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Research Article

BIBLIOGRAPHICAL REVIEW OF FISH COMMUNITIES IN THE IVORIAN INLAND FISHERIES: WHAT ARE THE INDICATORS FOR MANAGEMENT PURPOSE?

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ABSTRACT

The knowledge of the fish population structure provides information for fisheries management, especially the stocks of species of commercial interest. This study was undertaken with the aim of providing information on the ichthyological populations for the sustainable management of Ivorian inland fisheries. For this purpose, the results of nearly thirty scientific publications have been analysed. A total of 185 fish species were inventoried, including 40 with a marine or brackish affinity and 145 with a freshwater affinity. Streams are the richest in species, followed by rivers, small dam lakes, and hydroelectric reservoirs. These species belong to 23 orders and 46 families. The analysis of diversity in catches reveals that, in all the waterbodies, half of the species belong to six orders and six families. The Siluriformes still have the most species, followed by the Cichliformes and Osteoglossiformes. With regard to the the families, the Cichlidae regularly have the most species, followed by the Cyprinidae and Mormyridae and, to a lesser extent, the Alestidae. In terms of abundance in catches, the species caught most often belong to the Cichlidae, Alestidae, Schilbeidae and Mormyridae families and secondarily to the Claroteidae and Cyprinidae families. This indicates that the Siluriformes, Cichliformes, Characiformes, Osteoglossiformes and Cypriniformes appear to be the dominant orders in the catches of Ivorian inland waters. Studies on the selectivity of fishing gears used to catch these groups of fish would help ensure the sustainable management of these fisheries.

Keywords: Fish species, Abundance, Inland waters, Côte d'Ivoire.

INTRODUCTION

Côte d'Ivoire has numerous inland waterbodies. These aquatic environments include four major rivers, several coastal streams, the tributaries of the Volta and Niger rivers and a lagoon system covering 1,200 km^2 (Girard, 1971; Golé Bi *et al*., 2005). The rivers include the Bandama (950 km), Cavally (600 km), Comoé (900 km) and Sassandra (650 km) rivers, making a total length of 3,100 km (FAO, 2008). The major fisheries are the hydroelectric reservoirs built on the different rivers and on the Bia stream. They are Taabo (340,106 m^3), Ayamé 1 (849,106 m^3) and Ayamé 2 (68,106 m^3), Kossou (26,962,106 m^3), Buyo (7,000,106 m^3) and Soubré with an estimated volume of 83,000,000 m^3 (LTAAH, 2009; Kouadio, 2021). In the North of the country, hundreds of small dam lakes have a total surface area of around 12,000 ha (Traoré, 1996). All these waters are used for fishing purpose. Indeed, according to the Shep *et al*. (2013) survey on inland fishing in Côte d'Ivoire, fishing sites are present in all of the country's administrative regions. In terms of contributions, these inland waters provide 14% of national catches. Together with catches from marine and lagoon fisheries and aquaculture production, they are still insufficient to cover the country's needs in fish products. In 2017, for example, the value of imported fishes and fishery products reached461 million USD (FAO, 2021).

Inland fishing in Côte d'Ivoire faces many difficulties. The inaccessibility of many fishing sites and the mistrust

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and lack of cooperation of many fishermen are factors that are likely to underestimate the quantities of catches declared. These observations raise further questions about the real potential of these fisheries. The information on this subject is scarce. Da Costa *et al.* (1998) estimated the annual exploited production of small dam lakes in the North of the country. However, according to these authors, in view of the potential catches indicated by the FAO for this type of waterbody, there is scope for increasing exploited production. Ivorian inland fisheries could therefore provide more catches.

In addition to the comments made above, Ivorian inland fisheries face numerous constraints. The situation described by Diarra (2020) on the Kossou reservoir, one of the country's largest inland fisheries, is an example. A decline in the number of fishermen has been observed due to the depletion of the lake's fishery resources, the presence of aquatic vegetation constituting obstacles to fishing, the deterioration in water quality due to gold exploitation and, above all, the use of illegal fishing gears and fishing techniques. This last difficulty is the most compromising as it is likely to affect the renewal of fish stocks. Furthermore, in multispecies fisheries, fishing gear catches different species simultaneously. So what are the strategies that can be put in place to limit their impact on different fish stocks? The use of fishing gears with less harmful selectivity on the species most abundantly found in catches will contribute to the sustainable management of these fisheries. This requires in-depth knowledge of the ichthyological composition of all these various waterbodies.

In terms of regulations, current Ivorian legislation authorizes the use of five fishing gears types in inland fisheries. These are the fishing lines, traps, gillnets, sparrow hawks and longlines. The use of seine nets is prohibited. Concerning the gillnets, the use of nets with bar length less than 35 mm is prohibited (JORCI, 1981). However, some studies point to the relationship between types of fishing gears and target species. For example, Attingli *et al*. (2017) note that gillnets catch species of all sizes and all stages of critical maturity for stock renewal. Bamboo traps and net traps destroy spawning grounds and nurseries and capture spawning fishes. According to Ahouansou Montcho (2011), traps and sparrow hawks have a moderate nuisance effect. Longlines, on the other hand, have a low nuisance, not because they do not catch the species at the critical maturity stage, but because their catches are not rich in species. New management strategies for Ivorian inland fisheries must therefore take these realities into account.

The general aim of this study is to contribute to the implementation of strategies for the sustainable management of Ivoirian inland fisheries. Specifically, it will list the fish species present in these aquatic environments, identify the orders, families and species most abundant in each type of waterbody. The results could be used for any sustainable management policy for these fisheries. The works carried out on the ichthyological compositions in the Ivorian inland waters were analysed. Four types of aquatic environment have been considered. These were the streams, the rivers, the mall dam lakes and the hydroelectric reservoirs. The species identified were listed. The terminologies used in the book "Fishes of the world" (Nelson *et al*., 2016) were used to classify each species in its order and family. For species not mentioned in this book, the fishbase website was used. The scientific names of the same species varied in certain works. In such cases, choices have been made. For example, the genera Coptodon have been replaced by Tilapia, Enteromius by Barbus, Limbochromis by Chromidotilapia and Neochelon by Liza. The diversity of each order or family corresponds to the number of species to which they belong. This number can be transformed into a percentage. Finally, in this bibliographic summary, the dominant species in the catches were considered to be those with the highest percentages of abundance and whose sum is greater than 50%. The same applies to families. In the works where it was a question of percentage of occurrence, the dominant species are those with percentages of occurrence greater than 50%.

STUDY AREAS

The ichthyological compositions of eight (8) streams, four (4) rivers, twenty-one (21) small dam lakes and six (6) hydroelectric reservoirs were analysed. These waterbodies and their references are presented in the Table 1.

Table 1. Study areas considered in this review.

Streams	Bia stream including hydroelectric reservoirs Ayamé 1 and Ayamé 2 - Ayamé 1 reservoir and its upstream and downstream areas (Da Costa *et al*., 2000). - Ayamé I reservoir (Tah *et al*., 2009; Cissé *et al*., 2019). - Ayamé 2 reservoir (Adou *et al*., 2017). - Bia stream, Ayamé 1 reservoir and its upstream and downstream areas (Gourène *et al.*, 1999).
	Nero stream (N'Zi *et al*., 2015).
	Gô stream (Koné *et al*., 2003).
	Streams complex Brime-Mene-Nounoua (Tanoh Kamelan *et al*., 2013).
	Dodo stream (Kamelan *et al*., 2013).
	Hana stream (Kamelan *et al*., 2013).
	Agnebi stream (Da Costa *et al*., 2000).

	N'Zè stream (N'Guessan *et al.,* 2021).
Small dam lakes	Kaby lake (Kouadio *et al*., 2018).
	Songori lake (N'Dri *et al*., 2020).
	Solomougou lake (Kouassi *et al*., 2020).
	Lavononkaha lake (Diaby *et al*., 2022).
	Four northern small lakes (Da Costa *et al*., 1998).
	Thirteen northern small lakes (Da Costa *et al.*, 2005)
Rivers	Cavally river (Doffou *et al*., 2019)
	Comoé river (Yao *et al*., 2019).
	Sassandra river including hydroelectric reservoirs Buyo and Soubré - Buyo river (N'Dri *et al*., 2020). - Soubré river (Konan *et al*., 2022).
	Bandama river including hydroelectric reservoirs Kossou and Taabo - Taabo river (Aliko *et al*., 2010). - Taabo-village station (Kien *et al*., 2022). - Area of Bandama fauna and flora reserve (Zamblé Bi *et al*., 2021). - Upstream of Kossou reservoir, Kossou and Taabo reservoirs, area between Kossou and Taabo reservoirs, downstream Taabo reservoir (Aboua *et al*., 2010). - Main course of Bandama river and its tributaries Marahoué and N'Zi, Kossou reservoir, Taabo reservoir, (Aboua *et al*., 2012; Aboua *et al*., 2015). - Estuarine area of Bandama river (Koné *et al.,* 2021). - Bandama river area adjacent to Lampto scientific reserve (Adou *et al*., 2023).

OVERALL COMPOSITION OF FISH COMMUNUTIES

Species diversity

One hundred and eighty-five (185) fish species have been recorded. Forty (40) have a marine or brackish affinity and one hundred and forty-five (145) have a freshwater affinity. Those with a marine or brackish affinity are commonly found in streams and rivers and rarely in large or small reservoirs. In addition, more species are found in streams and secondarily in rivers and small dam lakes. Hydroelectric reservoirs therefore contain the fewest species. Forty-four (44) species have been found at least in one stream, one dam lake, one river and one hydroelectric reservoir. These were *Ctenopoma patherici, Parachanna obscura, Brycinus imberi, Brycinus longipinnis, Brycinus macrolepidotus, Brycinus nurse, Hepsetus odoe, Chromidotilapia ghuntheri, Hemichromis bimaculatus, Hemichromis fasciatus, Oreochromis niloticus, Sarotherodon galilaeus, Sarotherodon melanotheron, Tilapia guineensis, Tilapia mariae, Tilapia zillii, Pellonula leonensis, Barbus ablabes, Barbus macrops, Barbus trispilos, Labeo coubie, Labeo parvus, Raiamas senegalensis, Marcusenius furcidens, Marcusenius senegalensis, Marcusenius ussheri, Mormyrops anguilloides, Mormyrus rume, Petrocephalus bovei, Pollimyrus isidori, Papyrocranus afer, Heterotis niloticus, Polypterus endlicheri, Clarias anguillaris, Clarias buettikoferi, Heterobranchus isopterus, Heterobranchus longifilis, Chrysichthys maurus, Chrysichthys nigrodigitatus, Malapterurus electricus, Synodontis bastiani, Synodontis schall, Schilbe intermedius* and *Schilbe mandibularis*. However, eleven (11) were identified in all study areas. These were *Brycinus imberi, Hemichromis bimaculatus, Hemichromis fasciatus, Oreochromis niloticus, Tilapia guineensis, Mormyrops anguilloides, Heterotis niloticus, Clarias anguillaris, Chrysichthys maurus, Chrysichthys nigrodigitatus* and *Schilbe mandibularis* (Tables 2 and 3).

Table 2. Number of species recorded in study areas: A1, Ayamé 1; A2 Ayamé 2; B, Buyo; K, Kossou, S, Soubré ; T, Taabo ; Ba Bandama ; Ca, Cavally ; Co, Comoé ; Sa, Sassandra.

			Rivers				Hydroelectric reservoirs					
	Streams	Small dam lakes	Ba	Ca	Co	Sa	A 1	A2	B	K	S	T
Species with marine or brackish affinity	26	1	22	*2*	20	1	0	6	1	1	0	1
Freshwater species	99	59	80	73	46	49	38	70	31	36	41	56
Total number	125	60	102	75	66	50	38	76	32	37	41	57

Table 3. Fish species identified in study areas: A1, Ayamé 1; A2 Ayamé 2; B, Buyo; K, Kossou, S, Soubré ; T, Taabo ; Ba Bandama ; Ca, Cavally; Co, Comoé ; S, Sassandra (The species put with cells-stained blue are of marine or brackish affinity).

