The fish fauna of Anambra river basin, Nigeria: species abundance and morphometry

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Abstract: The fish yields of most Nigeria inland waters are generally on the decline for causes that may range from inadequate management of the fisheries to degradation of the water bodies. Sustainable exploitation requires knowledge of the ichthyofaunal composition in the water bodies. We did a survey of fish species in Anambra river basin for 22 months. Fish samples were collected using four different gears –hook and line of size 13, caste nets, gill nets, and cages of mesh sizes of 50mm, 75mm, and 100mm each. We recorded 52 fish species belonging to 17 families: 171, 236, and 169 individuals at Ogurugu, Otuocha, and Nsugbe stations respectively. Two families, Characidae, 19.5 %, and Mochokidae, 11.8%, constituted the dominant fish families in the river. The dominant fish species were *Citherinus citherius*, 9.02%, and *Alestes nurse*, 7.1%. Other fish species with significant abundance were *Synodontis clarias* 6.9%, *Macrolepidotus curvier* 5.7%, *Labeo coubie* 5.4%, *Distichodus rostrtus* 4.9%, and *Schilbe mystus* 4.5%. The meristic features of the two most abundant fish species caught are as follows: *Citharinus citharius* dorsal fins 20, anal fins 30, caudal fins 21, pectoral fins, 9 and 8 ventral fins, and *Alestes nurse* 10 dorsal fins, 14 anal fins, 31 caudal fins, 7 pectoral fins and 6 ventral fins. The morphometric features of the two most abundant fish species are *Citharinus citharius* total length 300mm, standard length 231mm, head length 69mm, body length 101mm, body girth 176 mm, body weight 900mg. *Alestes nurse* total length 200, standard length 140mm, head length 60mm, body length 80mm, body girth120mm, body weight 400mg. The most abundant animal utilizing the basin was *Ardea cinerea*(D3) with 22.2% occurrence (D4) and this was followed by *Caprini* with 13.51%, and *Varanus niloticus*, 10.04%. The least abundant animals utilizing basin were *Chephalophus rufilatus*, and *Erythrocebus patas*, with 0.58% each of occurrence. Rev. Biol. Trop. 57 (1-2): 177-186. Epub 2009 June 30.

Key words: Anambra River, ichthyofauna, biometry, Nigeria, Characidae, Mochokidae.

The fish yields of most Nigeria inland waters are generally on the decline (Jamu and Ayinla 2003). The decline of these fisheries has been attributed to a wide range of causes ranging from inadequate management of the fisheries resources to environmental degradation of the water bodies. For sustainable exploitation of these resources, a crucial management tool is to have a comprehensive understanding of the ichthyofaunal composition of the water bodies. The freshwater food fishes found in Nigeria are about 268 different fish species (Lévesque *et al.* 1992). They inhabit over 34 well-known

freshwater bodies (rivers, lakes, and reservoirs) which constitute about 12% of Nigeria's total surface area put at 94 185 000 ha (Ita 1993). Fish stocks in rivers are generally replenished from their adjacent flood plains after each flood season during which fish breed. Therefore, any natural phenomenon such as drought or artificial activities such as dam construction, which eventually affect the natural cycle of flooding, will certainly undermine fish species diversity both in lakes and wetlands. Considering this fact, therefore, that lakes, wetlands and reservoirs are supplied with fish by their inflowing

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rivers, the rivers would be characterized by higher species diversity (Ita 1993). Boulenger (1916) published a list of African freshwater fishes to include 976 species, referable to 185 genera and 43 families. But Welman (1948) produced a list of 181 species of fish that could be found in Nigeria inland waters. The report also revealed that Kaduna and Sokoto-Rima Rivers have 28 and 22 species respectively, in them. Cross River, Ogun, and OsunRivers have 39, 23, and 23 fish species respectively. Ita (1993) reported that an estimated 230 species of fish have been recorded from the rivers of Nigeria but no record is available on the species present in Rivers Echi, Anambra, Oji and Adada, which all empty directly into the ocean via River Niger. Information is scanty on the biometry and relative abundance of the ichthyofauna of Anambra River. For sustainable exploitation of these fishery resources in the river basin, a crucial management tool is would be a comprehensive understanding of the ichthyofaunal composition of the water bodies. This paper provides preliminary data on the composition, biometry, and relative abundance of the ichthyofauna of Anambra River. This forms part of a large and on going study on the fishes of the river basin. The information obtained in this investigation has been used to outline desirable management measures for the species in the basin.

