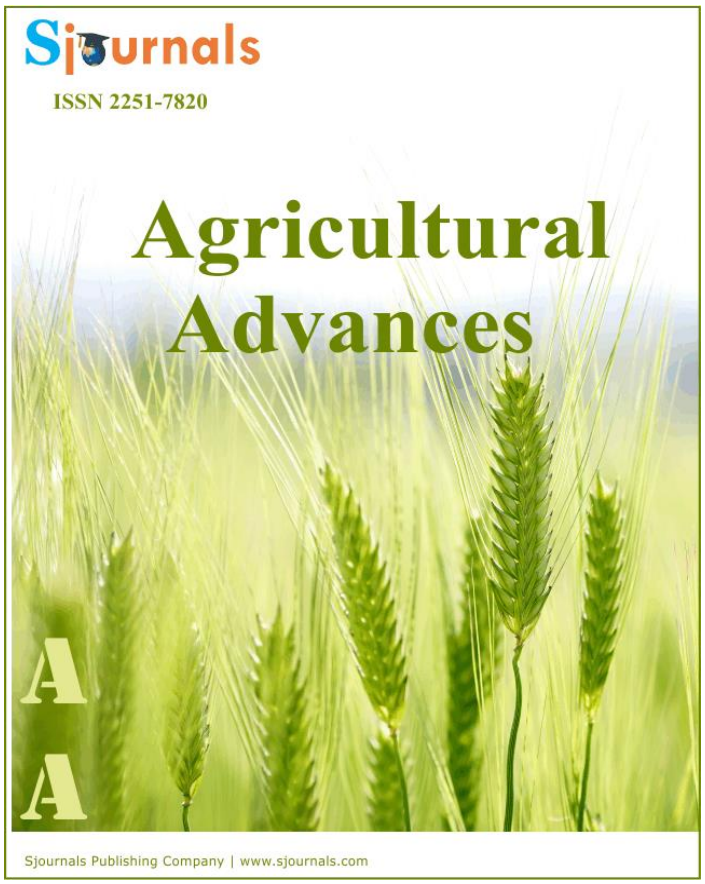

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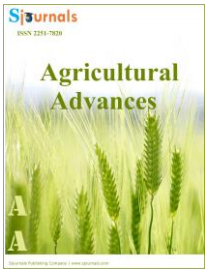

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Original article

A comparative study in fish biodiversity in Goronyo reservoir and downstream river Rima in Sokoto State Northwestern Nigeria

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ABSTRACT

This study was conducted between April and October, 2016 in Goronyo Reservoir and downstream River Rima in Sokoto State with the main objective of evaluating and comparing the fish biodiversities of the two water bodies in relation to types of gears used. A multistage sampling technique was used to select water bodies. Three landing sites were purposely selected from downstream River Rima and five from Goronyo reservoir because of their high fish landings and five fishermen were randomly selected and their catches monitored. The catches were identified at species level, counted, measured and weighed to the nearest centimeter and gram respectively. The results showed the presence of 14 and 15 fish families in river Rima and Goronyo reservoir, represented by 40 and 35 fish species respectively. The members of Mormyridae and Bagridae families were the dominant fishes in terms of numbers accounting for 44.92%, 16.92%in River Rima and 26.06%, 21.44% in Goronyo reservoir. The most rarely occurring families were Clarotidae and Cyprinidae in Goronyo reservoir accounting for 0.26% and 0.45% respectively. However, rarest species in Rima River was *Synodontis membranaceus* (0.11%). *Mormyrus rume* was the dominant species in both River Rima and Goronyo reservoir accounting for 23.64% and 15.31% by number. Simpson species richness showed Rima River with 40 and Goronyo reservoir with 35 fish species each exhibiting high (0.90) Simpson index of heterogeneity. Hook and line and gillnets were the most common fish gears used by the fishermen accounting for

29.87% and 30.37% respectively. Our study concluded that the two water bodies have fairly high fish diversities and recommended the reservoir should be enhanced by stocking it with *Lates niloticus* and *Labeo coubie* to serve as sport and commercial fishes in the reservoir.