	Hydroelectric reservoirs								Streams			
ESPECES	**A 1**	**A 2**	**B**	**K**	**S**	**T**	**Rivers**	**Small dam lakes**	**Ba**	**Ca**	**Co**	**S**
Pseudotolithus elongatus									x		x	
Pseudotolithus senegalensis											x	
Ctenopoma kingsleyae							x	x		x		
Ctenopoma patherici	x	x		x		x	x	x	x		x	
Parachanna obscura	x	x			x	x	x	x	x	x	x	x
Dalophis boulengeri							x					
Strongylura senegalensis							x					
Caranx hippos							x		x			
Caranx rhonchus											x	
Trachinotus teraia							x		x		x	
Polydactylus quadrifilis							x		x		x	
Protopterus annectens						x		x	x		x	
Alestes baremoze					x	x		x	x			x
Alestes dentex									x			
Alestopetersius smykalai							x					
Brycinus derhami										x		
Brycinus imberi	x	x	x	x	x	x	x	x	x	x	x	x
Brycinus longipinnis	x	x	x	x		x	x	x	x	x	x	x
Brycinus macrolepidotus	x	x		x	x	x	x	x	x	x	x	x
Brycinus nurse	x	x			x	x	x	x	x	x	x	x
Hydrocynus forskalii					x	x			x			x
Micralestes acutidens		x					x					
Micralestes eburneensis							x			x		
Micralestes elongatus		x					x		x			
Micralestes occidentalis	x	x				x	x		x	x		
Rhabdalestes septentrionalis								x				
Citharinus eburneensis							x					
Distichodus rostratus			x		x	x			x		x	x
Nannocharax fasciatus		x					x		x	x		
Neolebias unifasciatus		x					x		x			
Hepsetus akawo		x					x		x			
Hepsetus occidentalis							x			x		
Hepsetus odoe	x				x	x	x	x	x	x	x	x
Chromidotilapia cavalliensis	x						x			x		
Chromidotilapia ghuntheri		x		x	x	x	x	x	x	x		x
Hemichromis bimaculatus	x	x	x	x	x	x	x	x	x	x	x	x
Hemichromis fasciatus	x	x	x	x	x	x	x	x	x	x	x	x
Oreochromis niloticus	x	x	x	x	x	x	x	x	x	x	x	x
Pelmatolapia mariae									x		x	
Sarotherodon caudomarginatus										x		
Sarotherodon galilaeus		x	x	x	x	x	x	x	x			x
Sarotherodon melanotheron	x	x	x	x		x	x	x	x	x	x	x
Sarotherodon tournieri										x		
Thysochromis ansorgii		x					x		x	x		
Tilapia brevimanus		x								x		
Tilapia busumana	x						x	x				
Tilapia dagetii						x			x			
Tilapia discolor		x					x					
Tilapia guineensis	x	x	x	x	x	x	x	x	x	x	x	x
T. guineensis × T. zillii	x	x		x		x	x		x		x	
Tilapia mariae		x		x		x	x	x	x	x		

Tilapia walteri											x		
Tilapia zillii	x	x	x	x	x	x	x	x	x	x			x
Tylochromis intermedius									x		x		
Tylochromis jentinki		x					x		x		x		
Tylochromis leonensis		x					x						
Ethmalosa fimbriata							x						
Pellonula leonensis		x	x	x		x	x	x	x	x	x	x	
Pellonula vorax							x		x	x			
Barbus ablabes	x	x	x	x		x	x	x	x	x	x	x	
Barbus bigornei										x			
Barbus bynni waldroni						x			x				
Barbus chlorotaenia										x			
Barbus guildi									x				
Barbus inaequalis										x			
Barbus leonnensis										x			
Barbus macinensis									x				
Barbus macrops			x	x		x	x	x	x	x	x	x	
Barbus perince									x				
Barbus punctitaeniatus		x					x		x				
Barbus sacratus								x					
Barbus sublineatus				x		x		x	x				
Barbus tiekoroi							x						
Barbus trispilos		x					x	x	x	x			
Barbus wurtzi							x	x					
Clypeobarbus hypsolepis											x		
Labeobarbus bynni		x			x		x						x
Labeobarbus parawaldroni							x			x			
Labeobarbus wurtzi		x			x		x			x			x
Labeo coubie		x	x	x	x	x	x	x	x	x	x		x
Labeo parvus	x	x	x		x	x	x	x	x	x			x
Labeo senegalensis			x			x		x	x		x		x
Raiamas nigeriensis							x		x	x			
Raiamas senegalensis	x	x					x	x		x			
Aphyosemion petersii		x					x						
Epiplatys chaperi		x					x		x				
Epiplatys chaperi sheljuzhkoi							x						
Epiplatys dageti							x		x				
Epiplatys etzeli							x		x				
Epiplatys hildegarde										x			
Epiplatys olbrechtsi							x			x			
Fundulopanchax walkeri		x					x						
Scriptaphyosemion schmitti										x			
Aplocheilichthys normani		x					x						
Aplocheilichthys rancureli		x					x						
Aplocheilichthys schioetzi		x					x						
Aplocheilichthys spilauchen		x					x			x			
Poropanchax rancureli							x						
Procatopus schioetzi							x						
Rhexipanchax schiotzi							x		x				
Elops lacerta		x					x		x		x		
Kribia kribensis											x		
Kribia nana							x						
Dormitator lebrotonis											x		
Eleotris daganensis							x						
Eleotris senegalensis		x					x				x		
Eleotris vittata							x		x		x		
Parasicydium bandama							x						

Awaous lateristriga							x			x		x		
Gobionellus occidentalis							x							
Periophthalmus barbarus							x							
Sphyraena afra												x		
Sphyraena guachancho												x		
Liza falcipinnis		x					x			x		x		
Mugil cephalus												x		
Brienomyrus brachyistius	x	x					x				x	x		
Hippopotamyrus pictus											x			
Marcusenius furcidens	x	x			x	x	x		x		x	x		x
Marcusenius senegalensis		x		x	x	x	x		x		x	x		x
Marcusenius ussheri	x	x		x	x	x	x		x		x	x		x
Mormyrops anguilloides	x	x	x	x	x	x	x		x		x	x		x
Mormyrops breviceps											x			
Mormyrus hasselquisti									x		x			
Mormyrus rume	x	x	x		x	x	x		x		x	x		x
Mormyrus senegalensis			x											x
Mormyrus tapirus											x			
Mormyrus ussheri			x											x
Petrocephalus bovei	x	x		x	x	x	x		x		x	x		x
Petrocephalus pellegrini									x		x			
Pollimyrus isidori				x	x	x	x		x		x	x		x
Papyrocranus afer		x		x		x	x		x		x	x		
Heterotis niloticus	x	x	x	x	x	x	x		x		x	x		x
Eucinostomus melanopterus							x			x				
Gerres melanopterus							x			x				
Plectorhinchus macrolepis							x							
Pomadasys jubelini		x					x			x		x		
Pomadasys peroteti		x					x							
Lates niloticus			x	x	x	x			x		x		x	x
Lutjanus agennes										x				
Lutjanus dentatus										x				
Lutjanus goreensis							x			x				
Monodactylus sebae							x			x		x		
Cynoglossus monodi										x				
Cynoglossus senegalensis										x		x		
Citharichthys stampflii							x			x				
Polypterus endlicheri					x	x	x		x					x
Polypterus palmas							x				x			
Amphilius atesuensis		x					x			x				
Doumea chappuisi							x							
Auchenoglanis occidentalis				x		x			x					
Clarias anguillaris	x	x	x	x	x	x	x		x		x	x		x
Clarias buettikoferi		x					x		x			x		
Clarias ebriensis		x					x				x	x		
Clarias gariepinus		x				x			x			x		
Clarias laeviceps							x				x			
Clarias salae											x			
Gymnallables typus							x							
Heterobranchus isopterus	x	x			x	x	x		x		x	x		x
Heterobranchus longifilis	x	x	x		x	x	x		x		x			x
Chrysichthys auratus		x			x		x				x			x
Chrysichthys johnelsi		x					x				x			
Chrysichthys maurus	x	x	x	x	x	x	x		x		x	x		x
Chrysichthys nigrodigitatus	x	x	x	x	x	x	x		x		x	x		x

Chrysichthys teugelsi							x			x		
Malapterurus electricus	x	x	x	x	x	x	x	x	x			x
Malapterurus punctatus										x		
Chiloglanis occidentalis						x			x			
Synodontis bastiani	x	x	x	x	x	x	x	x	x		x	x
Synodontis comoensis		x					x					
Synodontis koensis			x		x							x
Synodontis nigrita								x				
Synodontis punctifer			x	x	x	x	x		x			x
Synodontis schall	x	x			x	x	x	x	x			x
Parailia pellucida		x		x		x	x		x	x	x	
Schilbe intermedius			x	x		x	x	x	x		x	x
Schilbe mandibularis	x	x	x	x	x	x	x	x	x	x	x	x
Schilbe mystus								x				
Lobotes surinamensis											x	
Aethiomastacembelus praensis	x	x					x					
Mastacembelus nigromarginatus	x	x					x		x	x		
Monopterus boueti									x			
Enneacampus ansorgii									x			
Enneacampus kaupi							x		x			
Microphis brachyurus											x	
Microphis brachyurus aculeatus							x					

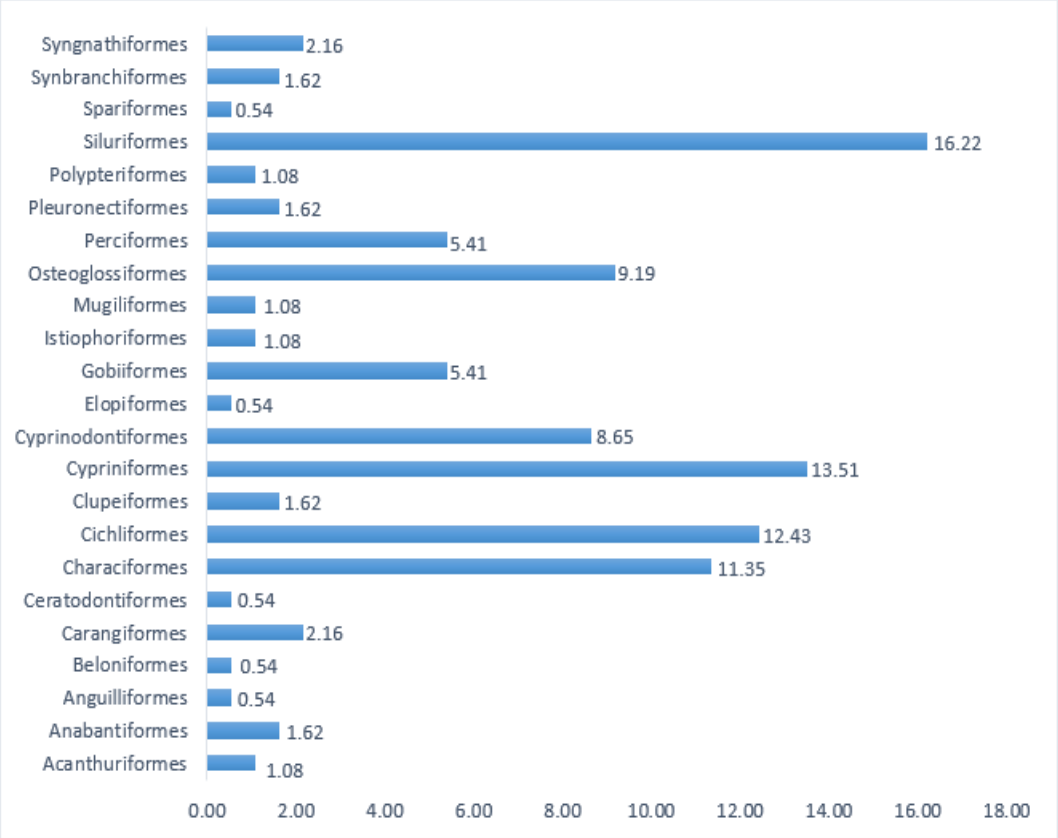

Figure 1. Numerical percentages of orders by number of species.