MATERIALS AND METHODS

The Anambra River basin: The Anambra River basin covers an area of approximately 14 014 km^2 (Awachie & Hare 1977). The River Anambra is approximately 207.4 km in length, rising from the Ankpa hills (ca. 305-610m above sea level) and discharging into the River Niger at Onitsha. There are two main seasons, the dry season (October/November – March) and the rainy season (April – September/October) approximately corresponding to the dry and flood phase, respectively, of the hydrological regime. The water temperature and Secchi disc reading in the river range from 24º C to 31º C and 5 cm to 85 cm, respectively (Odo 2004).

The mean annual rainfall is between 150 cm and 200 cm (Ilozumba 1980) (D5).

Between January 1998 and October 1999, monthly fish species were sampled from Ogurugu, Otuocha and Nsugbe stations of the Anambra River. The fishing gears used were of four different types, i.e. hook and line size 13, cast nets, gill nets and cages of mesh sizes of 50 mm,75 mm, and 100 mm. Preservation of fish samples was in 10% formalin. The surface water temperature of the river was taken with the use of dry mercury thermometer and the pH was monitored using the pH meter on a monthly basis. The dichotomous identification method of fish species determination arranged by Boulenger (1916) and Welman, (1948) and adopted by Oguzie (1997), was used to identify fish species. This was achieved by taking account of the meristic features of the various fishes. These features were dorsal, anal, caudal, pectoral, and ventral fin rays and spines, where present measurements were also taken on sampled fishes to aid the identification process. The morphometric data of each individual were taken. These measurements include total length of the fish (TL), measured from the mid-tip of the snout to the lateral mid base of the caudal fin, head-length (HL),which was measured from the mid-tip of the snout to the postero-dorsal junction of the membranous margin of the gill opening with the body, body depth (BD) and body girth (BG) (D6). The total number of fish caught from the river was recorded; this enabled the determination of the relative abundance of the various species in the river. The main system of classification of the species that were caught in the river was that of Madison (1992) (D8) as adopted by Babatunde and Raji, (1998). Aquatic and domestic wildlife animals sighted during the periods of data collection were counted and recorded. Droppings of domesticated animals utilizing the flood plain were evaluated and identified.

Data Analysis: The faunal similarities at different locations, based on nominal data, were analyzed using the Jackson Index (1989). The relative abundance of taxa that were

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common among the stations was calculated using Renkonen similarity (Renkonen 1975), and the Bellinger coefficient (Bellinger 1974) was calculated to evaluate discontinuities in the longitudinal distribution of species richness (d). The Shannon-Weiner index (H) and evenness index (Shannon and Wiener 1963) (E) were used to evaluate species diversity; Hutcheson's t-test was performed to detect the significant difference between general diversity indices. The mean Fulton's condition (K) of ten common and abundant species among the three stations was calculated (Bagenal & Tesch 1978) and compared using unpaired t-test ($n_1 \# n_2$); percentage data were transformed before analysis (Zar 1984). The total and relative abundance of aquatic and other animals utilizing the basin were calculated.

RESULTS

The results of the study showed that 52 fish species belonging to 17 families were recorded which comprised 171, 236, and 169 individual specimens at Ogurugu, Otuocha, and Nsugbe stations respectively (Table 1). Two families, Characidae 19.97%, and Mochokidae 11.8%, constituted the dominant fish families in the river (D7). *Citharinus citharius* 9.02%, and *Alestes nurse* 7.3 % (D8), were the dominant species respectively. Other fish species with significant abundance were *Synodontis clarias* 6.9%, *Macrolepidotus cuvier* 5.7%, *Labeo coubie* 5.4%, *Distichodus rostartus* 4.9%, and *Schilbe mystus* 4.5%. The meristic features of the two most abundant fish species caught were as follows: *Citherinus citharius* had: Dorsal fins, 20, Anal fins, 30, caudal fins 21, pectoral fins 9 and 8 ventral fins. *Alestes nurse* had 10 dorsal fins, 14 anal fins, 31 caudal fins, 7 pectoral fins and 6 ventral fins Table 3 (D9). The morphometric features of the two most abundant fish species are *Citherinus citharius*: total length 300 mm, standard length 231 mm, head length 69 mm, body length 101 mm, body girth 176 mm, body weight 900 mg. *Alestes nurse*: Total length 200 mm, standard length 140 mm, head length 60 mm, body length 80 mm, body girth 120 mm, body weight 400 mg (Table 3). All the most abundant and common fish species among the three stations were in good condition (K>1) (Table 6). Members of Ardeidae aquatic animal family were the most abundant and they were followed by Acciptridae while Sirenia were the least occurring in the basin (Table 7) (D10). The most abundant animal utilizing the basin was the *Ardea cinerea* (D11), with 22.2% occurrence and this was followed by *Caprini* sp. with 13.51%, and *Varanus niloticus* (D12) with 10.04%. The least abundant animals utilizing the basin were *Chephalophus rufilatus* and *Erythrocebus patas* with 0.58% of occurrence each (Table 7).

