www.biodicon.com Biological Diversity and Conservation

ISSN 1308-8084 Online; ISSN 1308-5301 Print 7/2 (2014) 1-9

Research article/Araştırma makalesi

Fish species diversity and abundance of Gubi Dam, Bauchi State of Nigeria

Gabriel Arome ATAGUBA [*1], Moses Ugondo TACHIA [2], Garba AMINU [3]

[1, 2] Department of Fisheries & Aquaculture, University of Agriculture, P.M.B. 2373 Makurdi, Nigeria
[3] Department of Fisheries Technology Abubakar Tatari Polytechnic Bauchi, Nigeria

Abstract

This study investigated the fish species diversity and abundance of Gubi dam in Bauchi State, Nigeria. The fish fauna of Gubi Dam was assessed using the fisheries dependent method to evaluate fish species composition. The dam had a total of 18 species of fish belonging to six families. Diversity indices estimated include Shannon's diversity index (H') with a monthly range of 1.811 to 2.366, Simpson's index (*D*); 0.130 to 0.313, Species heterogeneity (1 – *D*) index ranging from 0.687 to 0.870, species richness index (*d*); 2.003 to 2.371, and equitability index (*J*) ranging from 0.639 to 0.833. The most abundant family was Cichlidae (61.51%) with the species *S. galilaeus* being the most abundant (34.88%) while the family Mochokidae was least abundant (1.45%) and is represented by only one species. There is a low Species richness index in the dam. Species equitability index across the sites as well as months reveals an even distribution of species. There is great sample diversity from Gubi dam since 1 – *D* is close to 1 for the months studied. Anthropogenic activities are prominent on the lake and this can affect species diversity. Management measures are encouraged.

Key words: fish, diversity, abundance, heterogeneity, Gubi dam

1. Introduction

Alfred-Ockiya and Otobo (1990) reported 22 families of fish in Ofonitorebuo Lake of the Nigerian Delta. These include the common species that occur in the Niger and Benue rivers. They reported over eighty species representing 43 genera namely: *Cichlidae* (24.7%), *Characidae* (18.7%) and *Claridae* (11.4%).

C. nigrodigitatus is reported to be found more commonly in rivers than in swamps and juveniles of 80 – 120mm length are fairly common in commercial catches in November and December (Risch 1986). Nelson (2006) reported that *Auchenoglanis occidentalis* is fairly common between October and December especially in swamps and rivers. Daget (1984) documented that *Distichodus rostratus* is common along the grassy bank of rivers and swamps in the dry season when the water level is below the grass.

Ezealor (2002) reported that fish species in Lake Chad exhibit a wide distribution within the lake and its tributaries with species including: *Lates niloticus*, *Synodontis schall*, *Labeo senegalensis*, *Distichodus rostratus*, *Hydrcoynus forkalii* and *Schilbe mystus*. Changes in the Lakes water levels and quality as a result of drought affect the fish fauna especially as evidenced in the northern Nigeria 1972-75 drought (Benech *et al.* 1983 and Dumont 1992). During those years, decaying vegetations caused de-oxygenation of waters and local fish mortalities, the north basin isolated from the rest of the lake suffered large mortalities due to fishing pressure and degraded environmental conditions in the waters that remained in the lake basin (Benech *et al.* 1983).

According to Benech (1992), local extinctions occurred in the Lake Chad for fish species such as *Heterotis niloticus and Hydrocynus brevis* and only "marshy" species were favoured by natural selection to adapt and survive in the harsh environments with dominant species including: *Protopterus annectens, Polypterus senegalus, Oreochromis niloticus, Oreochromis aureus, Sarotherodon galilaeus, Brienomyrus niger* and *Clarias spp*. The species inhabiting any habitat differ in relative abundance with a few species being encountered more commonly than others (Colwell, 2009).

Nigeria has over 12.5 million hectares of water reservoirs, lakes, ponds and rivers capable of providing over 980,000 million metric tons of fish annually (Ita 1985). Gubi dam is one of such numerous reservoirs in the country not

[*] *Corresponding author* / Haberleşmeden sorumlu yazar: Tel.: 2348069312350; Fax.: 2348069312350; E-mail: gabynotepad@yahoo.co.uk
 BioDiCon. 357-0913

primarily constructed for fisheries purposes, but could serve as a potential water body for fish production. The dam was constructed without pre-impoundment studies of fisheries resources. Adeyemi, (2010) reported the economic value of the pollution control measures of the water treatment plant on the dam and concluded that the total benefit of the effects of pollution control in perpetuity is N399,767,698.20 ($2,514,262.25). Therefore, this study is to determine fish species of Gubi dam in Ganjuwa Local Government Area of Bauchi State, Nigeria.

