Online ISSN: 2588-3526

Journal of Wildlife and Biodiversity

Volume 9(3): 404-435 (2025) (http://www.wildlife-biodiversity.com/)

Research Article

Diversity and assemblage of Ichtyofauna in an unexplored tropical aquatic ecosystem: Inzia River, Congo basin

Daddy Menga Kaziala[1,2,4], Billy Nzau Matondo[2]*, Soleil Wamuini Lunkayilakio[3], Kasiama Gomez[4], Darell Kosi Zola[3], Julien Bwazani Balandi[1,2], Jean-Claude Micha[1,5], Michaël Ovidio[2]

[1]The Regional Post-Graduate Training School on Integrated Management of Tropical Forests and Lands (ERAIFT), B-B-B-15373, Democratic Republic of the Congo

Management of Aquatic Resources and Aquaculture Unit, Freshwater and Oceanic Science Unit of Research-FOCUS, University of Liège, 22 Quai E. Van Beneden, B-4020 Liège, Belgium

[3] Institut Supérieur Pédagogique de Mbanza-Ngungu, Section de Sciences et Technologies, Département de Biologie. B-127, Mbanza-Ngungu, DRC.

[4]Institut Supérieur Pédagogique de Kitoy, Section de Sciences et Technologies, Département des Sciences agro-vétérinaires. B-32 Kwilu, DRC.

[5]Environmental Biology Research Unit (URBE), Namur University, Brussels Street, 61 B-5000 Namur, Belgium

*Email: m.ovidio@uliege.be

Received: 17 June 2025 / Revised: 19 September 2025 / Accepted: 30 September 2025/ Published online: 18 October 2025.

How to cite: Kaziala, D.M., et al. (2025). Diversity and assemblage of Ichtyofauna in an unexplored tropical aquatic ecosystem: Inzia River, Congo basin, Journal of Wildlife and Biodiversity, 9(3), 404-435. DOI: https://doi.org/10.5281/zenodo.17390370

Abstract

Ichthyofauna diversity and assemblage in tropical aquatic ecosystems, particularly those of Central Africa, although rich in biodiversity, are far from being sufficiently known. The present study examines fish biodiversity along the tropical Inzia River catchment located in the Democratic Republic of Congo. From July to September 2022, a total of 22 stations were sampled and surveyed for an effort duration of 24 hours per station using various fishing equipment and techniques. These involved the use of still nets, floating lines, hawksbills, longlines, and catches from local fishermen. A total of 17,187 fish were caught, most (92.3%) of which were captured by the static net. Analysis of the data revealed 91 formally identified fish species, belonging to 57genera, 25 families, and 12 orders. Seven adult specimens were unknown, and their fin fragments were taken and preserved for identification by DNA analysis at the Royal Museum for Central Africa in Tervuren, Belgium. Fish species diversity was higher in the Inzia River than in its tributaries and showed an upward trend from the lower to the middle reaches of the basin. Our results confirm the abundant fish biodiversity in tropical aquatic ecosystems, and the unidentified individuals could probably be new species.

Keywords: Biodiversity, Longitudinal Distribution Pattern, Tropical Ecosystems, Fishing Techniques, fish

Introduction

Since the 1992 Convention on Biological Diversity in Rio de Janeiro (Lévêque, 1994), new attention has been paid to the conservation of species and natural environments (Paugy & Lévêque, 2006a). With a total freshwater surface area estimated at 86,080 km2, the Congolese nation (DRC) boasts a dense hydrographic network teeming with a rich and diverse fish fauna (Teugels & Guégan, 1994; Katemo et al., 2023). The DRC's estimated fish species richness of 1,551 species is the highest of any other African nation (FishBase, 2023). However, studies undertaken over the last few decades in certain rivers of the Congo Basin revealed a wealth of endemic species, genera, and families (Mutambwe, 1992; Micha & Mbenga, 2003; Mbenga, 2004; Wamuini, 2010; Ibala, 2010; Monsembula et al., 2013; Mahamba et al., 2018; Katemo, 2020; Mukabo et al., 2020; Ekyambe et al., 2023; Katemo et al, 2023). Despite the high number of species, scientific knowledge of the basin's fish fauna is still far from exhaustive (Mukabo et al, 2020; Fermon, 1996; Montchowui et al., 2007; Lévêque, 1994; Teugels & Guégan, 1994). Most studies on ichthyofauna diversity are more concentrated on the Congo River's main course, a few tributaries, and lakes that are frequently found close to urban centers (Mbimbi, 2011; Pwema et al., 2023).