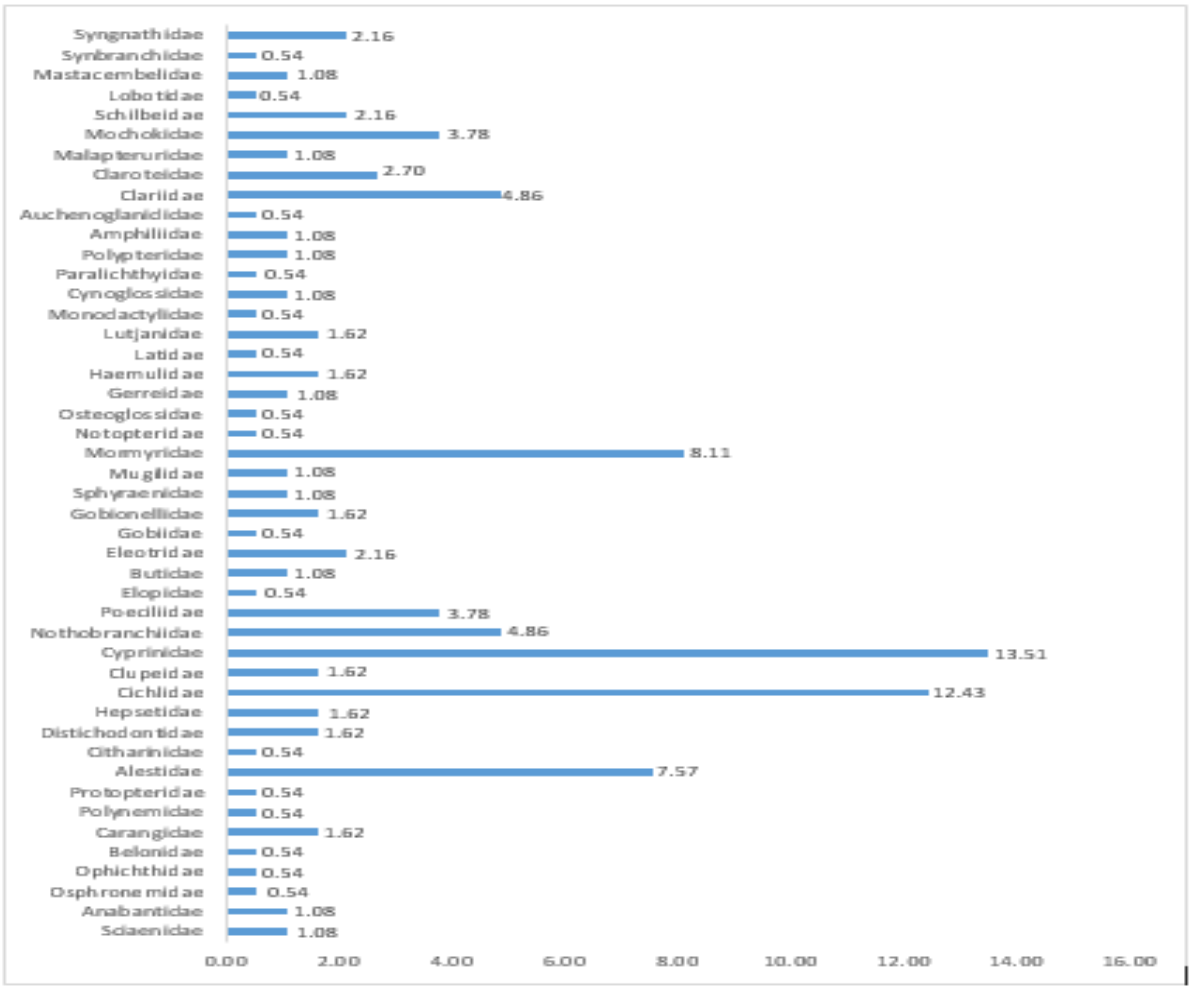

Figure 2. Numerical percentages of families by number of species.

Orders and family's diversity

The species recorded belong to twenty-three (23) orders. The Siluriformes have the highest number of species (16.22%), followed by Cyprinodontiformes, Cichliformes and Characiformes (Figure 1). They account for 53.51% of all the species. The different species are divided into forty-six (46) families, with the Cyprinidae (13.51%) and Cichlidae (12.43%) being the most abundant. Together with the Mormyridae, Alestidae, Nothobranchiidae and Clariidae, these six families account for half of the species (51.34%) (Figure 2).

Composition of fish communities in different waterbodies

Streams

Diversity of orders and families

Eighteen (18) orders, corresponding to 78.26% of the total number of orders recorded, inhabit streams. The Siluriformes (17.60%) have the most species, followed by the Characiformes, Cichliformes, Cyprinodontiformes and Cypriniformes. These five orders account for 66.40% of stream's species (Figure 3). There is also a great diversity of families (38 families, or 82.60% of all families). Cichlidae have the most species (12.80%), followed by Cyprinidae, Alestidae, Mormyridae, Clariidae, Poecilidae and Nothobranchiidae. These seven families account for more than half (53.60%) of the total species of the streams (Figure 4).

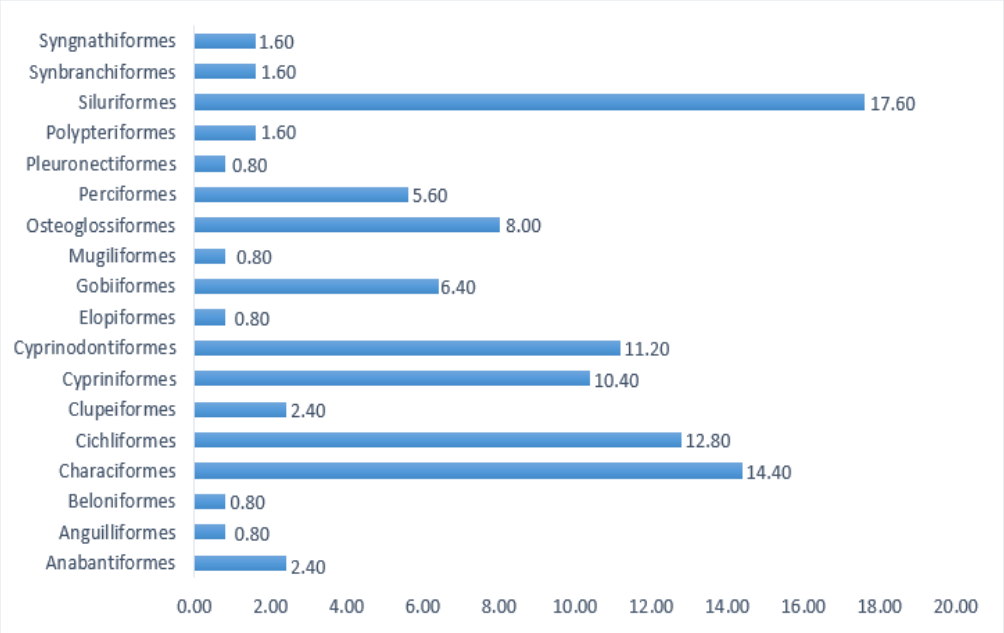

Figure 3. Numerical percentages of orders by number of species in streams

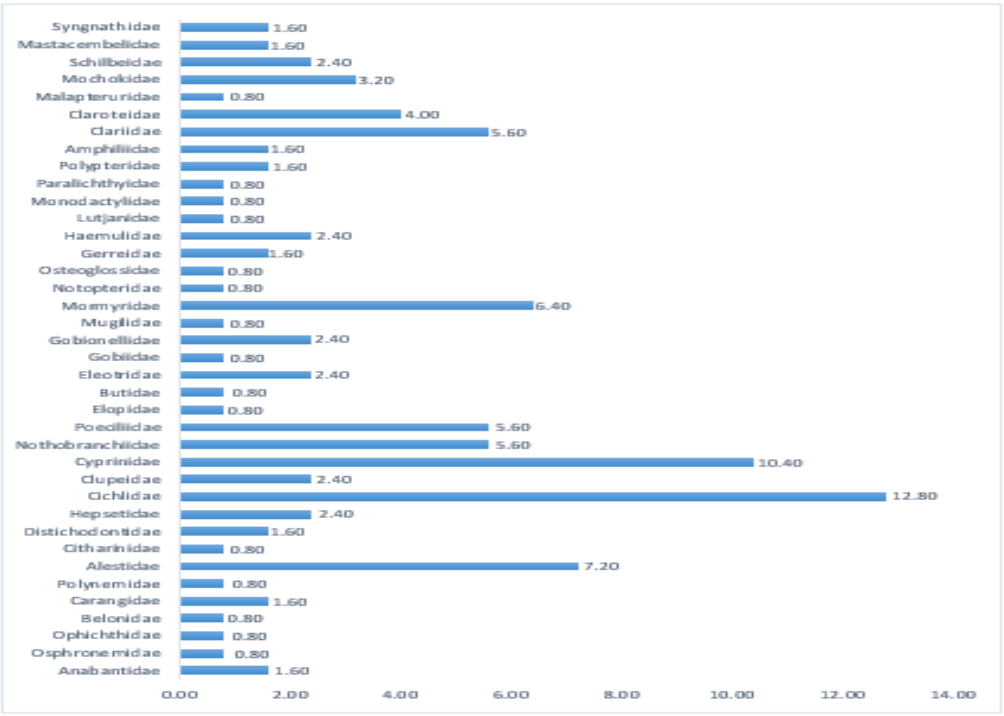

Figure 4. Numerical percentages of families by number of species in streams.

Abundance of families and species

With the exception of the Bia and the Agnebi streams, the Alestidae and Schilbeidae constitute or belong to the families that make up half of the catches. On the other hand, in the Dodo and Gô streams, the Cichlidae are more abundant, followed by the Gobiidae, Mochokidae, Characidae and Hepsetidae. Species belonging to the Alestidae and Schilbeidae families are present in large numbers of streams, along with other species. As for the species belonging to the Cichlidae family, apart from the Gô stream, only three species are found in the majority of catches (Table 4).

Table 4. Abundances of families and species in stream catches.

Bia stream
Fluvial area of Bia stream (upstream Ayamé 1 reservoir): *Labeo pawus, Micralestes elongatus, Brycinus imberi, Brycinus nurse* and *Barbus trispilos*. Downstream Ayamé 1 and 2 reservoirs : *Marcusenius furcidens, Elops lacerta, Papyrocranus afer, Tylochroinis leonensis, T. jentinki, Pellonula, leonensis, Liza falcipiniiis* and *Poniadasys jubelini* (Da Costa *et al*., 2000).
Nero stream
Families : Alestidae (21%), Schilbeidae (19%), Cyprinidae (17%) and Cichlidae (16%). Species : *Schilbe mandibularis* (19%) and *Brycinus longipinnis* (19%), less than 9% for each of the others (N'Zi *et al*., 2015) .
Gô stream
Upper course: Families: Cichlidae (38,4%) and Mochokidae (22,2%). Species: *Oreochromis niloticus* (35%), *Tilapia zillii* (30%) and *Tilapia guineeensis* (23%). Lower course: Families: Cichlidae (43,2%) and Characidae (33,3%). Species: *Sarotherodon melanotheron* (31%), *Sarotherodon galilaeus multifasciatus* (23%) and *Tilapia guineensis* (23%). Middle course: Families: Hepsetidae (25%), Characidae (16,1%) and Cichlidae (12,5%) (Koné *et al*., 2003).
Streams complex Brime-Mene-Nounoua
Families: Mormyridae (22,46%), Alestidae (24,45%) and Schilbeidae (20,66%). Species : *Petrocephalus bovei* (22,27%), *Schilbe mandibularis* (20,66%) and *Brycinus longipinnis* (18,86%) (Tanoh Kamelan *et al*., 2013).
Dodo stream
Families: Cichlidae (39,83%) and Gobiidae (27,03%). Species : *Gobionellus occidentalis* (25,68%) and *Hemichromis fasciatus* (23,87%) (Kamelan *et al*. (2013).
Hana stream
Families : Schilbeidae (25%), Alestidae (19%) and Mormyridae (18%). Species with occurrence percentages > 50% : *Polypterus palmas, Papyrocranus afer, Marcusenius senegalensis, Marcusenius ussheri, Petrocephalus bovei, Chrysichthys maurus, Schilbe mandibularis* and *Hemichromis fasciatus* (Kamelan *et al*. (2013).
Dominant species in Agnebi stream : *Schilbe intermedius, Pollimyrus isidori, Polypterus eiidlicheri, Heterobranclius longifilis, Heterotis niloticus, Citliarinus eburrteensis* and *Hemichromis fasciatus* (Da Costa *et al*. (2000).
N'zè stream
Families : Alestidae (39%) and Schilbeidae (38%). Species : *Schilbe mandibularis* (38%) and *Brycinus longipinnis* (21%) (N'Guessan *et al*., 2021).

Small dam lakes

Diversity of orders and families

With ten (10) orders and nine (9) families (43.47% and 41.30% respectively of the total number of orders and families), dam lakes are less rich than streams. The Siluriformes (41.30%) have the most species. Together with the Osteoglossiformes, Cypriniformes and Cichliformes, they contain 76.67% of the species in these waters. In addition, the Cichlidae, Cyprinidae and Mormyridae account for almost half (48.34%) of all species (Figures 5 and 6).