2. Materials and methods

2.1 Study area

The Gubi dam (total surface area 179 km^2) which was created from the damming of four converging rivers (Gubi, Makaranta, Ran and Tagwaye) is located at Piro, a village about 12 km North-East of Bauchi metropolis and 8 km off Bauchi - Maiduguri road for the primary purpose of providing potable and palatable water to Bauchi and its environs (Ezra and Nwankwo, 2001). The dam (Figure 1) lies within the boundary of longtitude 10^o 25'N to 10^o 26'N and latituide 9^o 51' E to 9^o 52'E (Wufem *et al*. 2009).

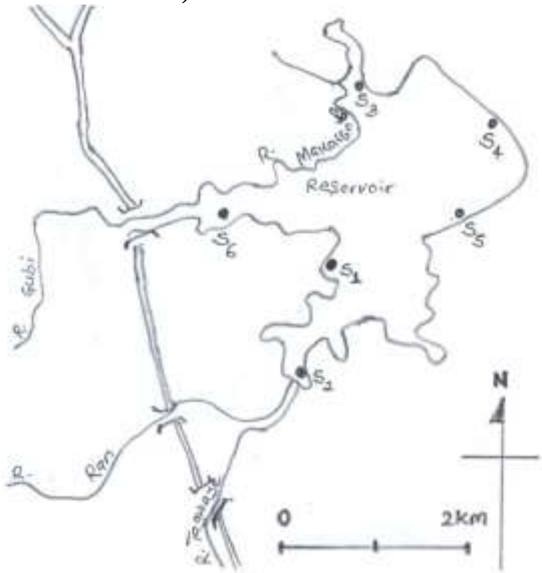

Figure 1. Gubi Dam with its four feeding rivers

2.2 Sampling sites

Six sites were identified and marked: the south- western basin- Tamunari (S_1), the Southern basin- Kumi (S_2), the Northern basin- Lara kana (S_3), Bayala and Kwarin kira (S_4) from the north east, Kwari (S_5) also known as Kwata from the east and Yashi (S_6) from the western end.

2.3 Fish sampling

The fish fauna of Gubi Dam was assessed using catches obtained from local fishermen operating at the Dam. Sampling sites were visited weekly and on each visit, six fishermen were randomly selected and fish from their catch were examined in their fresh state and immediately identified using identification key by Olaosebikan and Raji (1998). Gears used during the 4 months period (July 2011 to October 2011) were cast net, gill net, clap nets and some local fishing traps. On every sampling day, species landed were examined, identified and counted.

The fisheries dependent method was used to evaluate species composition of Gubi dam because it is the most commonly used method to evaluate the status of fisheries following Cheung *et al*, (2007), Hillborn (2007); Newton *et al* (2007) and Pauly, (2007).

2.4 Estimation of species abundance and diversity

a). Margalef's Diversity Index (*d*): This was estimated using the formula as reported by Clifford and Stephenson (1975) to measure the diversity in the community structure:

$$d = \frac{(S-1)}{\ln N}$$

Where:
d = Species richness index
S = Number of species in a population

N = Total number of individuals in S species

b). Shannon-Wiener diversity index (H'): This measures faunal diversity and gives the degree of uncertainty involved in predicting the species identified from randomly selected individuals. It was calculated using the following equation as given by Magurran (2004):

$$H' = -\sum\left[\left(\frac{n_i}{N}\right) \times ln\left(\frac{n_i}{N}\right)\right]$$

Where

ni = number of individuals or amount of each species (the i^{th} species)

N = total number of individuals for the site

c). Simpson's Index (D): is a measure of dominance and was calculated using the formula of Simpson (1949):

$$D = \sum\frac{n_i(n_i - 1)}{N(N-1)}$$

Where:

ni = number of individuals or amount of each species (i.e., the number of individuals of the i^{th} species) and

N = total number of individuals for the site.

This was then transformed into a measure of species heterogeneity using the complement of D as recommended by Lande (1996): $1 - D$.

d). Species Equitability or evenness Index (*J*): refers to the degree of relative dominance of each species in the dam. It was calculated according to Pielou (1966) as:

$$J = \frac{H'}{\ln S}$$

3. Results

3.1 Percentage abundance

Summary of the fish species observed between the month of July and October 2011 is presented in Table 1. Details of fish species abundance shows that *Sarotherodon galilaeus* was most abundant while *Micralestes acutidens* was least abundant. Table 2 on the other hand, shows the distribution of the species and families from the various sites investigated. In terms of monthly abundance (Table 1), *Tilapia zilli* was most abundant in July and August while *M. acutidens* and *Leptocypris niloticus* were least abundant. In September, *S. galilaeus* was most abundant while *M. acutidens* was least abundant. In October, *S. galilaeus* was most abundant while *M. acutidens* was the least abundant.