The Inzia River, which serves as the western boundary between Kwilu and Kwango provinces in the DRC, is characterized by a fish diversity that remains little known to this day. This river's watershed has a dense hydrographic network, which includes a multitude of rivers of varying sizes, including the Inzia, Lukula, Luie, Kafi, and Gobarri rivers, as well as their tributaries, and numerous small lakes (UNDP & UNOPS, 1998). The Inzia basin also has hydroelectric potential. The two most important are the Lippens waterfall on the Luie River (World Bank, 2021) and Péchi, a tributary that flows into the Kafi River and forms its outlet. These act as physical barriers that can promote fish speciation (Wamuini et al., 2010; Katembo, 2020). Hydroelectric power plant dams are detrimental to the ecological balance of the river (Ovidio & Philippart, 2002; Ovidio et al., 2021). Because of these, the Inzia river basin is thought to have a high level of biodiversity, potentially including new species that are spread across multiple habitats and occupy different ecological niches.

The Inzia basin, which spans a length of 461.10 Km and includes an area of 25,711.2 km², is the source of livelihood for approximately 3,243,446 people (CAID, 2023; Wikipedia, 2024). In addition to the substantial unregulated artisanal fishing activity that is observed in the above-mentioned rivers during the dry season (UNDP/UNOPS, 1998), other activities are also developed. These include conventional animal husbandry, non-intensive aquaculture, and traditional and industrial agriculture (Menga,2018). Human activities that are most likely to endanger the ichthyofauna diversity of the Inzia basin are : (i) bulding infrastructures (bridges, homes, factories, etc.) on the edges of certain wetlands, which can change fish habitats (Ibala, 2010) ; (ii) using phytosanitary insecticides and ichthyotoxic plants to poison rivers and catch fish, which has grown and become a concern (Debojit et al., 2025) ; (iii) using less-than-smart fishing gears and techniques (mosquito netting), which can lead to overfishing and the extinction of species (Micha, 2019 ; Micha, 2017) ; and (iv) introducing allochthonous species for enrichment purposes (Congo yasika: *Heterotis niloticus*), which may contribute to the elimination of other native species or alter the functioning of aquatic habitats, thus endangering natural biodiversity (Lévêque 1994; 1995a); (v) introducting foreign species (Congo yasika : *Heterotis niloticus*), whose effects can be harmful for the natural biodiversity (Lévêque 1994, 1995a ; Lazard & Lévêque, 2009) ; and (vi) the region's artisanal diamond and timber exploitation, slash-and-burn agriculture, and firewood (FONAREED- RDC, 2017). In the worst situation, these cause the complete disappearance of the forest, which degrades the watersheds and alters the water quality due to solid and liquid inputs (soluble chemicals) (Fanny, 2012; Piégay et al., 2022).

Due to the current pressures and threats that are impacting the aquatic habitats of the Inzia River and its tributaries, sampling campaigns are scheduled to inventory the fish that are currently inhabiting the basin. The overall aim of this study is to enhance the understanding of the fish fauna in the Inzia river basin by comparing it to that found elsewhere, and to work in conjunction with stakeholders to implement strategies for the sustainable management and exploitation of fishery resources. To this end, the study's specific objectives are to: (i) highlight the diversity of ichthyofauna, (ii) ascertain the relative abundance of species, and (iii) identify the environmental variables that influence the species distribution in the environment.