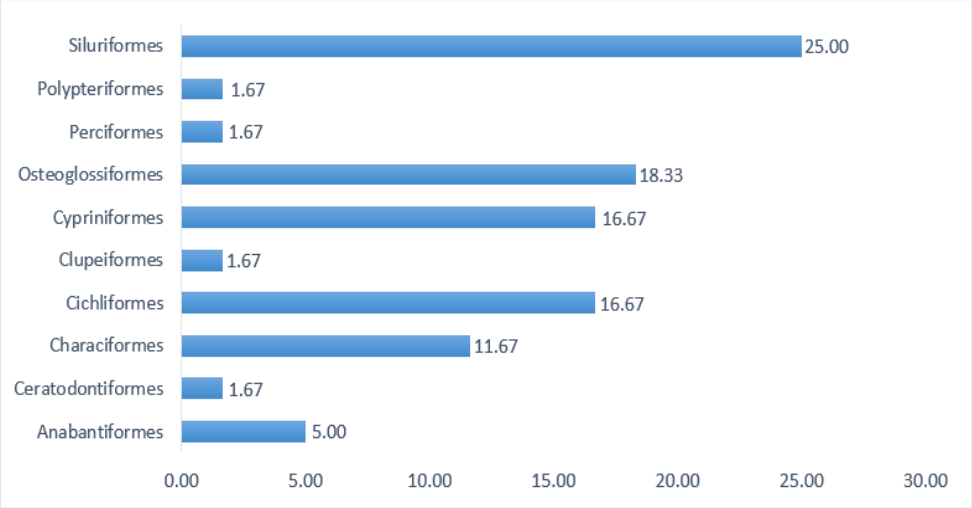

Figure 5. Numerical percentages of orders by number of species in small dam lakes.

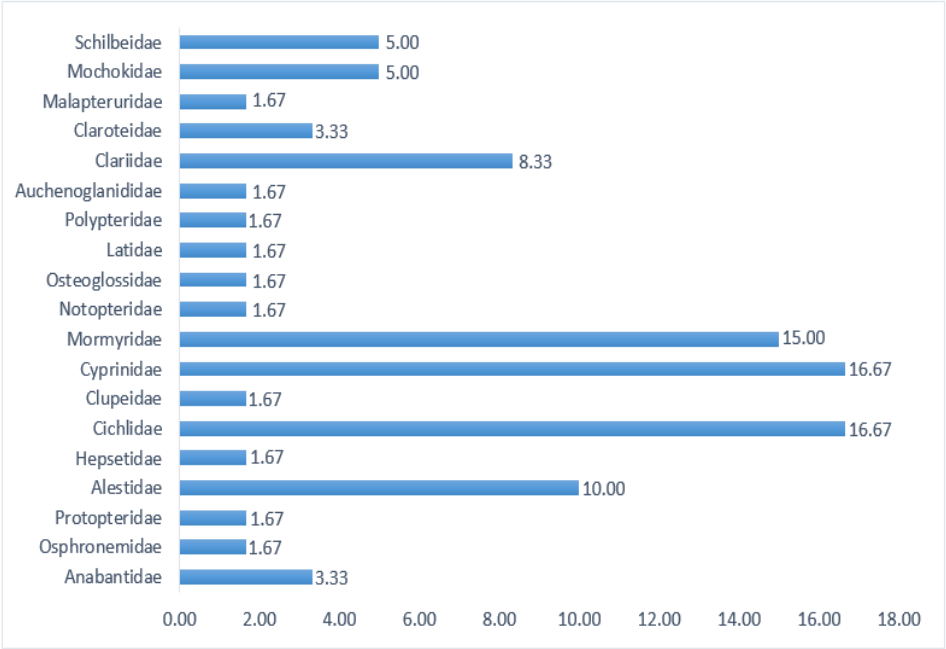

Figure 6. Numerical percentages of families by number of species in small dam lakes

Abundance of families and species

In relation to Da Costa *et al.* (2005) works in thirteen (13) small dam lakes, overall, *Barbus macrops* (36.79%) and *Schilbe intermedius* (18.80%) make up more than half of the catches. Apart from these results, the small dam lakes are particularly rich in Cichlidae family, with *Oreochromis niloticus* the dominant species. The Alestidae

are secondarily abundant with other species such as *Brycinus imberi, Synodontis schall, Sarotherodon galilaeus, Tilapia mariae, Tilapla zillii, Clarias spp, Heterotis niloticus* and *Chrysichthys spp* (Table 5).

Rivers

Bandama

Diversity of orders and families

The Bandama river contains the great number of orders (19 orders, i.e. 82.61% of all orders) and families (39 families, i.e. 84.78% of all families) of the rivers. The Siluriformes have the most species (16.67%), followed by the Cichliformes, Characiformes and Cypriniformes. These four orders account for 57.81% of the river's species. Among the families, the Cichlidae (14.71%) are richer in species, followed by the Cyprinidae, Alastidae and Mormyridae. These four families account for 44.12% of the rivers' species (Figures 7 and 8).

Abundance of families and species

In the Bandama river, six (6) families constitute the majority of the catches. These are the Alestidae, Mormyridae, Distichodontidae, Cichlidae, Claroteidae and Schilbeidae. Twenty-one (21) species are abundant. These are *Schilbe mandibularis, Brycinus macrolepidotus, Hemichromis facsiatus, Marcusenius ussheri, Petrocephalus bovei, Chromidotilapia guntheri, Tilapia zillii, Labeo coubie, Brycinus imberi, Chrysichthys nigrodigitatus, Heterobranchus isopterus, Oreochromis niloticus, Barbus macrops, Pellonula leonensis, Brycinus longipinnis, Hemichromis bimaculatus, Distichodus rostratus, Synodontis bastiani, Synodontis punctifer, Synodontis schall* and *Tilapia guineensis* (Table 6).

Table 5. Abundances of families and species in small dam lakes catches

Kaby lake : *Oreochromis niloticus* (90,5%) (Kouadio *et al*., 2018).
Songori lake : *Oreochromis niloticus* (68,10% and 78,89%) (N'Dri *et al*., 2020).
Solomougou lake Families : Cichlidae (41,87%) and Alestidae (14,47%). Species : *Brycinus imberi* (14,41%), *Synodontis schall* (12,76%), *Oreochromis niloticus* (11,62%), *Sarotherodon galilaeus* (8,96%) and *Tilapia mariae* (8,61%) (Kouassi *et al*., 2020).
Lavononkaha lake Families : Cichlidae (54.73%). Species : *Oreochromis niloticus* (88.31% in Cichlidae family and 48.33% in total catches) (Diaby *et al.*, 2022).
Four northern small lakes Five ubiquist species : *Sarotherodon galilaeus, Tilapla zillii, Clarias spp, Oreochromls niloticus* and *Heterotis niloticus*. Species with great weight in cathches : *Tilapia zillii, Oreochromis niloticus, Chrysichthys spp, Clarias spp, Heterotis niloticus* and *Sarotherodon galilaeus* (Da Costa *et al*. 1998)
Thirteen northern small lakes : *Barbus macrops* (36.79%) and *Schilbe intermedius* (18.80%) (Da Costa *et al*., 2005)

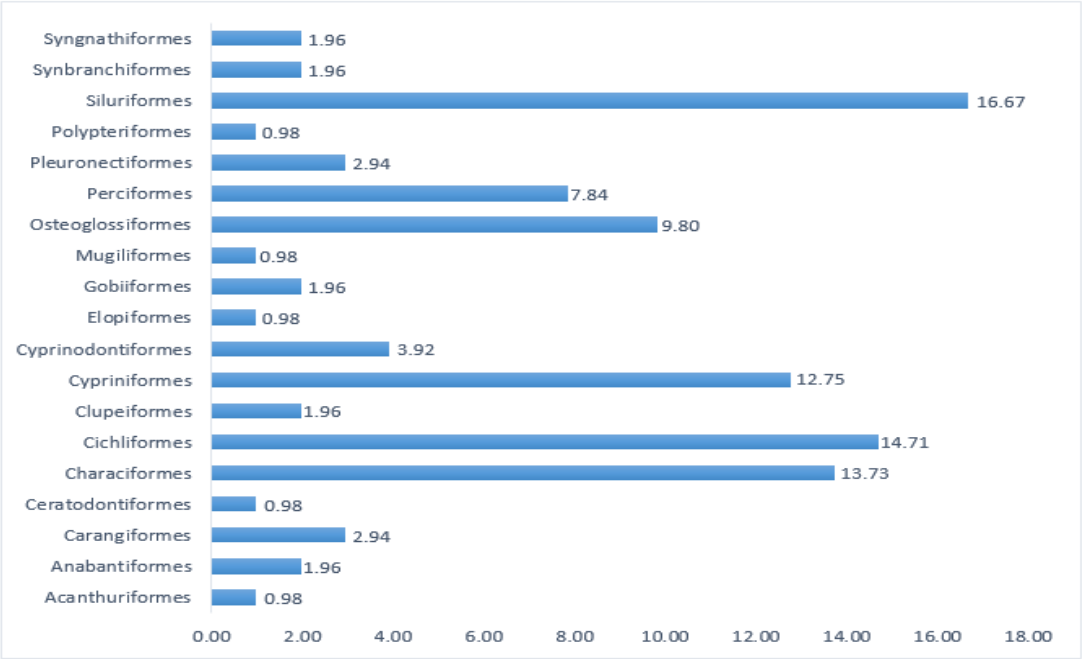

Figure 7. Numerical percentages of orders by number of species in Bandama river.

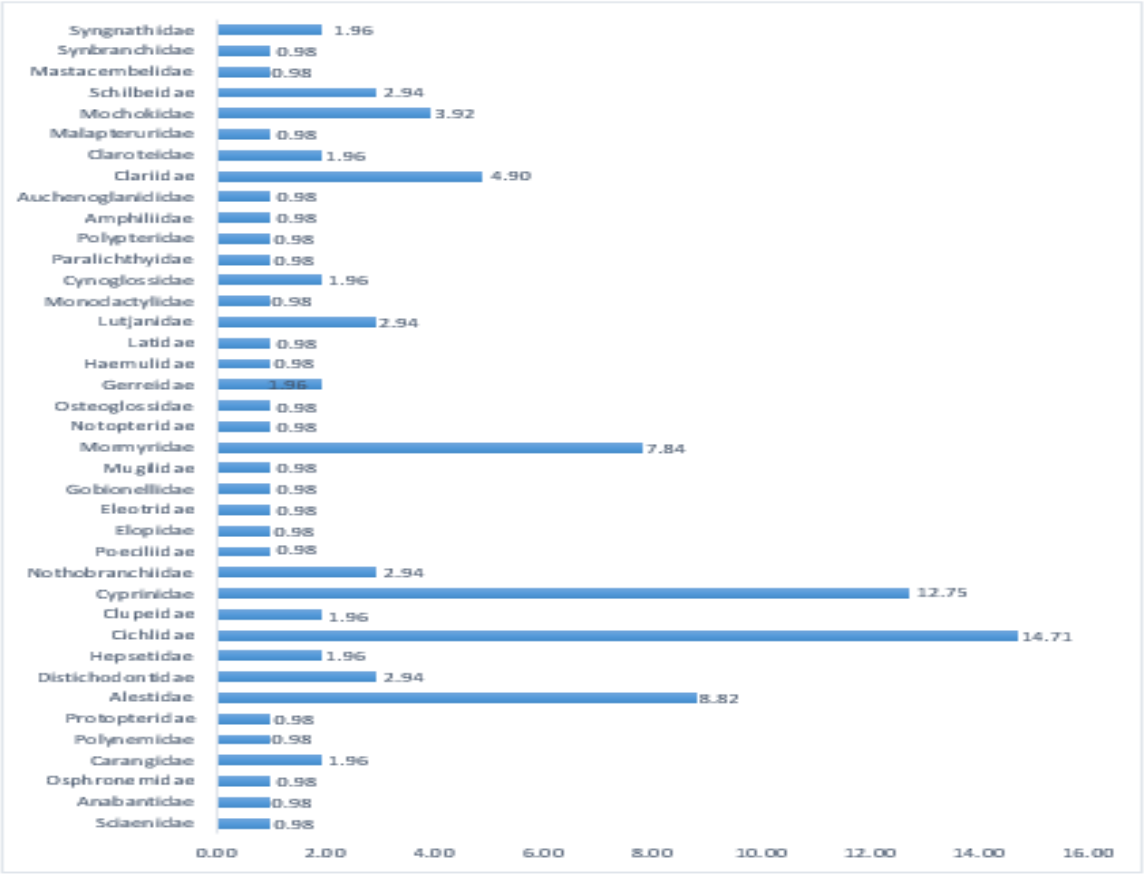

Figure 8. Numerical percentages of families by number of species in Bandama river.

Table 6. Abundances of families and species in Bandama river catches.