Table 1. Monthly catch composition of fish families and species of Gubi Dam by number and percentage

Family	Species	July	August	Sept	Oct	Total	%	Family %
Mormyridae	*Mormyrops anguilloides*	30	38	21	46	135	1.75	3.79
	Campylomormyrus tamandua	10	24	26	18	78	1.01	
	Mormyrus rume	18	11	31	20	80	1.04	
Alestidae	*Alestes dentex*	96	110	88	163	457	5.92	12.71
	Brycinus nurse	59	32	64	67	222	2.87	
	Brycinus brevis	34	38	49	30	151	1.95	
	Alestes macrophthalmus	25	46	43	23	137	1.77	
	Micralestes acutidens	5	0	10	0	15	0.19	
Claridae	*Clarias gariepinus*	66	84	98	130	378	4.89	9.16
	Heterobranchus longifilis	33	103	113	81	330	4.27	
Mochokidae	*Synodontis violaceus*	25	15	30	42	112	1.45	1.45
Cyprinidae	*Labeo senegalensis*	52	88	54	115	309	4.00	11.38
	Barbus byni	30	66	48	86	230	2.98	
	Labeo coubie	81	72	85	84	322	4.17	
	Leptocypris niloticus	6	0	8	4	18	0.23	
Cichlidae	*Tilapia zilli*	313	416	406	123	1258	16.28	61.51
	Oreochromis niloticus	162	186	119	332	799	10.34	
	Sarotherodon galilaeus	254	362	498	1581	2695	34.88	

S. galilaeus was most abundant in all the sites showing the prolific nature of tilapia while *M. acutidens* and *Leptocypris niloticus* were the least abundant across the sites.

Table 2. Catch composition of fish families and species of Gubi Dam at the various stations

Family	Species	S1	S2	S3	S4	S5	S6	Total
Mormyridae	*M. anguilloides*	23	34	13	18	22	25	135
	C. tamandua	13	0	18	20	15	12	78
	M. rume	14	9	16	17	11	13	80
Alestidae	*A. dentex*	101	112	78	65	26	75	457
	B. nurse	45	32	12	26	55	52	222
	B. brevis	31	23	18	34	17	28	151
	A. macrophthalmus	26	25	23	12	21	30	137
	M. acutidens	4	0	5	2	4	0	15
Claridae	*C. gariepinus*	65	78	29	65	58	83	378
	H. longifilis	46	78	45	57	81	23	330
Mochokidae	*S. violaceus*	34	12	18	17	14	17	112
Cyprinidae	*L. senegalensis*	56	48	54	62	51	38	309
	B. byni	23	34	43	36	57	37	230
	L. coubie	56	76	83	26	22	59	322
	L. niloticus	4	8	0	0	0	6	18
Cichlidae	*T. zilli*	231	143	352	182	228	122	1258
	O. niloticus	146	105	95	69	201	183	799
	S. galilaeus	476	523	368	342	484	502	2695

3.2 Diversity

Table 3 shows the monthly fish species diversity indices of Gubi Dam for the months studied. The monthly trend of the Shannon-Weiner index for the dam can be depicted as July > September > August > October. The maximum (2.366) value of fish species diversity was recorded in July whereas the minimum (1.811) was observed for October. Dominance was in the order October > September >August > July. The species richness index ranged from 2.003 (October) to 2.371 (July). The Equitability or evenness index was highest in August (0.833) and least (0.639) in October. Species heterogeneity was in the order July > August > September > October.

Table 3. Monthly diversity indices of fish species of Gubi Dam

Months	No. of Spps	No. of Individuals	Diversity Indices				
			Species Richness Index (*d*)	Shannon-Weiner Index (H')	Equitability Index (*J*)	Simpson's Index (*D*)	Species Heterogeneity (1 – *D*)
July	18	1299	2.371	2.366	0.818	0.130	0.870
August	16	1691	2.018	2.309	0.833	0.137	0.863
September	18	1791	2.270	2.314	0.800	0.149	0.851
October	17	2945	2.003	1.811	0.639	0.313	0.687

The trend of Shannon-Weiner index for stations on the dam (Table 4) can be depicted as $S_4 > S_1 > S_6 > S_2 > S_3 > S_5$. The maximum value (2.269) of fish species diversity was recorded in S_4 whereas the minimum (2.113) was observed for S_5. Dominance was in the order $S_2 = S_6 > S_5 > S_3 > S_1 > S_4$. The species richness index ranged from 2.083 (S_2) to 2.348 (S_1). The Equitability or evenness index was highest in S_4(0.801) and least (0.746) in S_5. Species heterogeneity was in the order $S_4 > S_1 > S_3 > S_5 > S_2 = S_6$.