Material and methods

Study environment

This research was conducted in the watershed of the Inzia River (Figure 1), which is a tributary of the Kwilu River and a sub-tributary of the Kasai River. It lies between 3.74° and 7.39° south latitude and 17.29° and 18.39° east longitude. The basin is located in the Kwilu and Kwango provinces. It is bordered to the north by the Kwilu River basin, which flows into Bagata territory, to the south by the Wamba basin in Kasongo-Lunda territory, to the east by the Kwenge basin in Bulungu and Masi-manimba territories, and to the west by the Wamba and Kwilu basins in Kasongo-Lunda and Bagata territories (Menga, 2018; UNDP and UNOPS, 1998; Google Earth, 2023).

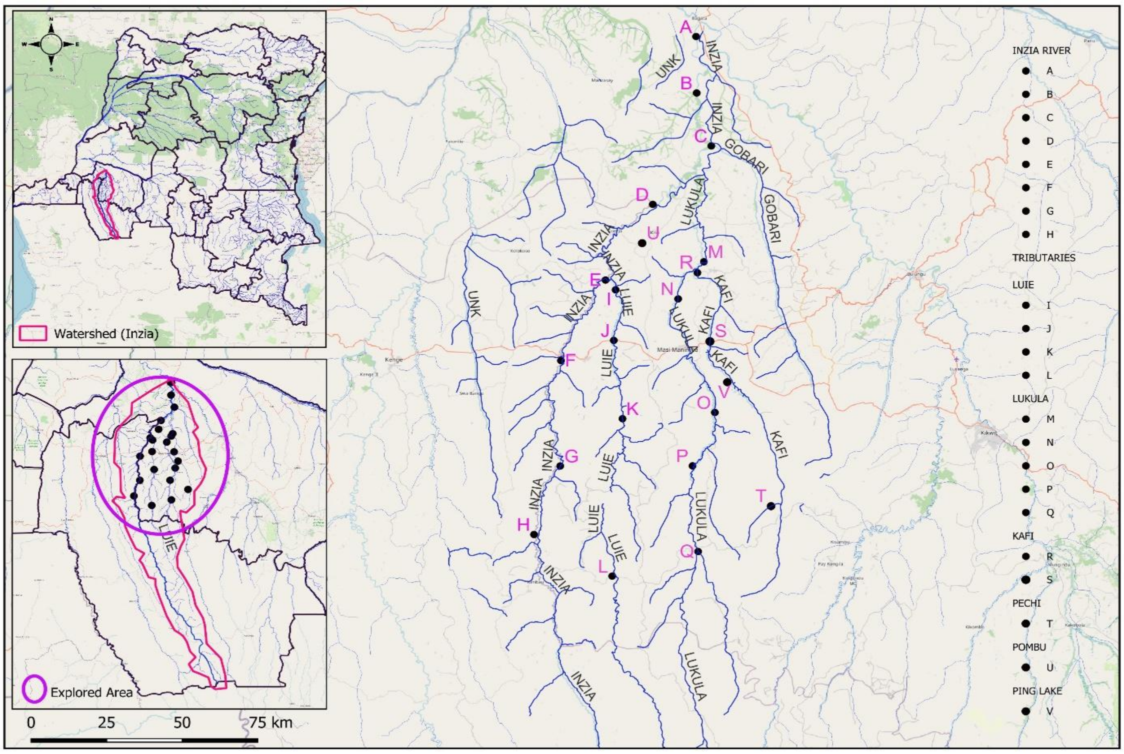

Figure 1. Map of sampling stations (A to V) in the Inzia basin hydrographic network