Upstream Kossou reservoir : *Petrocephalus bovei* (15%), *Brycinus longipinnis* (14%), ***Pellonula*** *leonensis* (13%) and *Brycinus imberi* (11%). Kosso reservoir : *Barbus macrops* (30%), *Petrocephalus bovei* (12%), *Chrysichthys nigrodigitatus* (9%), ***Pellonula*** *leonensis* (9%) and *Hemichromis fasciatus* (8%). Between Kossou and Taabo reservoirs : *Brycinus longipinnis* (35%) and *Brycinus imberi* (15%). Taabo reservoir : *Petrocephalus bovei* (19%), *Hemichromis fasciatus* (14%), *Barbus sp* (11%) and *Hemichromis bimaculatus* (10%). Downstream Taabo reservoir : *Brycinus longipinnis* (65%) (Aboua *et al*., 2010).
Bandama river Families : Alestidae (35%), Mormyridae (12%), Cichlidae (10%) and Schilbeidae (10%). Species with occurrence percentages > 50% : *Chrysichthys nigrodigitatus*, *Brycinus longipinnis*, *Schilbe mandibularis*, *Brycinus macrolepidotus*, *Hemichromis facsiatus*, *Brycinus imberi*, *Marcusenius ussheri*, *Petrocephalus bovei*, *Chromidotilapia guntheri* and *Tilapia zillii* (Aboua *et al*., 2015).
Area adjacent to Lampto scientific reserve : Claroteidae (59,13%) and *Chrysichthys nigrodigitatus* (53,95%) (Adou *et al*., 2023).
Area of Bandama fauna and flora reserve: Species with occurrence percentages > 50% : *Labeo coubie, Brycinus imberi, Chrysichthys nigrodigitatus, Heterobranchus isopterus, Oreochromis niloticus, Brycinus macrolepidotus, Synodontis bastiani, Synodontis punctifer, Synodontis schall* and *Tilapia guineensis* (Zamblé Bi T *et al*., 2021).
Estuarine area of Bandama river Families : Distichodontidae (17.16%), Cichlidae (13.89%), Claroteidae (10.95%) and Schilbeidae (10.95%). Species : *Distichodus rostratus* (17.16%), *Schilbe mandibularis* (10.84%) and *Chrysichthys nigrodigitatus* (7.58%) (Koné *et al*., 2021).

Cavally

Diversity of orders and families

The Cavally river has fewer orders (10 orders, 43.48% of total orders) and families (19 families, 41.30% of total families) than the Bandama. The Cichliformes, Siluriformes, Osteoglossiformes and Cypriniformes, with similar percentages of species richness, account for 73.34% of this river's species. The most diverse families are the Cichlidae, Cyprinidae and Mormyridae, which account for 52.00% of the species (Figures 9 and 10).

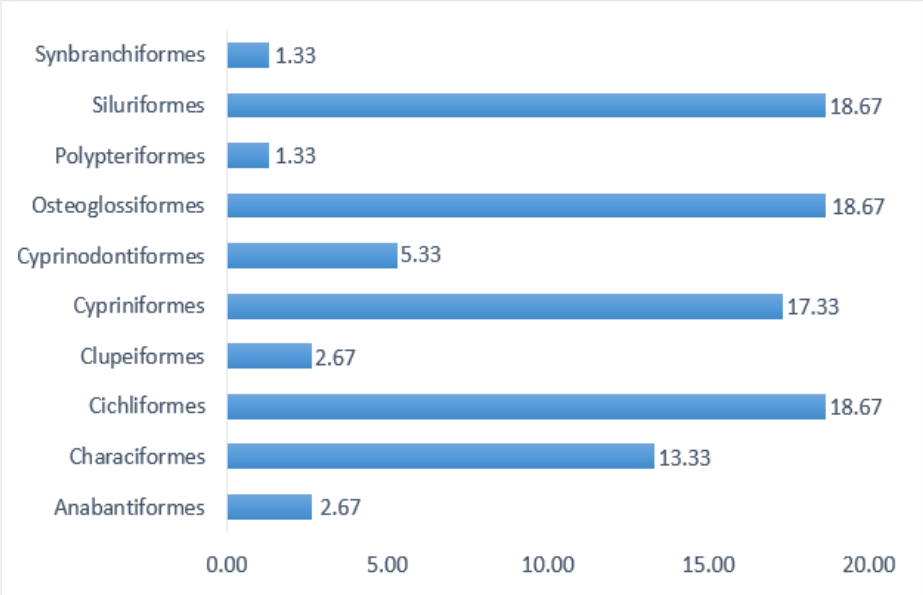

Figure 9. Numerical percentages of orders by number of species in Cavally river.

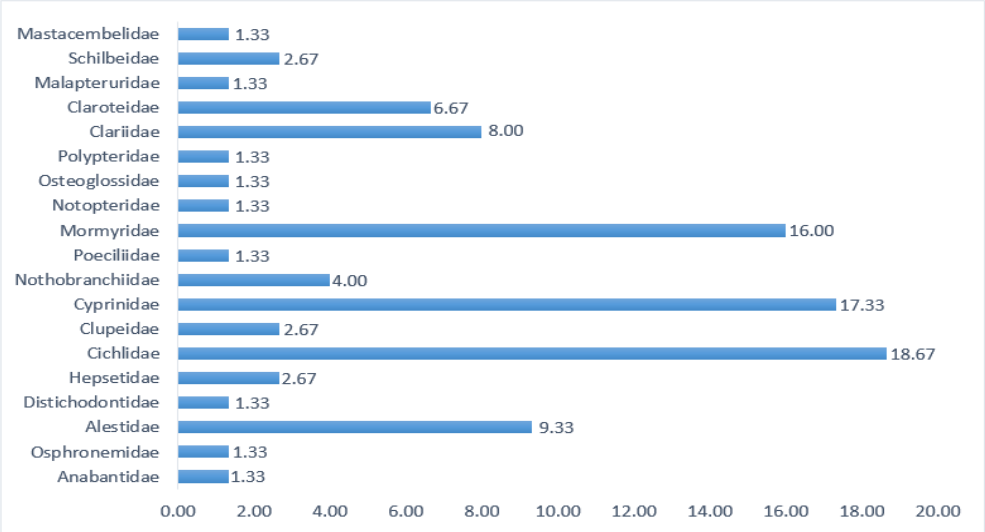

Figure 10. Numerical percentages of families by number of species in Cavally River.

Abundance of families and species

Doffou *et al.* (2019)'s study refers to occurrence frequencies. The species with occurrence frequencies above 50% are *Pellonula leonensis, Marcusenius senegalensis, Petrocephalus bovei, Pollimyrus isidori, Hepsetus odoe, Brycinus longipinnis, Brycinus nurse, Brycinus imberi, Brycinus macrolepidotus, Micralestes eburneensis, Schilbe mandibularis, Heterobranchus isopterus, Coptodon walteri, Coptodon zillii* and *Oreochromis niloticus*.

Comoé

Diversity of orders and families

The Comoé river has the largest number of orders (18 orders, 78.26% of all orders) and families (31 families, 67.39% of all families) after the Bandama river. Almost half of the species (45.46%) belong to the Siluriformes, Osteoglossiformes and Cichliformes orders. In terms of families, the Cichlidae and Mormyridae account for ¼ of the species in this water. Together with the Cyprinidae, Clariidae and Alestidae, these five families account for almost half the species (46.98%) in the Comoé river (Figures 11 and 12).

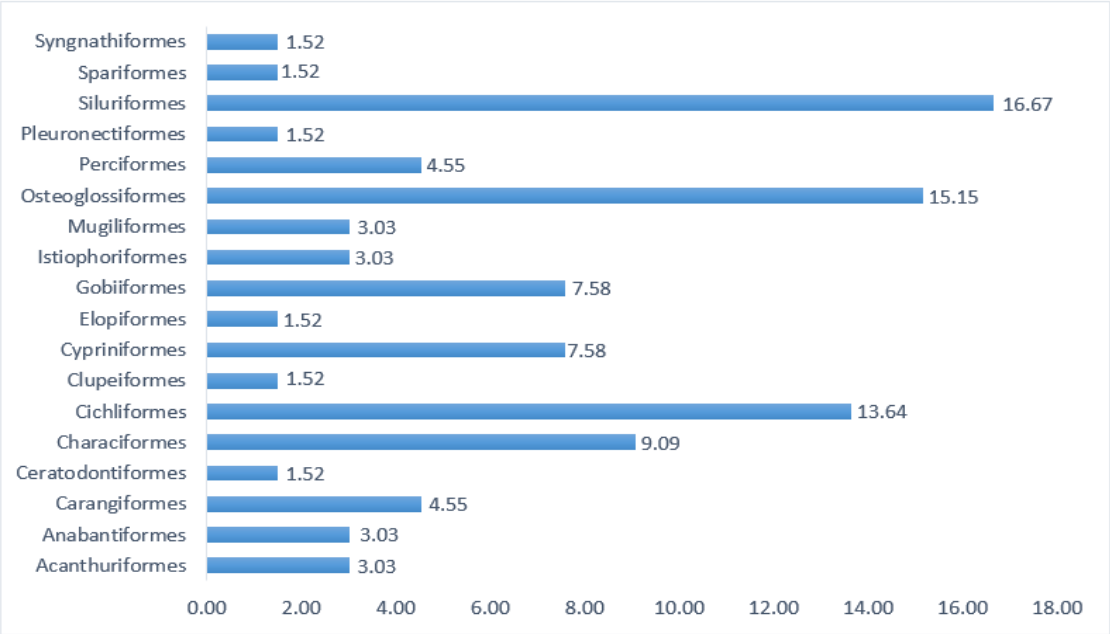

Figure 11. Numerical percentages of orders by number of species in Comoé river.

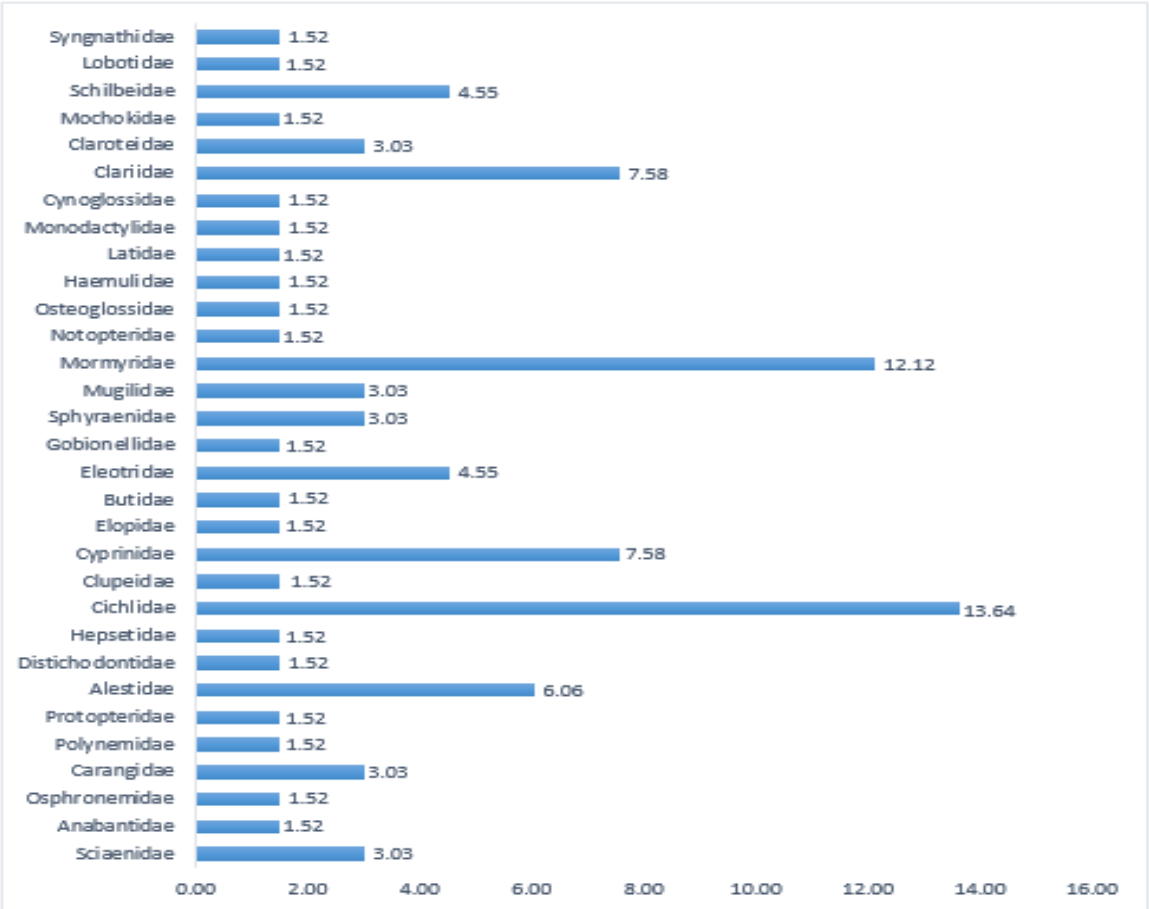

Figure 12. Numerical percentages of families by number of species in Comoé river.