3.3 Relative Abundance

The species abundance data was plotted as a rank abundance curve following Whittaker (1965). Each species is represented by a point on the line graph proportional to its abundance. Figure 2 shows the rank abundance plot. The long tail depicts rarer species being more in the community.

In order to deal with the skewed nature of the rank abundance plot, the species abundance were transformed using Preston's (1948) method to give a log-normal distribution of species abundance (Figure 3).

Table 4. Diversity indices of fish species at various stations of Gubi Dam

Stations	No. of Spps	No. of Individuals	Diversity Indices				
			Species Richness Index (*d*)	Shannon-Weiner Index (H')	Equitability Index (*J*)	Simpson's Index (*D*)	Species Heterogeneity (1 – *D*)
S_1	18	1394	2.348	2.224	0.770	0.169	0.831
S_2	16	1340	2.083	2.152	0.776	0.190	0.810
S_3	17	1270	2.239	2.133	0.753	0.180	0.820
S_4	17	1050	2.300	2.269	0.801	0.159	0.841
S_5	17	1367	2.216	2.113	0.746	0.186	0.814
S_6	17	1305	2.230	2.163	0.763	0.190	0.810

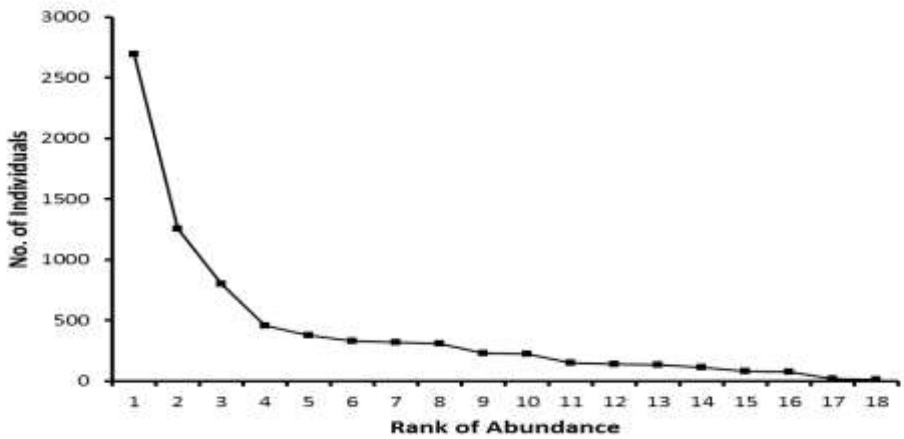

Figure 2. Rank-abundance curve for the fish community of Gubi Dam

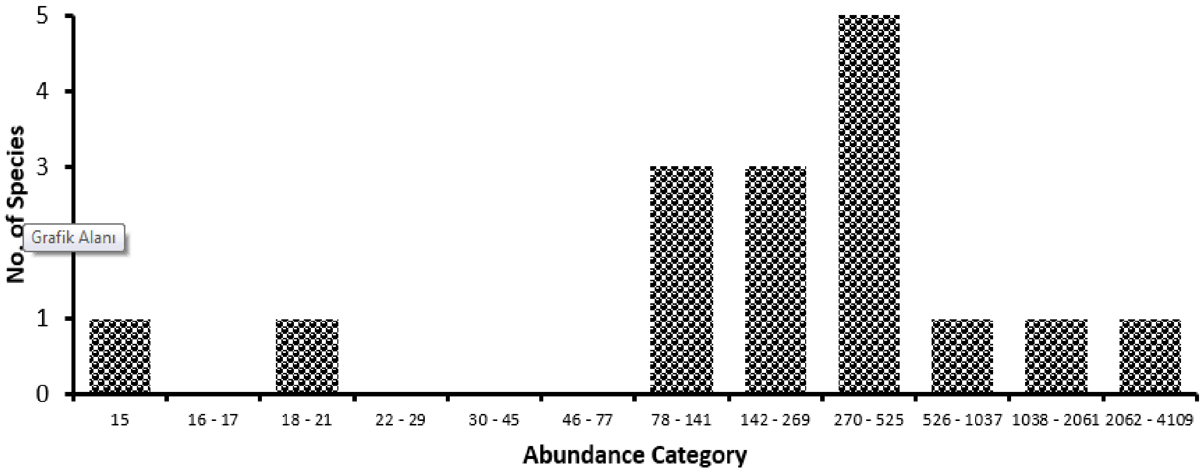

Figure 3. Log abundance plot of fish species in Gubi Dam

4. Conclusions and discussion

4.1 Species abundance

The six (6) families consisting of twelve (12) genera and eighteen (18) species observed during this study within the period of four months shows that the Gubi dam is rich in ichthyo-fauna when compared to the 4 fish families consisting of five (5) species identified by Lamai and Kolo (2003) in the Dan-Zaria dam within the same ecological zone. Three species were recorded for the genus *Synodontis* alone in Onah Lake, Nigeria by Olele *et al.*, (2008) whereas only one species, *S. violaceus* was recorded in this report for Gubi dam.

Tilapia (*Cichlidae*) which is little in size compared to other families like *Clariidae* and *Mormyridae* constituted 61.51% of total fish caught in Gubi dam. The dominance of *S. galilaeus* in this study and the low population of species like *H. longifilis*, *C. gariepinus* and *M. rume* may be due to the fact that in fisheries, aggressive and competitively dominant fish are often the first to be over fished and are often in the habit of preventing subordinate fishes from taking baits as observed by Mcclanahan *et al* (2010). The dominance of Tilapia may also be connected to its prolific reproductive nature which allows it to populate water bodies especially where the population of aggressive and carnivorous species that could control its population has declined.

4.2 Species diversity

The Shannon-wiener index (H') for the fish species from Gubi dam within the period of study were within the range of 1.5 to 3.5 as posited by Magurran (2004). The values obtained here are higher than those reported by Offem *et al.* (2011) for fish of the Ikwori Lake in South-Eastern Nigeria in the rainy season and also for three areas along the Anambra River as reported by Odo *et al.* (2009). Also, Emmanuel and Modupe (2010) reported values of H' ranging from 1.869 to 2.015 in three tributaries of River Ore which are lower than those reported in this study. The difference can be attributed to disparity in ecological zones. The values for H' both monthly and by station indicates a good spread of species diversity in Gubi dam.