Fish inventories were performed along the Inzia River, from its mouth in the Kwilu River at Bagata, to the village of Kibwila, near the Moanza Protestant Mission, a distance of 182 Km as the crow flies (Google Earth, 2023). They were also made along the River Luie, from its confluence with the Inzia at the Dunda CKE oil mill, to the village of Kitona, upstream of the Lippens waterfall, in a distance of 104 Km. They were also performed, along the Lukula River, from Kimbi Nsayala, where it flows into the Inzia, to the confluence of Lukula 1 and 2, upstream of the Kingungi Catholic Mission, at a distance of 142 Km. The Kafi River was also explored from the Kimbili CKE oil mill, where it flows into the Lukula, to Kikiadi village in the Kibolo sector, where a sample was taken from the Pechi tributary upstream of the falls, a distance of 86.04 Km. Along the same river (Kafi), fish were also counted in Ping Lake, which is 1 km long and 81,804 m², or 8.18 ha in area. This small, linear natural lake is located in the village of Kiko, close to the Lumbi Catholic mission. Finally, a station was surveyed along the Pombu River, a small tributary of the Inzia, at its confluence with the Moshi River, close to the Kitoy sector chief town (Google Earth Engine, 2023).

Station selection and fish capture

Twenty-two (22) stations were selected and surveyed during the campaign from July 16 to September 02, 2022, following a watershed approach. The selection of these stations was based on the site accessibility; the typological diversity of habitats and the longitudinal profile (upstream and downstream parts of the river), according (Fig. 2). For each site, we first had to introduce ourselves to the local authorities, then contact the fishermen's organization to solicit one or two local fishermen, and finally carry out the fishing.

Various fishing tools and techniques were employed for an effort duration of 24 hours per station, i.e., 12 hours per day. These included 10 static nets with varying mesh sizes (10, 12, 15, 20, 25, 30, and 40 mm), each unit measuring 30 m in length and 1.50 m in height. We used the floating line fishing with hooks of sizes 6, 8, 12, 14, 16, 18, 20, and the scooping upstream of a tributary of the Inzia (Moshi River) at shallow depth (less than 60 cm) and low flow. Hawk fishing (15 and 20 mm mesh), and examination of local fishermen's catches were also applied (Ekyamba et al., 2023; Katemo et al., 2023).

The same fishing techniques were used at all sampled stations (Mahamba et al, 2018). At each station, the captured individuals were grouped and counted by fishing gear and dated (Wamuini, 2010; Ibala, 2010). Each identified and unidentified species was photographed (Figure 3) using a Nikon D3200 camera, and the vernacular name and geographical coordinates of the capture station determined using a Garmin 64x GPS were recorded (Table 1). The 10% of the catch was placed in small plastic fuses with a capacity of 30 liters, containing 10% formaldehyde and hermetically sealed for laboratory identification (Ngoy a Ngoy et al, 2017).

Ecological habitats characterization

From August to October 2024, a habitat characterization campaign was conducted at eight stations. These stations were selected based on their high catch abundance during the previous fishing campaign and the typological diversity of their habitats, as well as security considerations for researchers, given that some areas were experiencing political unrest. We assessed the bottom substrate at six different locations within each station and analyzed the substrate composition at the Pedology Laboratory of the Faculty of Agricultural Sciences at the University of Kinshasa. Water current velocity was measured using a timed floating float. Other environmental variables (Table 1) were measured using an Oyster 018180 multimeter, a pulse oximeter, an H22Px digital sonar, a Garmin 64x GPS, and a decameter. The banks were assessed based on the dominance or rarity of trees and grasses.

To assess the influence of these parameters on fish distribution, a standardized fishing method was also applied. Six static nets of 10, 12, 20, 25, and 30 mm mesh sizes, placed side by side, were used. The nets were set at 5 p.m., and fish harvesting began at 6 a.m. at all experimental stations.

Table 1. Variables measured from August to October 2024 at the ecological stations (B, D, E, H, J, N, O, and T) in the Inzia River basin. Mean ± standard deviation values. Repartition between gravel, sand, loam, clay, and dead leaves was expressed in relative abundance.