DISCUSSION

The catch composition from this study showed that Characidae, 19.5%, and Mochokidae, 11.8%, constituted the dominant fish families in the river. Regarding catch and species composition, our results agreed with other studies conducted on a number of rivers in Nigeria. Analysis of catch in the preliminary survey of the fresh water fish of Nigeria by Welman, 1948, revealed that Kaduna and Sokoto/Rima rivers have Mochokidae, 28, and Osteoglossidae, 22, species respectively in them. In Cross River, Ogun and Osun rivers, 39, 23, and 27 fish species were recorded from them. But in this study, 52 fish species were recorded from the river, which comprised 171 236 and 169 individual fish specimens at Ogurugu, Otuocha and Nsugbe respectively .The trend in the development of fish fauna and the sequence of changes in fish populations are complex and variable in south-eastern African rivers. The present fauna in the river is dominated by weed associated mesopredators (Welcomme, 1979). Our results suggest low inter-annual variation in species composition. These may be based on stable phytoplankton populations, nutrient and physicochemical parameters (not studied). Perhaps in-situ manipulations of isolated portions of this system would be needed to demonstrate such interrelations. It is possible that the very low number of fish species recorded at

TABLE 1

Percentage composition of fish caught from Anambra River Basin

Fish species	Number (percentage) of fish caught			total No (%)
	Ogurugu	Otuocha	Nsugbe	
Clupeid				
*Pellonula afzelinus*Günter 1968	-	9(1.5)	1(0.2)	10(1.7)
Gynothrisamento regan	1(0.2)	4(0.9)	-	5(0.9)
Sierathrissa leonensis Boulenger 1908	-	1(0.2)	-	1(0.2)
Papyrocranus afer	17(2.9)	4(0.7)	-6(1.0)	27(4.6)
Xenomystus nigri Gunther 1868	2(0.3)	-	-	2(0.3)
Pantodon bucholzi Peters 1902	1(0.2)	2(0.3)	-	3(0.5)
Osteoglossidae				
Heterotis niloticus Muller 1843	1(0.2)	8(1.4)	1(0.2)	10(1.7)
Gymnarchus niloticus Cuvier 1829	7(1.2)	1(0.2)	3(0.5)	11(1.9)
Mormyridae				
Mormyrus fume Leach 1818	1(0.2)	4(0.7)	1(0.2	6(1.04)
Petrocephalus bane Boulenger 1898	4(0.7)	5(0.8)	1(0.2)	10(1.7)
Petrocephalus simus Boulenger 1898	1(0.2)	-	1(0.2)	2(0.4)
Characidae				
Hydrocynus lineatus Bleeker 1861	2(0.3)	1(0.2)	-	3(0.5)
Hydrocynus brevis Gunther 1864	-	2(0.3)	1(0.2)	3(0.5)
Hydrocynus forskhali Cuvier 1819	2(0.3)	-	1(0.2)	3(0.5)
Hepsetus Odoe Black 1794	1(0.2)	2(0.3)	1(0.2)	4(0.7)
Alestes nurse Ruppłe1832	16(2.7)	16(2.7)	10(1.7)	42(7.1)
Macrolepidotus (Alestes) Cuvier 1849	12(2.0)	10(1.7)	11(1.9)	33(5.6)
Alestes deutex Linnaeus 1757	1(0.2)	8(1.4)	6(1.0)	15(2.6)
Alestes baremosa	4(0.7)	6(1.0)	1(0.2)	11(1.9)
Micralestes acutidens Petae 1868	-	1(0.2)	-	1(0.2)
Citharinidae				
Citharinus citharus Geoffrey 1809	2(0.3)	14(2.4)	36(6.3)	52(9.0)
Cyprinidae				
Labeo senegalensis Cuvier 1840	3(0.5)	11(1.9)	2(0.3)	16(2.8)
Labeo coubie Rupple 1832	15(2.5)	8(1.4)	8(1.4)	31(5.4)
Distichontidae				
Distichodus rostratus Muller 1864	13(2.2)	6(1.0)	9(1.5)	28(4.9)
Ichthyobridae				
Phago loricatus Gunther 1865	1(0.2)	2(0.3)	1(0.2)	4(0.7)
Bagridae				
Bagrus bayad macopterus (Boulenger) 1875	2(0.3)	1(0.2)	2(0.3)	5(0.8)
Chysichthys nigrodigitatus Lacepede 1802	1(0.2)	7(1.2)	5(0.8)	13(2.3)
Chrysichthys auratus Geoffroy 1809	-	1(0.2)	3(0.5)	4(0.7)
Clarotes laticeps Rupple, 1829	4(0.7)	5(0.8)	7(1.2)	16(2.8)