1. Introduction

Nigeria has a large spread of freshwater resources that exist in the form of lakes, reservoirs, canals and rivers. Freshwater is critical to human society and sustains all terrestrial and aquatic ecosystems (Millennium Ecosystem Assessment, 2005). The fish population of any water body that is capable of reproducing naturally in the wild and exploiting its fish diversity which varies from one water body and another (Ita, 1993). Biodiversity is a fundamental property of every living system that manifests at every level of hierarchy from molecular to ecosystem (Gupta and Gupta, 2008). Fish occurs in water bodies in different proportions and composition, in other words, Ichthyofauna composition of any water body, marine or fresh water differs in its fish species diversity and abundance (Ita, 1993; Joseph et al., 2015). Gupta and Gupta (2008) reported that fish exhibit the greatest diversity among the world vertebrates, with over 22,000-30,000 species and counting. The authors noted biodiversity is essential for balancing the ecosystem and facing varied problems to the environment.

Ita (1993), Dankishiya et al. (2013) and Josep et al. (2015) observed that a community of fish is said to have high species diversity if many equally or nearly equal abundant species are present. Conversely, if a community is composed of a very few species or if only a few species are abundant, then species diversity is low (Ibrahim et al., 2009). Gupta and Gupta (2008) further reported that high species diversity indicates a highly complex community, for a greater variety of species allows for a larger array of species interaction. Thus, population interaction involving energy transfer (food webs), predation, competition and niche apportionment are theoretically more complex and varied in a community of high species diversity (Joseph et al., 2015). Balogun (2005) and Joseph et al. (2015) reported that high species diversity correlates with community stability; the ability of community structure to be unaffected by disturbance of its components.

In a review of the Nigerian fisheries resources, Ita (1993) reported about 511 fish families from different aquatic habitats. Out of these fish families, about 22% of their fish species belong to brackish water and 44% is fresh water fish species inhibiting water of low salinity, (Ita, 1993). The author further reported that about 34% of the species are restricted to an exclusive economic zone (EEZ) covering about 220 nautical miles offshore.

The fish biodiversity in downstream River Rima in comparison to that of Goronyo reservoir was not adequately investigated. The information available is scanty and misleading, hence this paper aims at providing up to date information on fish species diversities in the two water bodies in relation to the fish gears used by the fishermen.

2. Materials and methods

2.1. Description of the study site/location

The study was conducted in River Rima and Goronyo reservoir all in Sokoto State, Northwestern Nigeria. The state lies between longitudes 5.14 0 E and 5.30 0 E and latitudes 12.96 0 N and 13.08 0 N. (Eniolorunda, 2012). The upper Rima was seasonal before it was dammed at Goronyo village, and flows during the rainy season overflowing its banks in August and September (Ita et al., 1982). The reservoir formed after damming the Rima river is known as Goronyo reservoir, it lies on coordinates 13^0 31′50″N 05^0 52′56″E (Google earth, 2016). The reservoir has a storage capacity of 976,000,000 cubic meters (Sembenelli Consulting, 2010). It has rivers Bunsuru, Maradi and Gangare as its main tributaries.

2.2. Data collection and sample size

A multistage sampling technique was used in this study. Two water bodies were purposely selected (downstream River Rima and Goronyo reservoir). Three landing sites from river Rima were selected (Usmanu

Danfodiyo University Bridge, Kwalkwalawa and Dundaye villages)and designated as stations A, B, and C. Additional five fish landing sites which comprised of Killaro, Rimawa, Keita, Katsira and Gidan yar fara also at Goronyo reservoir were also purposively selected because of their high fish landings and five fishermen were randomly selected from each station and landing site giving a total of 40 fishermen and their catches monitored. A total of 2,554 fish specimens were collected both at River Rima and Goronyo reservoir for data collection. The data was collected on monthly basis for a period of six months from April to October, 2016.