Parameters	Macurmbiem (B)	Misimbidi (D)	Dunda (E)	Kibwila (H)	Kiwawa (J)	Dondo (N)	Mukomo (O)	Pechi (T)
Width (m)	106.16 ± 5.77	82.76±4.78	68.57±5.19	52.6±3.36	30.5±3.61	29.33±5.78	22.66±2.26	7±0.89
Depth (m)	1.95±0.33	2.3±0.48	2.21±0.28	2.96±1.5	2.53±0.47	2.38±0.84	2.13±0.50	1.61±0.23
Distance from source (Km)	448	415	392	195	254	181	139	14
Elevation (m)	270±	271	348	371	374	368	403	662
Slope (m/Km)	0.4±0.08	0.6±0.14	0.8±0.12	1.3±0.11	0.8±0.7	0.7±0.10	0.9±0.10	19±0.13
Canopy height (m)	24.83±2.22	21.16±2.31	20.85±1.86	24.4±2.60	19.5±4.46	22.83±2.48	21±2.09	14±3.68
Canopy cover (%)	3.93±3.99	6,66±1,75	8.14±1.32	11±2.57	15.8±3.45	17.33±7.31	20.5±8.68	74.5±11.72
Water temperature (°C)	25.86±0.52	24.7±0.60	24.62±0.24	24.1±0.12	24.66±0.16	25.11±0.41	24.25±0.28	23.1±0.40
Oxygen (mg/l)	8.2±0.17	8.33±0.04	8.46±0.10	8.64±0.14	8.46±0.04	8.3±0.12	8.6±0.22	8.96±0.05
Ph	7.78±0.24	7.91±0.66	7.81±0.12	8.03±0.19	8.06±0.18	7.82±0.23	8.22±0.16	8.59±0.30
Water speed (m/s)	0.65±0.08	0.88±0.14	1.05±0.12	1.14±0.11	1.21±0.07	1.05±0.10	1.15±0.10	1.45±0.13
TDS (ppm)	2.18±0.27	2.23±0.36	1.98±0.09	1.81±0.01	1.62±0.03	1.88±0.02	1.65±0.01	14±006
Transparency (m)	0.77±0.02	0.79±0.06	0.72±0.03	0.84±0.01	0.81±0.04	0.74±0.01	0.84±0.01	087±003
Gravel	0	0	0	0.04	0.1	0	0	05
Sand	0.7	0.7	0.8	0.7	0.6	0.7	0.7	0.4
Loam	0	0	0	0.1	0.2	0.08	0.1	0.1
Clay	0.1	0.1	0.04	0.11	0.1	0.11	0.2	0
Dead leaves	0.2	0.2	0.16	0.09	0	0.11	0	0
Boulder (presence/absence)	0	0	0	1	1	0	1	1
Bank (tree/grass)	1	1	1	1	0	1	1	0