For the abundance of families and species, no reference is available on this river.

Sassandra

Diversity of orders and families

The Sassandra river is the least rich in orders (9 orders, or 39.13% of all orders) and families (16 families, or 34.78% of all families). The Siluriformes and Osteoglossiformes account for almost half the species (46%). Then, come the Cichliformes, Characiformes and Cypriniformes, the latter three also accounting for 46% of species. In total, these five orders account for more than 90% of the species in this waterbody. The most abundant families are the Mormyridae, followed by the Cichlidae, Cyprinidae and Alestidae. They account for 60% of the species in this river (Figures 13 and 14).

Abundance of families and species

The data available on the Sassanbra river were collected from the Buyo and Soubré hydroelectric reservoirs. So, the abundance of families and species was therefore discussed in the section related to hydroelectric reservoirs.

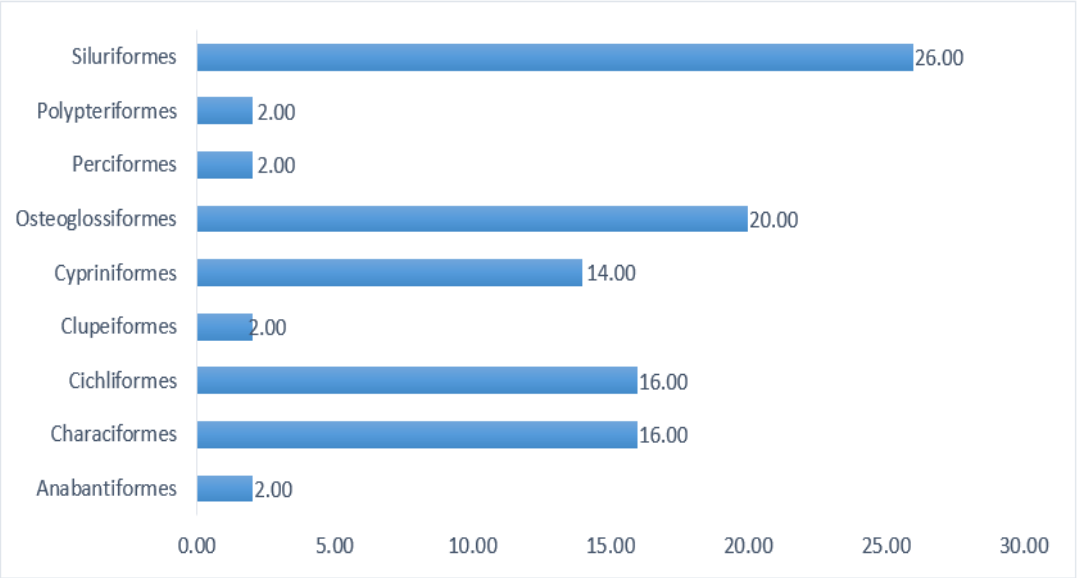

Figure 13. Numerical percentages of orders by number of species in Sassandra river.

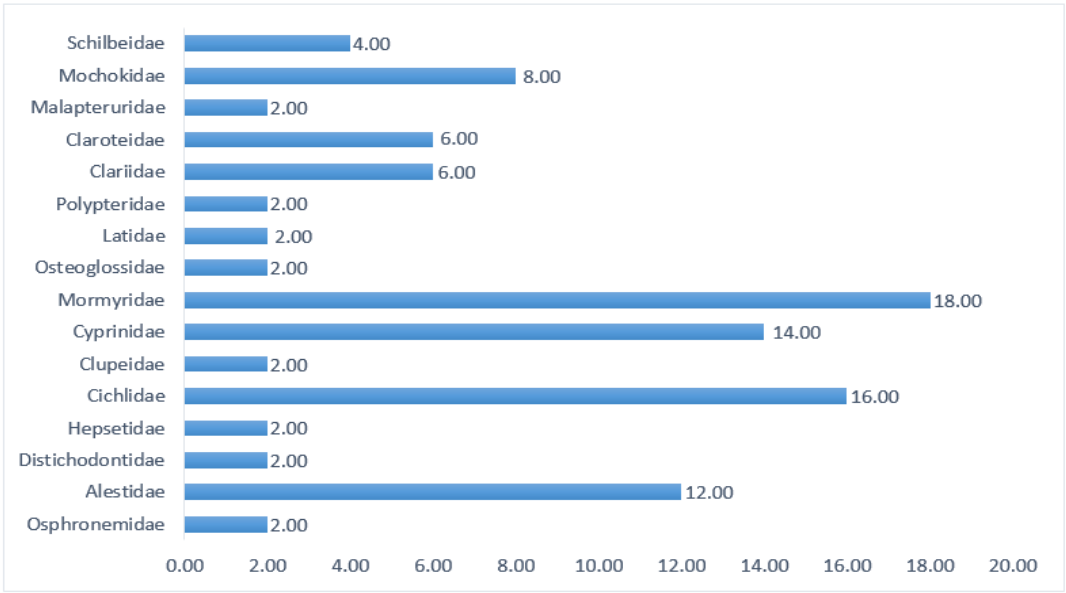

Figure 14. Numerical percentages of families by number of species in Sassandra river.

Hydroelectric reservoirs

Ayamé 1

Diversity of orders and families

Built on the Bia stream, seven (7) orders have been recorded in Ayamé 1 (corresponding to 50% of the stream's orders). Almost half of the species belong to the Cichliformes and Siluriformes orders (47.36%). In addition, 63.64% of all the families of the Bia river are present in the Ayamé 1 reservoir. The Cichlidae, Mormyridae and Alestidae account for 52.63% of the species in this lake (Figures 15 and 16).

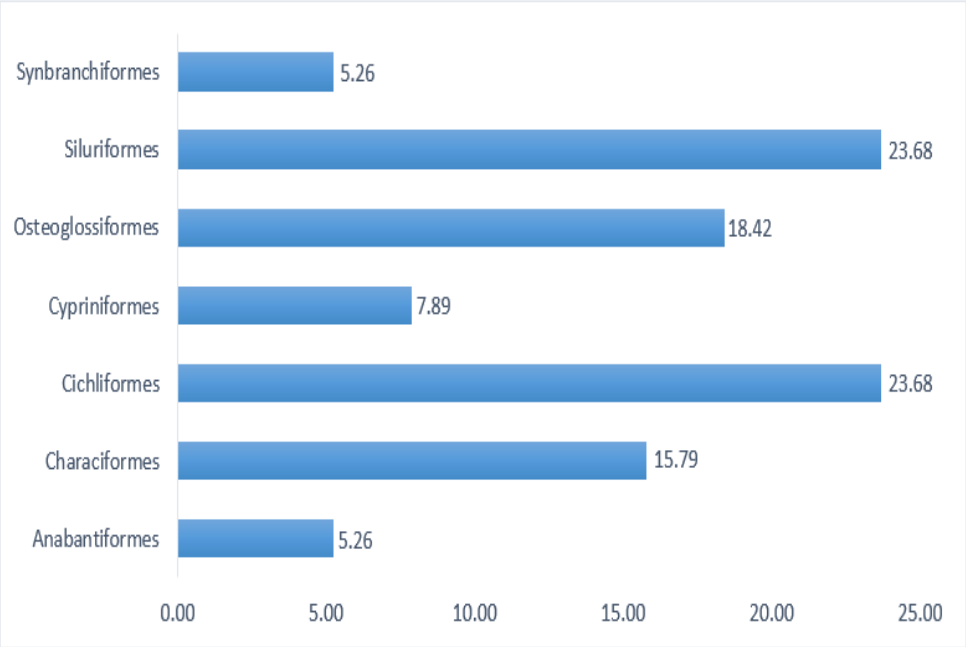

Figure 15. Numerical percentages of orders by number of species in Ayamé 1 reservoir.

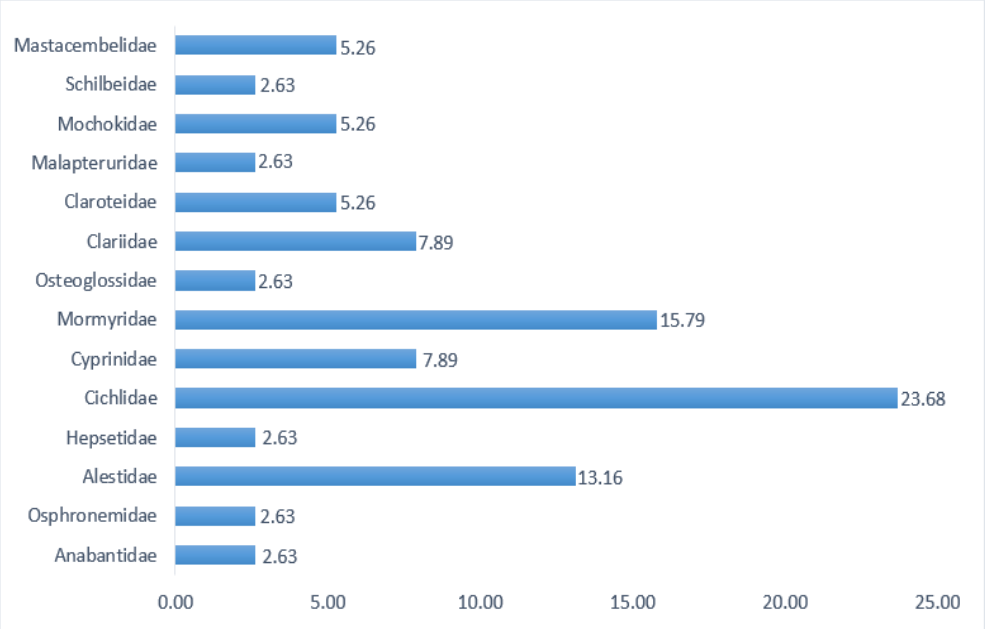

Figure 16. Numerical percentages of families by number of species in Ayamé 1 reservoir.

Abundance of families and species

Without mentioning percentages of abundance, Da Costa *et al.* (2000) indicated that hybrid Tilapia, *Sarotherodon melanotheron, Chrysichthys spp, Mormyrops anguilloides, Hemichromis bimaculatus, Petrocephalus bovei* and *Schilbe mandibularis* were dominant in the catches. According to Tah *et al*. (2009), the weight composition of the capture was dominated by Sarotherodon melanotheron (57%). Finally, Cissé *et al.* (2019) reported that the Alestidae (36.61%) and Cichlidae (34.19%) make up 70.80% of the catches. The two species caught in the majority were *Brycinus macrolepidotus* (16.19%) and *Sarotherodon melanotheron* (12.41%). In terms of biomass, the Cichlidae (41.79%) and Claroteidae (19.91%), as well as *Sarotherodon melanotheron* (23.19%), *Chrysichthys nigrodigitatus* (15.71%), *Brycinus macrolepidotus* (7.2%) and *Heterotis niloticus* (6.63%) accounted for more than half of the catches.

Ayamé 2

Diversity of orders and families

The Ayamé 2 hydroelectric reservoir contains almost all the orders (92.86% of the river's orders) and families (100% of the river's families) of the Bia river. As in the Ayamé 1 reservoir, the Siluriformes and Cichliformes account for almost half of the species (42.11%). In terms of families, the Cichlidae contain the most species, followed by the Cyprinidae, Mormyridae and Alestidae. They account for almost half the species (48.69%) (Figures 17 and 18).

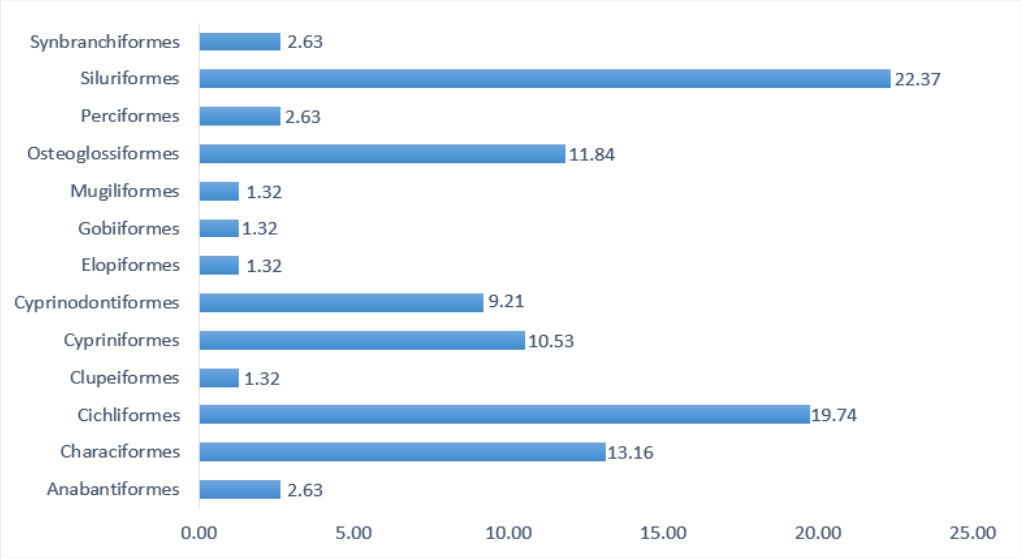

Figure 17. Numerical percentages of orders by number of species in Ayamé 2 reservoir.