2.3. The fish identification and number

The number of individuals of the same fish family, genus and species was identified and counted according to the procedure described by Gusau et al. (2016).

2.4. The fish length/size

The length of the individual fish specimen was measured using a meter rule to the nearest mm expressed as total and standard lengths as described by Shinkafi et al. (2013).

2.5. The fish weight

The individual fish specimen of each species was weighed using a weighing balance to the nearest gram (g) as described by Bagenal and Tesch (1978).

2.6. Species density and relative abundance

The information obtained from the above procedures served as inputs based on the scale of the frequency of occurrence as described by Benech et al. (1983) for species dominance determination as follows:

Dominant = when a species occurred more than or equal to 10% (≥ 10%) in the population of fishes caught by the fishermen.

Sub-dominant = when species occurred from one percent to nine percent (1-9%) in the population of fishes caught by the fishermen.

Occasional = when a species occurred less than one or equal to one percent (≤ 1%) in the population of fishes caught by the fishermen.

Rare = when it was caught only once (1) in the population of fishes caught by the fishermen.

Extinct = when any species that was in the reservoir or river before but was not caught during this field study.

2.7. Simpson index of heterogeneity

The fish specimens from artisanal fishermen catches were sorted out according to species, counted and the values fitted into the following model for Simpson index of heterogeneity determination using Simpson index calculator developed by Al Young Studio, 2017 version.

$$Ds = 1 - \sum \frac{\{ni\{ni-1\}\}}{N\{N-1\}}$$ where;

Ds = Simpson's index of diversity;

N = Total number of individuals of all species;

n_i = Total number of individuals of the species.

2.8. Data analysis

The data generated were analyzed using IBM SPSS version 22.0 (Armonk, NY: IBM Corp) and the results expressed in descriptive statistics by simple percentages and frequencies.

3. Results and discussion

The results for the fish diversities in the two water bodies were summarized in Table 1. The families Mormyridae and Bagridae were the dominant in both Goronyo reservoir and the downstream river Rima while one of the rarest occurring families in Goronyo reservoir was Cyprinidae. The species *Mormyrus rume* and *Bagrus bayad macropterus* were the dominant fish species accounting for 23.64%, 11.17% by number and 27.52%, 15.16% by weight in River Rima respectively (Table 2). The same species accounted for 15.31%, 15.60% (by number) and

21.06%, 21.25% (by weight) in Goronyo reservoir. *Lates niloticus* accounted for 0.43% and 10. 7% by weight in Rima and Goronyo respectively. *Synodontis membranaceus* occurred rarely (0.11% by number) in River Rima and also accounted for 0.03% and 0.003% by weights in river Rima and Goronyo reservoir respectively.

Table 1
The comparative statuses of fish families in numbers, weight and percentage in river Rima and Goronyo reservoir.

	Number	(A)	Percentage	Number (RA)	Weight (kg)		Percentage	Weight
Family	**RR**	**GR**	**RR**	**GR**	**RR**	**GR**	**RR**	**GR**
Mormyridae	417	291	44.92	26.06	142.72	44.92	54.65	23.22
Bagridae	157	240	16.92	21.44	65.24	16.92	24.50	39.14
Claridae	40	47	4.31	4.21	15.32	4.31	6.07	7.76
Cichlidae	44	98	4.76	8.78	6.93	4.76	2.62	3.44
Mochokidae	117	123	12.62	11.07	12.44	12.62	4.77	3.23
Schilbedae	68	93	7	8.32	2.44	5.13	0.93	1.18
Centropomidae	2	47	0.22	4.21	1.20	58.58	0.47	13.43
Polypteridae	-	33	-	2.95	-	5.51	-	1.26
Malapteruridae	11	37	1.19	3.31	1.65	6.64	0.63	1.52
Lepidoserinidae	22	77	2.26	6.89	4.73	23.40	1.81	5.36
Clarotidae	10	3	1.08	0.26	2.26	0.67	0.86	0.15
Characidae	12	7	1.29	0.63	0.23	0.72	1.11	0.17
Cyprinidae	16	5	1.70	0.45	1.69	0.03	0.65	0.017
Distichontidae	13	16	1.40	1.43	4.55	5.16	1.72	1.18
Total	928	1117	100	100	261.06	436.26	100	100

Keys: RR = River Rima; GR = Goronyo Reservoir; - = Not found; Source: Field work, 2016.