Fish species	Number (percentage) of fish caught			total No (%)
	Ogurugu	Otuocha	Nsugbe	
Auchenoglanis biscutatus				
Cuvier and Valencinnes 1840	-	2(0.3)	-	2(0.4)
Clariidae				
Clarias anguillaris Linnaeus 1762	5(0.8)	11(1.9)	5(0.8)	21 (3.5)
Clarias lazera Cuvier and Valencinnes 1840	3(0.5)	11(1.9)	2(0.3)	16(2.7)
Heterobranchus bidorsalis Geoffroy, 1818	-	7(1.2)	-	7(1.2)
Malapteruridae				
Malapterurus electricus Forskali 1775	-	4(0.7)	3(0.5)	7(1.2)
Mochokidae				
Synodontis ocellifer	2(0.3)	4(0.7)	-	6(1.0)
Synodontis gambiensis Cuvier 1840	1(0.2)	4(0.7)	1(0.2)	6(1.04)
Synodontis nigrita Cuvier 1840-	1(0.2)	4(0.7)	1(0.2)	6(1.04)
Synodontis clarias Linnaeus 1762	8(1.4)	16(2.7)	6(2.7)	40(6.9)
S. gobroni	-	2(0.3)	-	2(0.4)
S. membranaceus Geoffroy, 1809	1(0.2)	(0.2)	1(0.2)	3(0.5)
S. batensoda Ruppel 1832	4(0.7)	1(0.2)	-	5(0.9)
Schilbeidae				
Physailia pellucida Boulenger, 1901	-	4(0.7)	-	4(0.7)
Schilbe mystus Linnaeus 1762	6(1.0)	12(0.3)	8(1.4)	26(4.5)
Siluranodon auritus Bleeker 1858	-	-	1(0.2)	1((0.2)
Channidae				
Ophyocephalus scurus Guntheri 1861	1(0.2)	1(0.2)	1(0.2)	3(0.5)
Pomadasydae				
Pristopoma jubeleni Cuvier	-	1(0.2)	-	1(0.2)
Ctenopoma kings leyae Cuvier 1864	-	1(0.2)	-	1(0.2)
Centropomidae				
Lates niloticus Linnaeus 1762	3(0.5)	2(0.3)	3(0.5)	8(1.4)
Cichlidae				
Tilapia zillii Gervais 1848	9(1.5)	4(0.7)	5(0.8)	18(3.1)
T. nilotica Linnaeus 1757-	2(0.3)	-	-	2(0.3)
T. galilaea Artedi 1757	3(0.3)	3(0.3)	4(0.7)	10(1.3)
Tetraonontidae				
Tetraodon fahake Steindachner 1870	10(1.7)	-	-	10(1.7)
Total	**171**	**236**	**169**	**576(D14)**

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TABLE 2

Preliminary check-list of aquatic and other animals utilizing Anambra flood plain