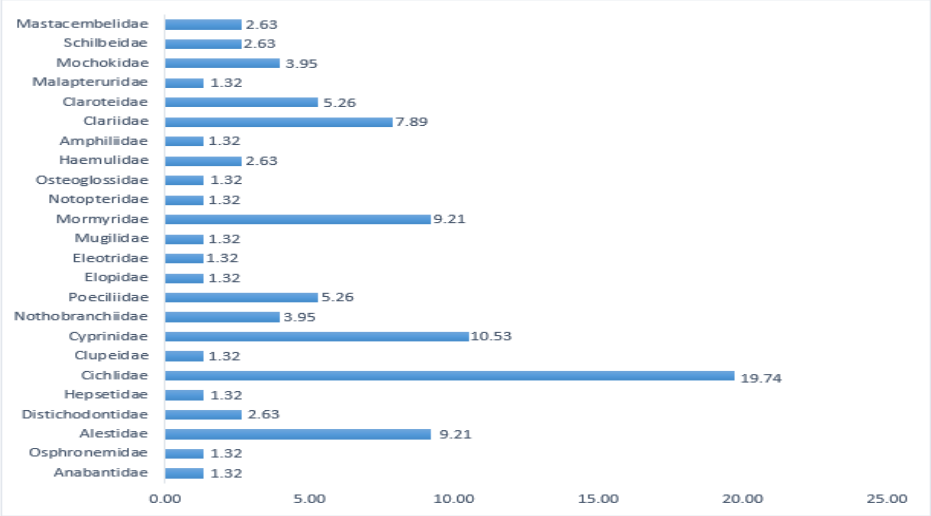

Figure 18. Numerical percentages of families by number of species in Ayamé 2 reservoir.

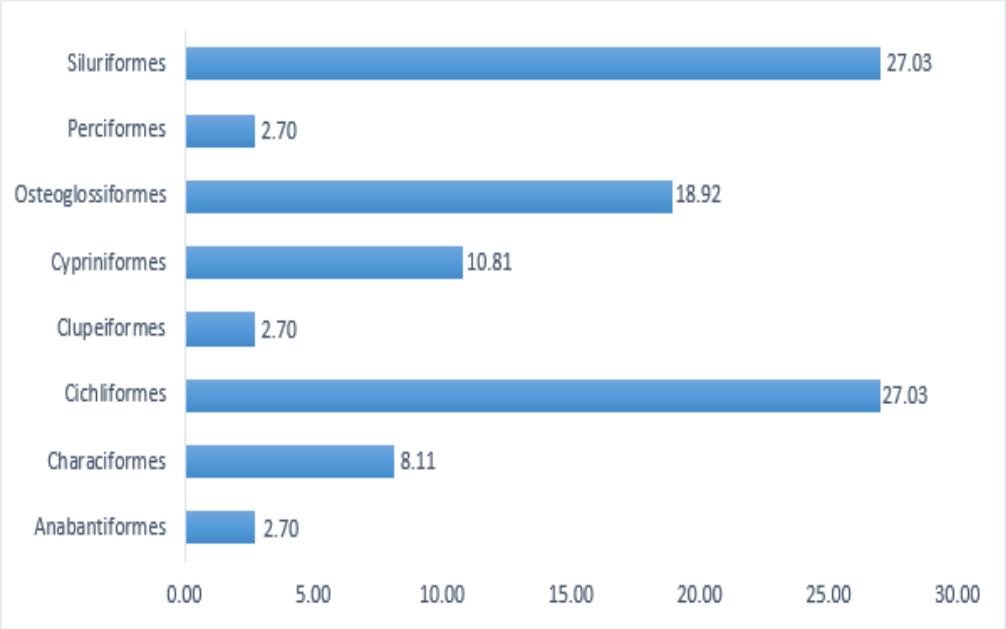

Figure 19. Numerical percentages of orders by number of species in Kossou reservoir.

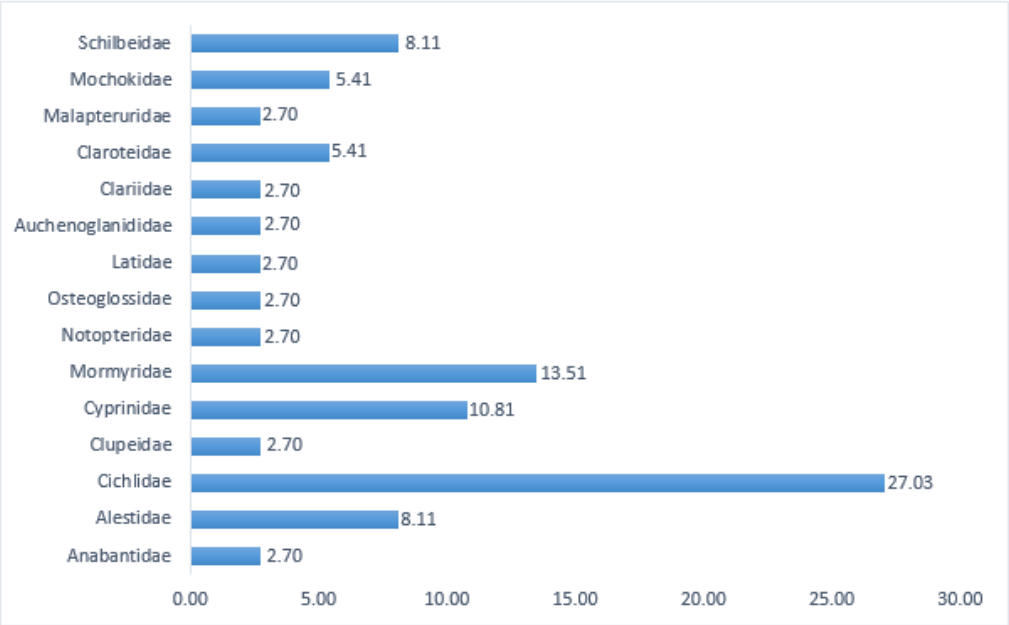

Figure 20. Numerical percentages of families by number of species in Kossou reservoir.

Abundance of families and species

In the Ayamé 2 hydroelectric reservoir, the Cichlidae (35.04%), Claroteidae (28.89%) and Alestidae (24.91%) accounted for 88.84% of catches. The dominant species are *Oreochromis niloticus* (30.99%), *Chrysichthys nigrodigitatus* (17.90%) and *Brycinus nurse* (11.74%).

Kossou

Diversity of orders and families

The Kossou hydroelectric reservoir, built on the the Bandama river, contains less than half of the orders and families recorded in this river (42.11% and 38.46% respectively). The Siluriformes and Cichliformes each account for 27.03% of species, or 54.06% in total. Concerning the families, the majority of species belong to the Cichlidae (27.03%). Then come the Mormyridae and Cyprinidae. These three families contain half of the reservoir's species (51.35%) (Figures 19 and 20).

Abundance of families and species

With reference to the work of Aboua *et al*. (2010), the species *Barbus macrops* (30%), *Petrocephalus bovei* (12%), *Chrysichthys nigrodigitatus* (9%), *Pellonula leonensis* (9%) and *Hemichromis fasciatus* (8%) are the most commonly caught and account for more than half of all landings.

Buyo

Diversity of orders and families

The Buyo reservoir contains 77.78% and 81.25% respectively of the orders and families of the Bandama river on which it is built. The Siluriformes and Cichliformes account for 53.13% of the reservoir's species. As in the Kossou reservoir, the majority of the species belong to the Cichlidae family (21.88%) and secondarily to the Cyprinidae and Mormyridae ones. These three families contain half of the Buyo resevoir's species (50.01%) (Figures 21 and 22).

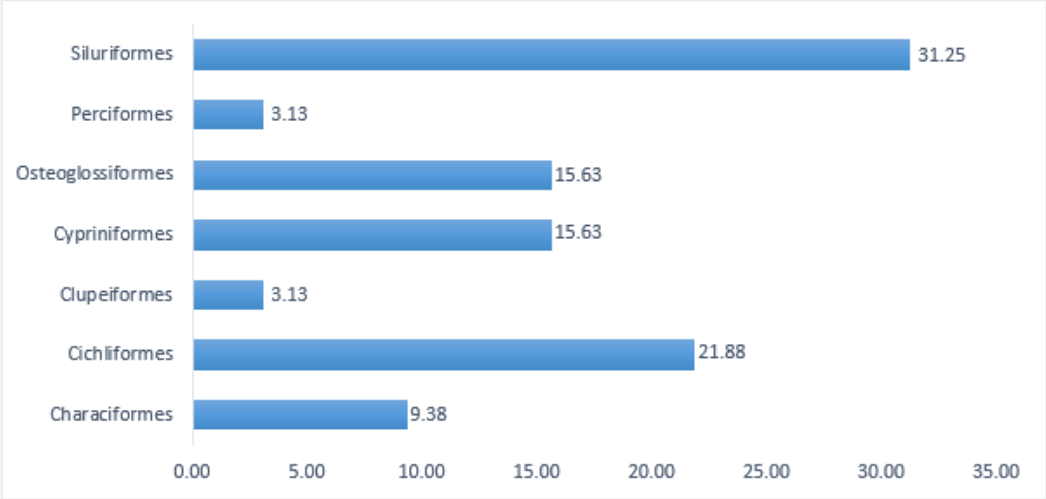

Figure 21. Numerical percentages of orders by number of species in Buyo reservoir.

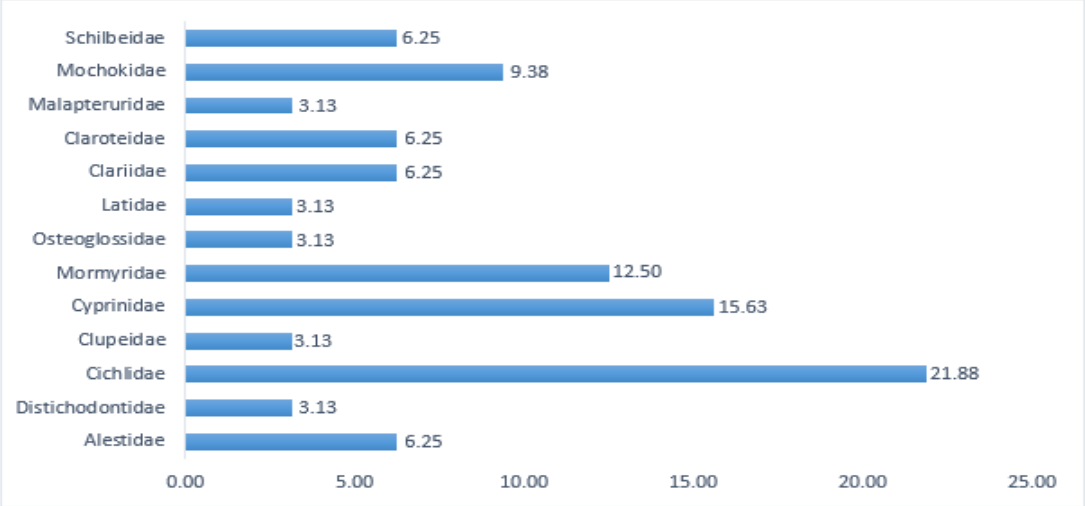

Figure 22. Numerical percentages of families by number of species in Buyo reservoir.

Abundance of families and species

In their study, N'Dri *et al.* (2020) noted that among the species caught the most, *Coptodon zillii*, also known as *Tilapia zillii* (26.5%), *Barbus macrops* (13%) and *Oreochromis niloticus* (8.3%) accounted for almost half of the captures, i.e. 47.8%.

Soubré

Diversity of orders and families

Almost all the orders and families of the Sassandra river are found in the Soubré hydroelectric reservoir, with 88.89% and 93.75% respectively. The Siluriformes have the most species, followed by Osteoglossiformes, Cichliformes and

Characiformes. These orders account for 82.92% of the species in this reservoir. As for families, the Mormyridae and Cichlidae are still the most rich in species. Together with the Alestidae, these three families contain just under half (46.34%) of the reservoir total species (Figures 23 and 24).