Table 3 showed the results of Simpson index of heterogeneity for the two fairly uniform water bodies (0.92) in both river Rima and Goronyo reservoir. Furthermore, the arrays of fishing gears used by the fishermen are presented in Table 4. Hook and line and gillnets were the most common gears used and accounted for 29.87% and 35.60% respectively. The least (0.31%) gear used by the fishermen at Goronyo reservoir was seine nets. Gourds accounted for 98.28% of fishing equipment at Goronyo reservoir.

Table 4
The percentage fishing gears and equipment used by the fishermen at river Rima and Goronyo reservoir.

S/No.	Gear type	Status RR	GR	River Rima (%)	Goronyo (%)
1	Malian trap	X	x	26.74	22.78
2	Gill net	X	x	14.15	35.60
3	Clap net	X	x	23.58	10.85
4	Cast net	X	-	3.14	-
5	Seine net (taru)	X	x	0.31	0.43
6	Hook and line	X	x	29.87	29.28
7	Pole and line	X	x	1.90	0.87
8	Ndrutu	-	x	-	10.85
9	Fish barrier	X	-	0.16	-
10	Yawa	X	-	0.16	-
	Total			100	100
	Equipment				
1	Gourd	X	x	96.10	98.28
2	Canoe	-	x	5.90	1.72
	Total			100	100

Source: Field work, 2016.

Table 3
The Simpson index of heterogeneity (1 –D) for river Rima and Goronyo reservoir.

	No. of Individuals (N)	(N-1)	$n_i(n-1)$	No. of Individual (N)	(N– 1)	$n_i(n-1)$
Species name	**River**	**Rima**		**Goronyo**	**Reservoir**	
Bagrus bayad	216	215	46440	225	224	50400
Bagrus docmac	23	22	506	101	100	10100
Bagrus filamentosus	5	4	20	3	2	6
Auchenoglanis occidentalis	7	6	42	2	1	2
Auchenoglanis biscutatus	5	4	20	2	1	2
Clarotes laticep	24	23	552	4	3	12
Schilbe mystus	53	52	2756	79	78	6162
Schilbe intermedius	68	67	4556	17	16	272
Parailia pelucida	15	14	210	14	13	182
Synodontis clarias	41	40	1640	45	44	1980
Synodontis sorex	14	13	182	9	8	72
Synodontis nigrata	11	10	253	30	29	870
Synodontis membranaceus	2	1	2	3	2	6
Synodontis gobroni	-----	----	-----	7	8	56
Synodontis budgetti	13	12	156	2	1	2
Synodontis eupterus	15	14	210	---	----	-----
Synodontis courteti	10	9	90	6	5	30
Synodontis vermiculatus	15	14	210	---	----	----
Synodontis filamentosus	7	6	42	---	---	---
Clarias anguillaris	12	11	132	17	16	272
Clarias gariepinus	24	23	552	30	29	870
Hetrobronchus bidorsalis	7	6	42	--	----	-----
Alestes baremose	12	11	132	5	4	20
Alestes nurse	4	3	12	---	---	----
Hydrocinus forskalii	2	1	2	---	----	-----
Malapterirus electricus	11	10	110	37	36	1332
Lates niloticus	47	46	2162	2	1	2
Oreochromis niloticus	42	41	1722	94	93	8742
Hemichromis fasciatus	2	1		---	---	----
Tilapia zilli	-----	----	----	2	1	2
Saratherodon melanotheron	2	1	2	2	1	2
Mormyrus rume	279	278	77562	206	205	42230
Marcusinius senegalensis	57	56	3192	16	15	240
Gnathemona abadii	28	27	756	38	37	1406
Hyperopisus bebe occidentalis	130	129	16770	98	97	9506
M. tapirus	10	9	90	27	26	702
Petrocephalus bovie	98	97	9506	16	15	240
Mormyrus macrophthalmus	--	---	----	18	17	306
Labeo senegalensis	12	11	132	9	8	72
Labeo coubie	3	2	6	---	---	-----
Barbus occidentalis	--	---	----	4	3	12
Protopterus annectens	21	20	420	77	76	5852
Polypterus senegalus senegalus	---	---	----	3	2	6
Distichodus rostratus	13	12	156	16	15	240