Common name	Species
Plover	Charadridae
Wated plover	*Venellus senegallus*
Little ringed plover	*Charadrius dubius*
Egret	Ardeidae
Ardea Cattle egret	*Ardeola ibis*
	Egretta garzetta
Little egret heron	*Ardea cinerea*
Duck/geese	Antidae
Pygmy goose	*Nettapus auritus*
	Jananidae
Little trotler	*Actophilornils Africana*
White-headed vulture	Acciptridae
	Trigonoceps occipitallis
Kite	*Milvus migrans*
Short-toed eagle	*Ciraeceatus gallicus*
Fish eagle	*Haliaetus vocites*
	Artiodactyla
Bushbuck	*Tragelaphus scriprus*
Buffalo-bush-cow	*Syncerns caffer*
Red-flanked duiker	*Chephalophus rufilatus*
Kob	*Kobus kobus*
	Lagomorphs
Hare	*Lepus capensis*
	Primate
Red patas monkey	*Erythrocebus patas*
	Sirenia
African manatee	*Trichechus senegalensis*
	Reptilia
Monitor lizard	*Varanus niloticus*
	Chelidae
Artiodactyla	*Tortoise*
Cattle	Bovidae
	Bos taurus
Goats & Sheep	Capriniae
	Caprini sp.

TABLE 3

Meristic features of fish species caught in Anambra River, Nigeria

	N	D. fin	A. fin	C. fin	P. fin	V. fin
Papyrocranus afer	27	6	70	6	9	-
Alestes nurse	42	10	14	31	7	6
Macrolepidotus Cuvier	33	9	20	21	6	5
Citharinus citharius	52	20	30	21	9	8
Labeo coubie	31	12	10	17	8	6
Distichodus rostatus	28	26	12	20	4	5
Clarias anguillaris	21	70	59	11	4	3
Synodontis clarias	40	7	8	18	9	4
Schilbe mystus	26	6	62	19	8	4
Tilapia zilli	18	15	10	13	11	7

Numerals represent number of fin rays: D. Fin: Dorsal fin; A. Fin: Anal Fin; C. Fin: Caudal Fin; P. Fin: Pectoral Fin; V. Fin: Ventral Fin.

TABLE 4

Morph metric features of fish species caught in Anambra River, Nigeria

	N	TL	SL	HL	BD	BG	WG
Papyrocranus afer	27	571	395	80	90	160	301
Alestes nurse	42	200	140	60	80	120	400
Macrolepidotus cuvier	33	481	401	90	130	180	700
Citharinus citharius	52	300	231	69	101	176	900
Labeo coubie	31	600	501	122	140	191	1001
Distichodus rostatus	28	480	411	96	110	171	1200
Clarias anguillaris	21	800	602	180	171	196	1160
Synodontis clarias	40	240	203	109	190	170	270
Schilbe mystus	26	280	210	80	140	130	240
Tilapia zillii	18	275	201	79	97	200	230

All measurements are millimeters (mm): TL: Total Length; SL: Standard Length; HL: Head Length; BD: Body Length; BG: Body Girth; BW: Body weight (mg).

TABLE 5

Diversity of fish fauna in the Anambra River

Sampled station	Ogurugu	Otuocha	Nsugbe
Number of samples	44	44	44
Number of species	51	52	51
Number of individuals	171	236	169
Species richness (d)	3.19	3.01	2.97
General diversity (H)	0.82	1.10	0.78
Evenness (E)	0.56	0.70	0.49

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TABLE 6

Comparison of mean Fulton's condition factors (k^l) for common and abundant fish species, Anambra River

	Fish species	Ogurugu		Otuocha		Nsugbe		t-value
		N	Mean ±tsd	N	Mean ± tsd	N	Mean ± tsd	
1	*Papyrocranus afer*	17	2.04±0.49	4	1.47±0.10	6	2.89±0.31	1.81
2	*Alestes nurse*	16	1.20±0.30	16	2.71±0.35	10	2.09±0.31	0.49
3	*Macrolepidotus cuver*	12	2.50±0.33	10	2.50±0.33	11	2.71±0.5	0.45
4	*Citharinus cithanus*	12	3.02±0.41	14	3.62±0.51	36	3.19±0.62	0.53
5	*Labeo coubie*	15	1.17±0.45	8	1.91±0.23	8	1.91±0.23	0.20
6	*Distichodus rostratus*	23	3.01±0.10	6	2.01±0.50	9	2.01±0.50	0.37
7	*Clarias anguillaris*	5	1.51±0.20	11	1.78±.32	5	1.78±.32	0.67
8	*Synodontis clarias*	17	2.3±0.31	16	2.08±0.10	16	2.08±0.10	0.20
9	*Schilbe mystus*	6	1.89±0.32	12	1.87±0.30	8	1.87±0.30	0.57
10	*Tilapia zillii*	9	2.60±0.41	4	1.80±0.21	5	1.80±.21	0.67

