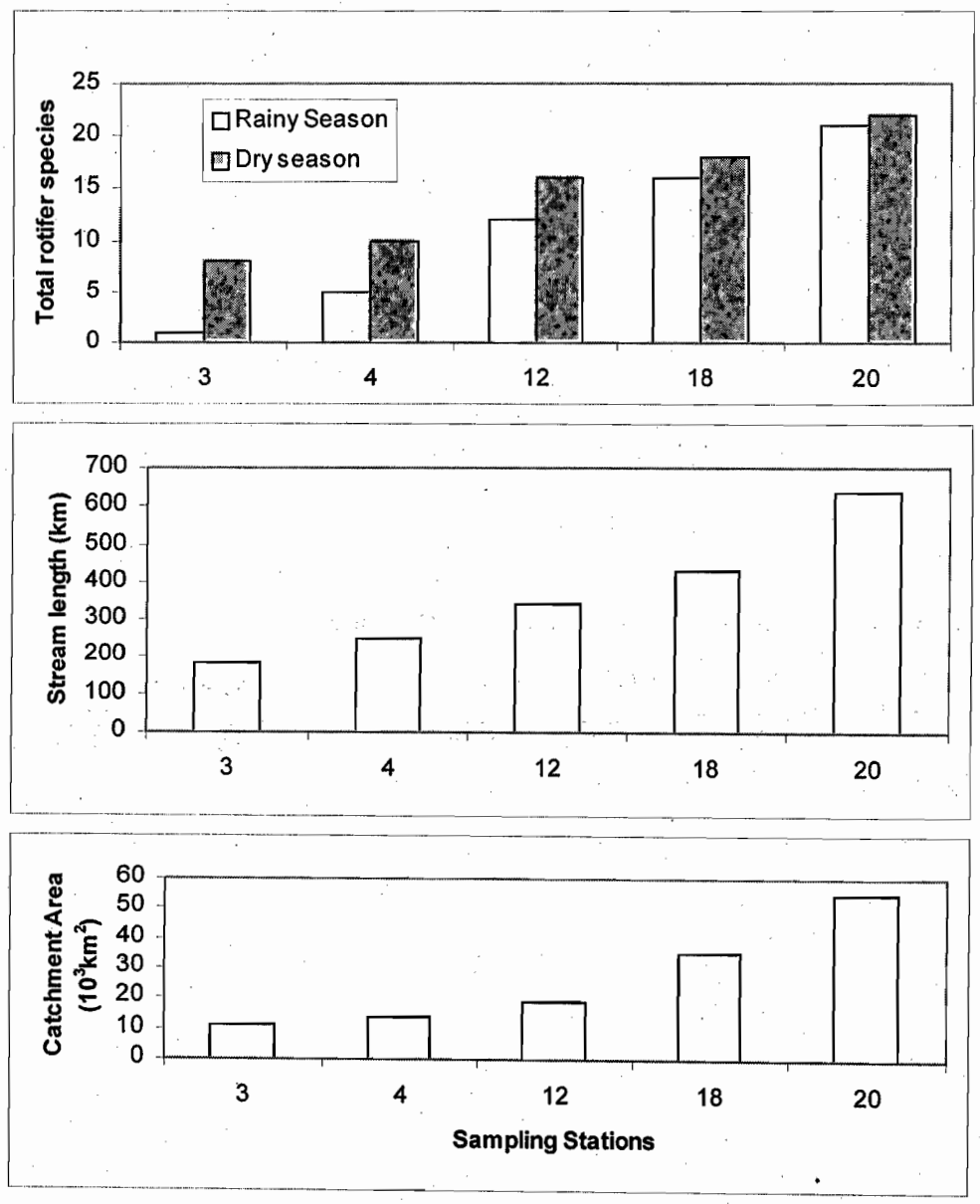


Figure 4: Variation in total rotifer number in relation to river length and catchment Area.

abundance from the middle to the lower reach. *Lecane curvicornis* showed increased abundance from the upper reach through the middle to the lower reach. Species richness and diversity increased steadily from the upper to the lower reach while species evenness index showed the reverse pattern. A number of species occurred abundantly in the seasonal ponds but sparse or absent in the big permanent reservoirs and vice versa (Table 6). Hill's evenness index tended to decrease with increase in the size of lenthic waters and/or from upper reach to the lower reach of lotic water (Tables 5 and 6).

(c) Interhabitat Relationship

Figure 5 is the result of the cluster analysis showing the relationship between the representative habitat types on the basis of the rainy season abundance records of all the species. Loose clusters were established with regard to habitat type and each habitat cluster was characterized by a rotifer association. The occurrence of *Testudinella patina, Brachionus falcatus, Filinia opoliensis* as well as the relative abundance of *Keratella tropica* was useful in separating the different habitats broadly into the lotic and static series. *Testudinella patina* and *Brachionus* occurred in lotic and seasonally static waterbodies but absent from the permanent and relatively big lenthic waterbodies.