Distichodus engycephalus	2	1	2	---	--	---
∑ of the Parameters			1322			1232
Total of Fish Species	40			35		
Total number of fish Specimens	1362			1224		
Average Population Size	34.06			34.07		
Region	Rima			Goronyo		
Simpson Index of heterogeneity (1 -D)			0.90			0.90

Source: Field work, 2016.

Table 2
The fish species composition, relative abundance and dominance in both Goronyo Reservoir and River Rima.

	Status		Number (A)		Weight (kg)		Percentage (RA)	Percentage Number		Percentage Weight	Remarks	
Family/Species	**RR**	**GR**	**RR**	**GR**	**RR**	**GR**	**RR**	**GR**	**RR**	**GR**	**RR**	**GR**
Mormyridae												
Mormyrus rume	x	X	218	172	77.05	60.19	23.64	15.31	27.52	21.06	D	D
M. tapirus	x	X	16	17	6.04	8.43	1.74	1.53	2.16	1.55	S	S
M. macrophthalmus	x	X	3	6	0.83	1.8	0.33	0.54	0.30	0.33	O	O
Hyperopisus bebe occidentalis	x	X	90	47	33.31	11.74	9.76	4.24	11.90	2.16	D	S
Marcusinius senegalensis	x	X	52	14	5.23	0.67	5.64	1.26	1.87	0.12	S	O
G. abadii	x	X	38	25	24.95	18.30	4.12	2.25	8.91	3.36	S	S
Petrocephalus bovie	x	X	98	10	-	0.20	----	0.90	---	0.04	E	R
Sub total			417	291	147.41	101.33	45.19	25.23	52.65	18.62		
Bagridae												
Bagrus bayad macropterus	x	X	103	173	42.43	115.60	11.17	15.60	15.16	21.25	D	D
Bagrus docmac	x	X	25	60	16.82	48.49	2.71	5.41	6.01	8.91	S	S
B. filamentosus	x	X	5	3	1.65	1.60	0.54	0.27	0.58	0.29	O	O
Auchenoglanis biscutatus	x	X	5	2	0.87	0.5	0.54	0.18	0.31	0.09	O	R
A. Occidentalis	x	X	7	4	1.32	0.17	0.76	0.36	0.47	9.03	O	S
Sub total			145	242	63	166.19	15.80	20.82	22.53	40.03		
Clarotidae												
Clarotes laticep	x	X	24	4	4.34	0.70	2.60	0.36	1.55	0.13	S	O
Sub total			24	4	4.34	0.70	2.60	0.36	1.55	0.13		
Claridae												
Clarias gariepinus	x	X	24	30	7.12	23.44	2.60	2.70	2.54	4.31	S	S
C. anguillaris	x	X	12	17	5.65	10.44	1.30	1.53	2.02	1.92	S	S
Hetrobronchus bidorsalis	x	-	4	-	2.55	---	0.43	---	0.91	---	R	E
Sub total			40	37	12.77	36.43	4.33	4.23	5.47	6.23		
Cichlidae												
Oreochromis niloticus	x	X	42	94	6.45	14.09	4.56	8.00	2.30	2.59	S	S
Hemichromis fasciatus	x	-	2	-	0.38	-	0.22	----	0.14	----	O	E
Tilapia zilli	-	X	-	2	-	0.5	----	0.18	----	0.09	E	R
Saratherodon melanotheron	x	X	2	2	-	0.32	----	0.18	----	0.06	E	R
Sub total			44	98	6.83	14.91	4.78	8.36	2.44	2.74		
Mochokidae												
Synodontis clarias	x	X	41	55	4.56	8.29	4.44	4.96	1.63	1.52	S	S
S. nigrata	x	X	11	30	1.29	3.12	1.19	2.70	0.46	0.57	O	O
S. sorex	x	X	14	9	0.88	1.09	1.51	0.81	0.31	0.20	O	O
S. membranaceus	x	X	2	3	0.09	0.02	0.11	2.27	0.03	0.003	R	R
S. budgetti	x	X	13	2	0.59	0.69	1.4	0.18	0.21	0.13	O	O
S. eupterus	x	-	-	15		4.44	--	1.35	----	0.82	E	O