The Species heterogeneity index (1 – *D*), reported for the sites and months for Gubi dam compare favourably with those reported for Igbesa and Iba tributaries of River Ore by Emmanuel and Modupe (2010). There is great diversity from Gubi dam since 1 – *D* is close to 1. There is also a greater diversity in Gubi dam than Lakes Oguta, Oyan, Dadin Kowa, Tiga, Asa and Opi as reported by Yem *et al.* (2011). According to Colwell (2009), H' and 1 – *D* will not rank communities in the same manner but will increase as richness increases, given a pattern of evenness, and rises as evenness increases, given a particular richness.

The species richness index (*d*) of Gubi dam is lower than those reported for three tributaries of the Anambra River by Odo *et al.* (2009). This is attributable to the difference in number of species encountered hence Anambra river is richer in species than Gubi dam. This measure is however not sensitive to environmental disturbance hence, it cannot be absolutely concluded that this value differs for both areas which are in different ecological zones.

Species equitability index across the sites as well as months reveals that the distribution of species or fish population is even since the values are close to 1. The values are also close to those reported by Emmanuel and Modupe, (2011) for River Ore but greater than those reported for the Anambra River by Odo *et al.*, (2009).

The rank of abundance shows that *S. galilaeus*, *T. zilli*, and *O. niloticus* were highest while *C. tamandua, Leptocypris niloticus* and *M. acutidens* were the least in ranking. The log-normal plot normalized the spread of the fish population as propounded by Magurran (2004) hence the normal shape of the curve.

Conclusively, anthropogenic activities such as sand mining, logging and waste disposal into the water was observed in all the sites studied. These have negative impacts on the quality of the water as well as fish faunal diversity. Poor management of the fishery resources in Gubi Dam ought to be addressed in order to make the dam produce fish sustainably and to ensure that fish species continue to exist in the dam..

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Appendix

a. *Alestes brevis* **b.** *Alestes dentex* **c.** *Alestes macrophthalmus* **d.** *Barbus bynii* **e.** *Brycinus nurse*
f. *Clarias gariepinus* **g.** *Campylomormyrus tamandua* **h.** *Heterobranchus longifilis*
i. *Labeo coubie* **j.** *Leptocypris niloticus*

k. *Labeo senegalensis* **l.** *Micralestes acutidens* **m.** *Mormyrops anguilloides* **n.** *Mormyrus rume*
o. *Oreochromis niloticus* **p.** *Sarotherodon galilaeus* **q.** *Synodontis violaceus*
r. *Tilapia zilli*

(Received for publication 23 September 2013; The date of publication 15 August 2014)