TABLE 7

The relative abundance of aquatic and other animals utilizing Anambra river basin

Species	Number (percentage) of animals caught per station			Total No (%)
	Ogurugu	Otuocha	Nsugbe	
Venellus senegallus	2 (0.39)	6 (1.16)	1 (0.39)	9 (2.32)
Charadrius dubius	0	2 (0.39)	3 (0.58)	5 (0.96)
Ardeola ibis	1 (0.19)	0	5 (0.96)	6 (1.16)
Egretta garzetta	20 (3.4)	10 (1.9)	8 (3.47)	48 (9.27)
Ardea cinerea	30 (5.8)	35 (6.76)	50 (965)	115 (22.20)
Nettapus auritus	0	3 (0.58)	1 (0.19)	4 (0.77)
Actophilornils africana	5 (0.96)	10 (1.9)	2 (0.39)	17 (3.28)
Trigonoceps occipitallis	10 (1.9)	17 (3.28)	4 (0.77)	31 (5.98)
Milvus migrans	12 (2.3)	9 (1.74)	3 (0.58)	24 (4.63)
Ciraeceatus gallicus	0	6 (1.16)	2 (0.4)	8 (1.54)
Haliaetus vocites	1 (0.19)	0	4 (0.77)	5 (0.96)
Tragelaphus scriprus	2 (0.39)	0	6 (1.16)	8 (1.5)
Syncerns caffer	1 (0.19)	0	2 (0.39)	3 (0.58)
Chephalophus rufilatus	0	3 (0.58)	0	3 (0.58)
Kobus kobus	2 (0.39)	2 (0.39)	0	4 (1.16)
Lepus capensis	4 (0.77)	7 (1.40)	11 (2.12)	22 (4.25)
Erythrocebus patas	2 (0.39)	0	1 (0.19)	3 (0.58)
Trichechus senegalensis	11 (2.120)	8 (1.5)	1 (0.19)	20 (3.86)
Varanus niloticus	20 (3.86)	19 (3.67)	13 (2.51)	52 (10.04)
Bos indicus	5 (0.96)	20 (2.12)	15 (2.90)	40 (7.72)
Caprini	26 (5.01)	31 (5.98)	13 (5.98)	70 (13.51)
Tortoise sp.	1 (0.19)	4 (0.77)	0	5 (0.96)
Total	155	192	169	516

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Ogurugu and Nsugbe stations must have been as a result of synergistic effects from the various industries. These effects were discharge of municipal wastes and individual pollutants including warm- water effects from power stations. Toxic effects of detergents, petroleum products and household factories have been documented (Omoregie, 1995). In addition to the fish species found in the river, there are some other forms of aquatic fauna. The crab *Sudanonantes african* occurs in large quantity, as well as snails, crocodiles, and snakes. Both the numbers and distribution of large mammals on the River basin have been greatly reduced due increased human influence such as hunting, burning, (Ndakide 1988, personal communication). Fish eating birds, always the most abundant species, were confined largely to the vicinity of River Anambra and shoreline. Domestic animal populations are on the increase. The moist and easily saturated soil condition for some months of the year might favour growth of herbaceous grasses and forbs which could serve as fodder to the livestock. In fact more than 300 domestic animals were counted during the dry season utilizing the plain. The availability of forage species coupled with perennial fodder shortage for the Nigeria livestock populations indicate that River basin might serve a good dry season grazing areas for both resident animals. This confirms that natural aquatic environment houses a variety of aquatic lives (Kindersley,1991). The surface temperature undergoes relatively small fluctuations, there was a fairly consistent thermal regime of about 29.5 ºC and the pH range was between 6.8 and 7.7. This range fell within the recommended range that support aquatic life including fishes (Boyd,1979). The water quality of the river can be improved further by controlling and /or prohibiting the discharge of municipal effluents and domestic garbage into the river as well as the use of the riparian zone for crop agriculture. The maintenance of a 50-60 m thick riparian vegetation can act as a buffer strip to check erosion by acting as sediment break/filter.

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