5. Discussion

The number of rotifera taxa that have been recorded for individual Nigerian inland waterbodies is quite variable, occurring over a wide range of 17-117 species (Table 7). At 95 % confidence interval the average number is in the range of 33-61 species per waterbody/river basin. As many as 227 species were recorded for a number of lakes in the flood plains of the Niger Delta (Segers *et al*., 1993) while altogether about 380 species have been recorded for the entire country from the known studies. Thus, the 30 species recorded for R. Gongola in the present study is considered low especially in relation to the size and varied range of environmental conditions in the river basin. This is most probably due to the low intensity of sampling carried out and the fact that a number of the stations were sampled only once (during the rainy season) as they dried up during the dry season. The species recorded however compare well with that of Lake Chad (with 30 species) into which R. Yobe (with a basin area of about 106,000 km^2) drains. The number is significantly higher than that of Shiroro Lake (a flow- through reservoir on R. Kaduna with a basin area of 66,000 km^2) with only 19 species of rotifers (Ovie and Adeniji, 1994).

Inspite of the relatively low species richness of the rotifer fauna of Gongola River basin, the fauna exhibits a high degree of similarity with many other Nigerian waterbodies especially the lotic series (Table 7). This may be due in part to the fact that the Gongola fauna does not contain any endemic species, as known so far. All the recorded species have been known elsewhere in Nigeria and are either cosmopolitan or cosmotropical in distribution following the definitions of the terms by Green (1972).

In addition, many of the Nigerian inland waterbodies have a number of species in common while the dominant group are either members of the Brachionidae or Lecanidae. In the present study the two families together made up 66 % of the rotifera fauna with members of Brachionidae forming the dominant group (43 %) and Lecanidae the subdominant group (23 %). This is the known pattern for all the available records for Nigerian inland waters except for Ikpoba River in which members of Lecanidae are dominant (33 %) and Brachionidae (17 %) the subdominant group (Egborge and Chigbu, 1988). The predominance of these two families in most waters in general could be attributed in part to the fact that species of the major genera involved (*Brachionus, Keratella, Platyias, Lecane* and *Monostyla*) are omnivorous feeders (Goldman and Horne, 1983) and hence versatile in exploiting a wide range of niches in aquatic ecosystems. The same reason probably explain why *Asplanchna* and *Synchaeta* species (which are largely predatory) were poorly represented in the fauna (3.3 % each) and their respective families also poorly represented in the Nigerian waterbodies so far investigated (Asplanchinidae = 4.2±1.2 %, Synchaetidae = 5.1±2.3 %).

A major feature of the rotifer fauna of the Gongola basin as also revealed in this study is the fact that the lotic water series are qualitatively richer but quantitatively poorer than the lenthic water series especially during the rainy season (Table 3). The qualitative richness of the fauna relates to the available basin area (Figure 4). Virtually all the borrow-pit ponds and pools are recent man-made excavations which are characterized by relatively small watershed area. This is in contrast to the Gongola River which is characterized along its length by increasingly larger basin area from which rich allochtonous materials and organisms can be derived. With the characteristic high flood discharge of the river during the rainy season many organisms are apt to be scoured from the riverbed and/or dislodged from the littoral vegetation to enrich the river fauna qualitatively. However, in view of high stream flow velocity, high water turbidity (reflecting water quality) and the dilution effect of the flood water, plankton development is usually reduced to the minimum hence stream fauna is usually quantitatively poorer during the rainy season. This effect in which plankton composition is obviously governed by seasonality of rainfall and discharge has been