S. courteti	x	X	10	6	0.27	0.46	1.08	0.54	0.10	0.08	O	O
S. vermiculatus	x	-	5	-	0.08	-	0.54	---	0.01	-----	R	E
S. filamentosus	x	-	7	-	0.24	-	0.76	----	0.27	-----	O	R
S. gobroni	-	X	7	-	19	-	0.76	----	6.79	----	O	E
Sub total			109	120	31	121.58	11.79	12.60	9.81	3.32		
Schilbedae												
Schilbe mytus	x	X	53	79	1.47	2.82	5.75	7.12	0.53	0.53	S	O
Parailia pelucida	x	X	15	14	0.14	0.11	1.63	1.26	0.05	0.02	S	O
Sub total			68	93	1.61	2.93	7.38	8.38	0.58	0.55		
Centropomidae												
Lates niloticus	x	X	47	2	1.2	58.58	0.22	4.24	0.43	10.77	O	O
Sub total			2	47	1.2	58.58	0.22	4.24	0.43	10.77		
Polypteridae												
Polypterus senegalus senegalus	-	X	-	33	-	5.51	---	2.98	---	1.01	E	S
Sub total			-	33		5.51	----	2.98	----	1.01		
Malapteruridae												
Malapterirus electricus	x	X	11	37	1.65	6.64	1.19	3.34	0.59	1.22	S	S
Sub total			11	37	1.65	6.64	1.19	3.34	0.59	1.22		
Lepidoserinidae												
Protopterus annectens	x	X	21	77	4.73	23.40	2.28	6.94	1.69	4.30	S	S
Sub total			21	77	4.73	23.40	2.28	6.94	1.69	4.30		
Characidae												
Alestes baremose	x	X	12	5	1.14	0.03	1.30	0.45	0.41	0.005	S	R
A. Nurse	x	-	4	-	0.55	-	0.43	-	0.20	----	O	E
Sub total			16	5	0.55	0.03	1.73	0.45	0.61	0.005		
Cyprinidae												
Labeo senegalensis	x	X	9	3	0.22	0.55	0.98	0.27	0.08	0.10	O	O
L. coubie	x	-	3	-	0.08	-	0.32	---	0.03	----	R	E
Barbus occidentalis	-	X	-	4	-	0.17	----	0.36	---	0.03	E	R
Sub total			12	9	0.30	0.72	1.3	0.63	0.11	0.13		
Distichontidae												
Distichodus rostratus	x	X	13	16	4.55	5.16	1.4	1.44	1.63	0.95	S	O
Sub total			13	16	4.55	5.16	1.4	1.44	1.63	0.95		
Grand Total			922	1,109	279.94	544.11	100	100	100	100		

Source: Fieldwork, 2016. X = Found, - = not found, RR = River Rima, GR = Goronyo Reservoir, A = Abundance, R.A. = Relative abundance, D = Dominant, S = Subdominant, O = Occasional, R = Rare, E = Extinct.