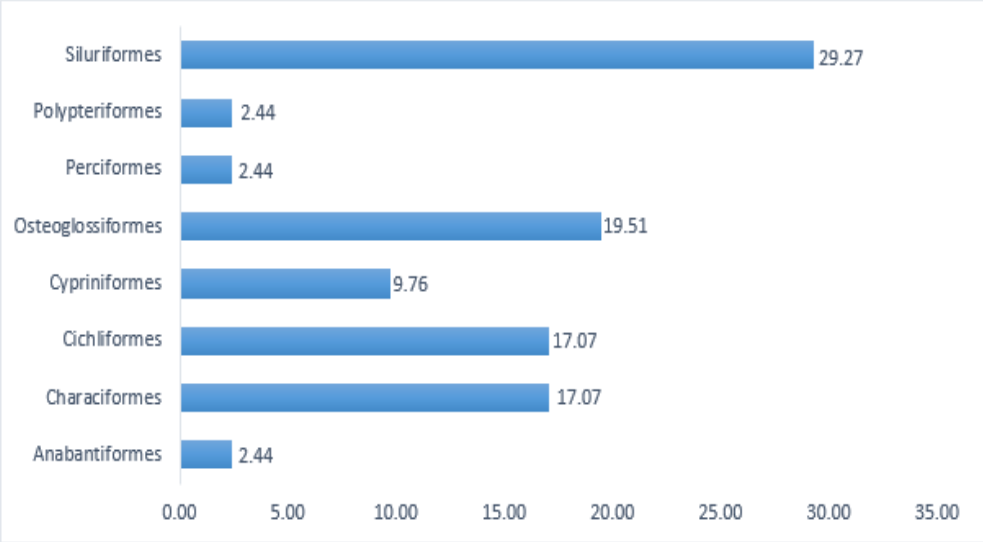

Figure 23. Numerical percentages of orders by number of species in Soubré reservoir.

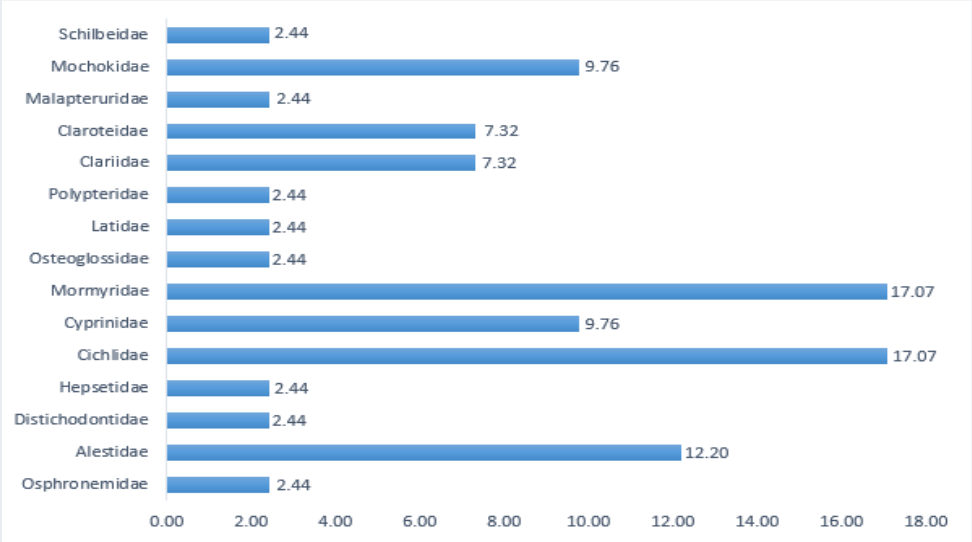

Figure 24. Numerical percentages of families by number of species in Soubré reservoir.

Abundance of families and species

In terms of numerical percentages, the species caught the most were *Marcusenius senegalensis* (17%), *Chrysichthys nigrodigitatus* (16%), *Synodontis schall* (11%), *Coptodon zillii* (*Tilapia zillii*) (9%) and *Synodontis bastiani* (9%). At the biomass level, *Chrysichthys nigrodigitatus* (16%), *Marcusenius senegalensis* (8%), *Lates niloticus* (8%), *Heterotis niloticus* (8%), *Coptodon zillii* (*Tilapia zillii*) (6%), *Mormyrus rume* (6%), *Oreochromis niloticus* (6%) and *Synodontis bastiani* (5%) are the dominant species (Konan *et al*., 2022).

Taabo

Diversity of orders and families

The Taabo hydroelectric reservoir contains half of the orders and families of fish in the Bandama river on which it is built (52.63% and 51.28% respectively). The Siluriformes and Cichliformes account for just under half

of the lake's species (45.62%). Concerning the families, the Cichlidae that have the most species, followed by the Mormyridae, Cyprinidae and Alestidae. These three families account for 56.14% of the reservoir's species (Figures 25 and 26).

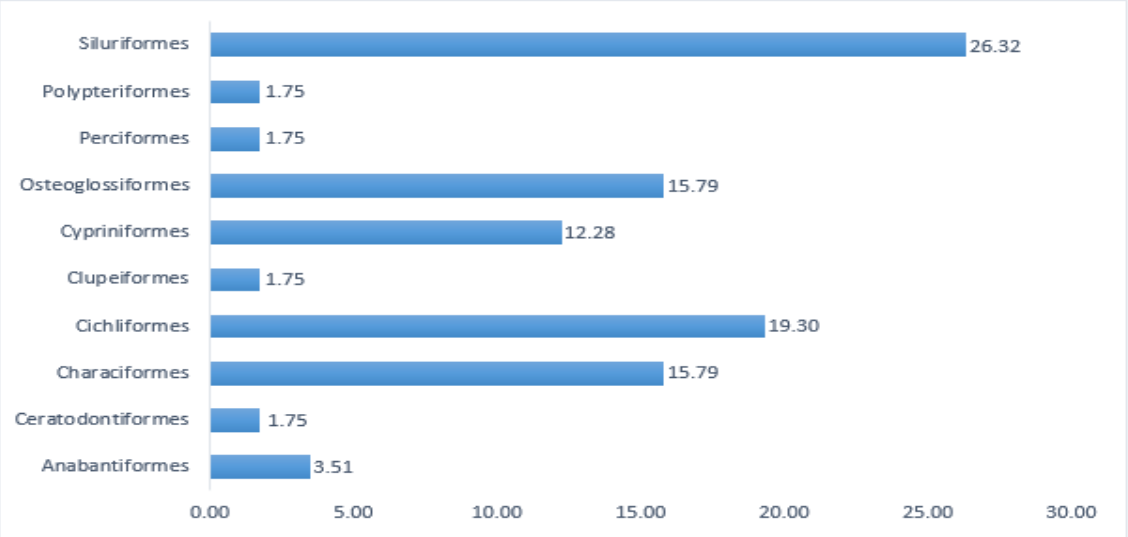

Figure 25. Numerical percentages of orders by number of species in Taabo reservoir.

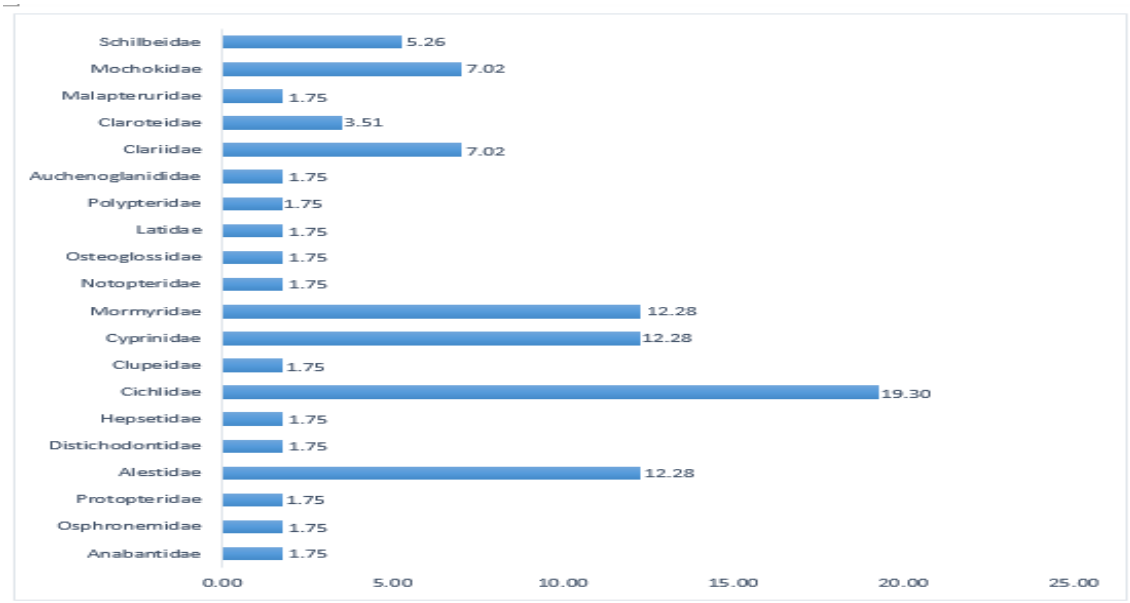

Figure 26. Numerical percentages of families by number of species in Taabo reservoir.

Abundance of families and species

According to Aliko *et al.* (2010), the species with occurrence frequencies above 50% are *Oreochromis niloticus, Tilapia zillii, Chrysichthys nigrodigitatus, Labeo coubie, Distichodus rostratus, Synodontis bastiani, Synodontis punctifer, Synodontis schall, Marcusenius senegalensis, Mormyrops anguilloides, Heterotis niloticus* and Schilbe mandibularis. In terms of numerical abundance, Kien *et al*. (2022) indicated that the Claroteidae (47%) and Mochokidae (19%) families account for more than half of the catches, with *Chrysichthys nigrodigitatus* (46%), *Schilbe mandibularis* (9%) and *Synodontis bastiani* (8%) as the dominant species. In terms of weight percentages, the Claroteidae (32%) and Cichlidae (18%) were dominant, with *Chrysichthys nigrodigitatus* (31%) and *Labeo coubie* (17%) as representative species. Finally, Aboua *et al*. (2010) noted that *Petrocephalus bovei* (19%), *Hemichromis fasciatus* (14%), *Barbus sp*. (11%) and *Hemichromis bimaculatus* (10%) make up more than 50% of the catches.

FISH COMMUNITIES ABUNDANCE FOR MANAGEMENT PURPOSE

The study of fish diversity showed that in the different studies, the highest number of species in the half of catches belong to six (6) orders and six (6) families. The orders are those of Siluriformes, Characiformes, Cichliformes, Cyprinodontiformes, Cypriniformes and Osteoglossiformes. However, the Siluriformes still have the most species, followed by the Cichliformes and the Osteoglossiformes. The families concerned are the Cichlidae, Cyprinidae, Alestidae, Mormyridae, Clariidae and Poecilidae. The Cichlidae regularly have the most species, followed by the Cyprinidae and Mormyridae, and to a lesser extent the Alestidae.

Concerning their abundance in catches, almost twenty families are regularly present in the half of catches. These are Elopidae, Notopteridae, Mochokidae, Characidae, Hepsetidae, Gobiidae, Mormyridae, Clupeidae, Alestidae, Cichlidae, Cyprinidae, Distichodontidae, Claroteidae, Schilbeidae, Idaclarie and Osteoglossidae. However, the most captured species belong mainly to the families of Cichlidae, Alestidae, Schilbeidae and Mormyridae and secondarily to those of Claroteidae and Cyprinidae. This indicates that the Siluriformes, Cichliformes, Characiformes, Osteoglossiformes and Cypriniformes appear as the dominant orders in the Ivorian inland fisheries catches. In relation to the observations of Attingli *et al*. (2017) and Ahouansou Montcho (2011), which report the relationship between the fishing gears types and the target species, the studies on the selectivity of fishing gears used to catch these groups of fish should be conducted should be conducted for the sustainable management of these fisheries.

CONCLUSION

The fish communities in Ivorian inland waters are very diverse. The species belong mainly to the order of Siluriformes, Cichliformes and Osteoglossiformes and to the families of Cichlidae, Cyprinidae, Mormyridae and Alestidae. In terms of abundance in the catches, the species belong mainly to the families of Cichlidae, Alestidae, Schilbeidae and Mormyridae and secondarily to those of Claroteidae and Cyprinidae. This indicates that the Siluriformes, Cichliformes, Characiformes, Osteoglossiformes and Cypriniformes appear as the dominant orders in the Ivorian inland fisheries catches. The management project of these fisheries should be focus toward these groups of fish.

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CONFLICT OF INTERESTS

The authors declare no conflict of interest

ETHICS APPROVAL

Not applicable

AI TOOL DECLARATION

The authors declares that no AI and related tools are used to write the scientific content of this manuscript.

DATA AVAILABILITY

Data will be available on request

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