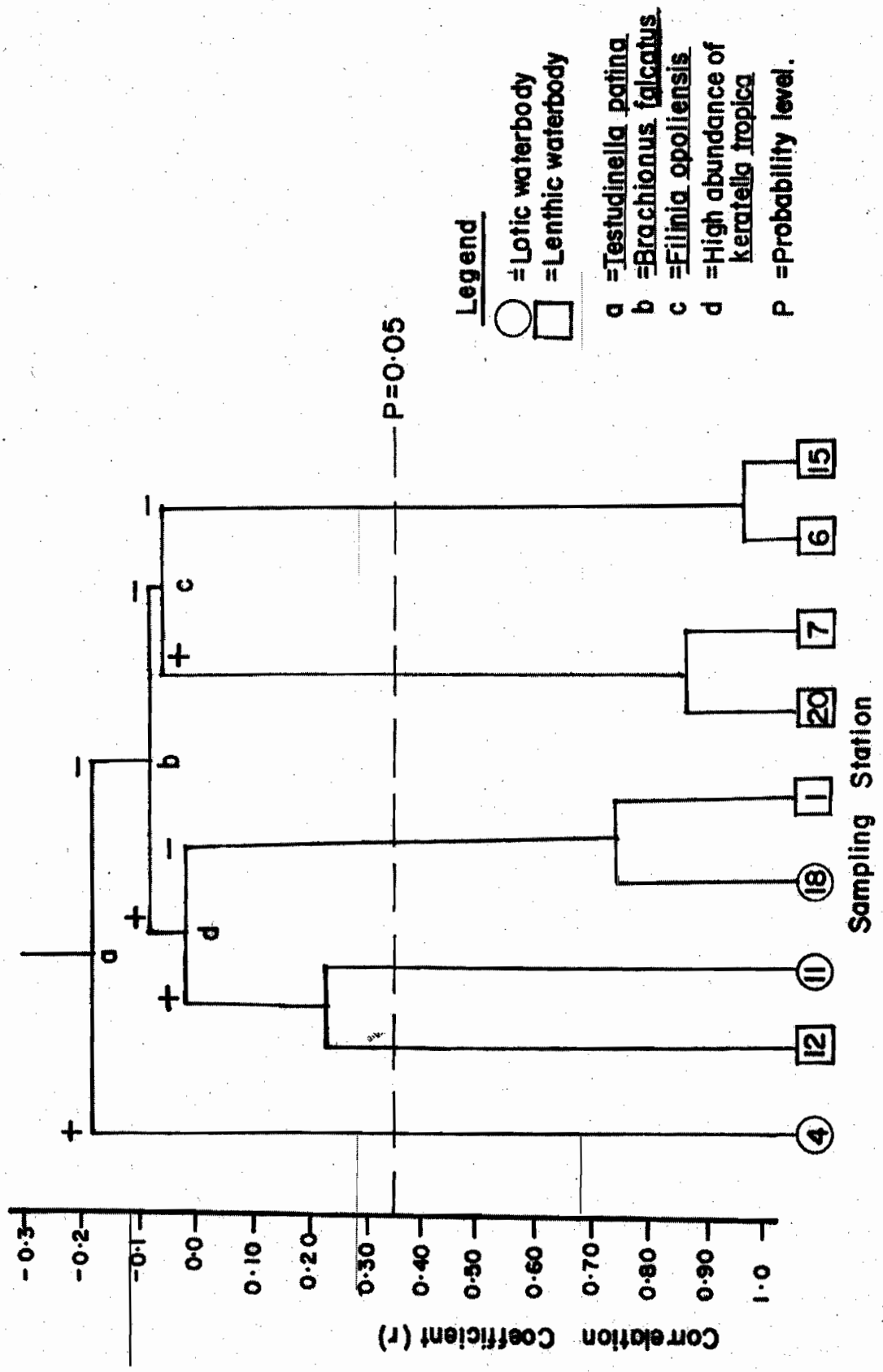


Figure 5: Cluster analysis showing relationship between representative water habitats with regard to occurrence of rotifers.

reported for many other tropical waters including the Amazonian waters (van De Heide, 1982).

The present study has provided some insight into the great complexity in the community structure of the rotifera fauna of the study area. Structure in ecosystems can be thought of as the organization of species populations into appropriate levels (Welch and Lindell, 1992). All the community indices considered in the present study varied both within and between the investigated ecosystems (Tables 4-6). Among these are the two most commonly used diversity indices, the Simpson index and the Shannon index. Whereas the Simpson index is weighted in favour of the common species in the population, the Shannon index is weighted in favour of the rare ones (Odum, 1975). However, because the two indices do convey somewhat different information and together give a fuller picture of the diversity profile of the community they have been jointly used in the present study. Compared with biotic indices and scores, diversity indices are more objective values of environmental quality being derived mathematically from quantitative data. They do not however make use of autecological information regarding the response of the individual taxa (Hawkes, 1978).

The general predominance of the Simpson index over the Shannon index in the present work reflects the greater contribution of the rare and less common species to those of the common and very common ones in the diversity structure of the rotifera fauna. On the average the number of common species of the fauna is only about one-third that of the rare and less common ones. This ratio tended to show a decrease from the upper reach of the Gongola River to the lower reach. In line with the corollary that diversity tends to be low in immature systems and high in mature systems (Welch and Lindell, 1992) it can thus be inferred that R. Gongola tends to increase in maturity downstream with regard to its rotifera fauna. With increase in maturity the probability for fewer species to become more and more dominant in the community increases hence the associated reduction in taxa evenness as observed. In general the complexity of community structure observed in the fauna calls for more study for a clearer elucidation.

6. Conclusion

The River Gongola, the principal tributary of the Benue in Nigeria drains about 7% of the surface area of the country and contains 30 species of rotifers. The number of species recorded is approximately 8% of the total species so far known in Nigeria (380 species) and it is likely to be higher with a more intensive survey. The fauna shows high similarity with those of most other Nigerian rivers by comprising mostly cosmopolitan or cosmotropical taxa and being dominated by members of the families Brachionidae and Lecanidae. The occurrence and abundance of Rotifera species are strongly influenced by seasonality in rainfall and flood discharge pattern in the river basin. The rotifer populations showed a gradual increase in community maturity (as represented by diversity index) downstream of the Gongola River.

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