The results on fish biodiversity in the two water bodies followed a similar pattern reported in some Nigerian water bodies. Rivers are known to typically support more fish species than their associated reservoirs, often as a result of large scale changes in regimes of temperature, turbidity, flow, allochthonous nutrient inputs and availability of food resources (Williams et al., 1998). The result of the present finding had indicated the species compositions were almost equal with 14 versus 15 for River Rima and Goronyo reservoir respectively.

However, fish distribution and abundance in tropical water bodies have been variously attributed to several factors. Some of these factors were principally the water depth (Chapman and Kramer, 1991), water temperature and transparency (Agremier and Karr, 1983), reported availability of food and migratory nature of some fishes (Adebisi, 1988; Wine Miller and Japsen, 1988). Besides, to some of these factors responsible for different fish distribution in some water bodies, the prevailing ecological conditions like the nutrients level also plays role in uneven fish distribution (Ita et al., 1982). In this study, the nutrients level, current speed and nature of the bottom deposit, may have acted singly or synergistically to influence the presence status of fish abundance and distribution in River Rima and Goronyo reservoir. Similar observations were reported by Petr (1975) and Odum (1995) in the Ethiope River of southern Nigeria.

Ita et al. (1982) reported only nine fish families in the river Rima, but this study observed 14 families, thereby indicating encroachment or inversion and colonizing some portion of the two water bodies by new species. Both the two water bodies exhibited high species richness with 40 and 35 fish species, for river Rima and Goronyo reservoir respectively compared to 20 species (Ita et al., 1982). This is because, of the difference in scope and

length of periods in the two studies. Other studies that reported high species richness in Nigerian water bodies like this study includes the study conducted by Bolarinwa et al. (2015) in the coastal areas of Ondo State, Nigeria. The authors reported 36 families represented by 67 species therefore exhibiting higher species richness. Ali and Abubakar (2015) also reported the presence of 26 species from 14 families in Dadinkowa dam in Gombe, with *Bagrus bayad* been the dominant fish species. A similar study in some parts of Africa was conducted by Mohammed (2012) and reported 23 species from 13 families in Jabel Awlia dam and White Nile River in Sudan with Alestes species accounting for 19.26% of the total catches.

Compared to this study, however, some Nigerian water bodies exhibited low species richness; for example, Edward (2012) reported low species richness (8 species from 5 families) in Egbe Reservoir in Ekiti state with Cichlids dominating the catches compared to this study. The dominance of *Mormyrus rume* in terms of number in both River Rima (23.64%) and Goronyo reservoir (15.31%) shows that the dominant fish species as a detritivore is the primary consumers, thus indicating the high potential to fish production under adequate management (Ita and Balogun, 1982).

Most of the gears used by the fishermen were local fishing gears commonly used by Nigerian fishermen, with gillnet and hook and line dominating the rest. Reed et al. (1967) also reported high use of gillnet and hook and lines by the northern Nigerian fishermen. Furthermore, Dan-kishiya et al. (2012) also reported the dominance of gillnets by the fishermen of Lower Usuma reservoir, Bwari in Abuja, Nigeria. This shows the versatility of gill nets in being able to trap fish of different sizes and shapes. According to Sikoki et al. (1998), gill nets could catch fish of all sizes, shapes and species in all water habitats.

4. Conclusion and recommendations

The findings in this study revealed high species richness and diversity in both River Rima and Goronyo reservoir. These findings have provided baseline information for proper fisheries management in the reservoir and the river Rima in terms of species enhancement, management and protection. Based on the results on fish biodiversity in the reservoir and river Rima, the present work recommended the restocking of the water bodies with *Lates niloticus* and *Labeo coubie*, regulating the fishing gears' use and conducting a further study on forage-predator fish species ratio.

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