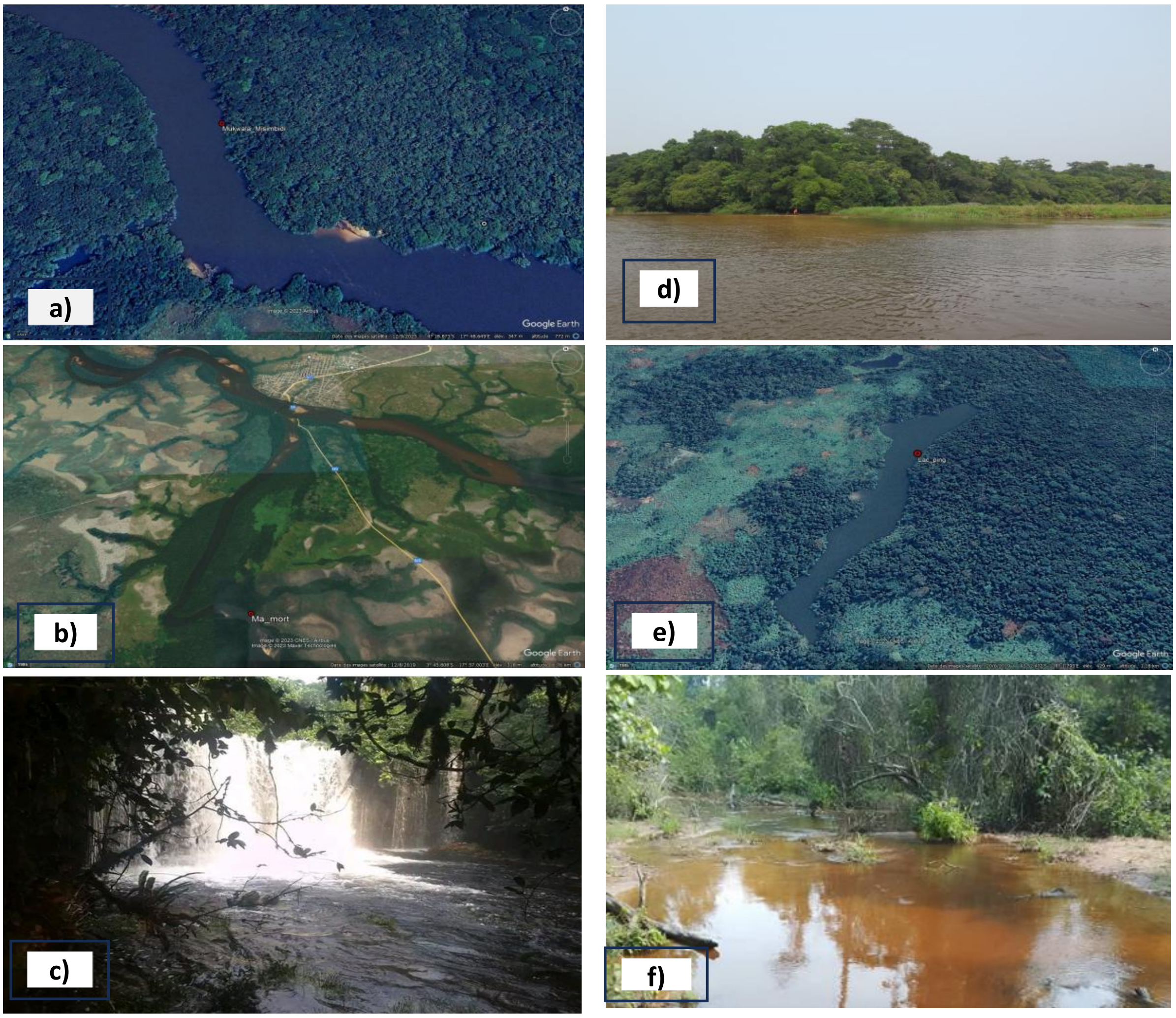

Figure 2. Typological diversity of habitats explored: a) river in dense forest and large swampy areas; b) river near a large urban area where the environment is degraded; c) river upstream and downstream of a waterfall or physical barrier; d) river in meadow-forest; e) lake environment; f) small, shallow river.

Specimen identification

Pre-identification was carried out in the field using the keys proposed by Poll and Gosse (1995). Identifications continued in the biology laboratory of the Mbanza-Ngungu Higher Pedagogical Institute from December 2022 to September 2023. The specimens were removed from formalin two hours before handling and placed in a freshwater tank. Identification was completed using identification cards by species, genus, and family, referring to the work of Boulenger (1909, 1911, and 1915), Poll (1967b and 1971), Paugy (1986), Tshibwabwa and Teugels (1995), Tshibwabwa (1997), Boden et al. (1997), Roberts (2003), Tshibwabwa et al. (2006), and Stiassny et al. (2007), Retzer (2010) and Ferraris et al. (2011). We also used the literature of Ibala (2010); Brooks et al. (2011) as well as that of Mbimbi (2013) to facilitate identifications. The validity of the species names used was checked using FishBase (2023). Fish sizes were taken using two calipers.

All difficult-to-identify individuals were preserved and a piece of right pelvic fin was collected for identification by DNA analysis at the Royal Museum for Central Africa in Tervuren (Belgium). The collected sample was numbered and stored in a small polyethylene tube filled with 98% ethanol. The tube number corresponded to that of the unidentified specimen (Wamuini, 2010; Louizi, 2019).

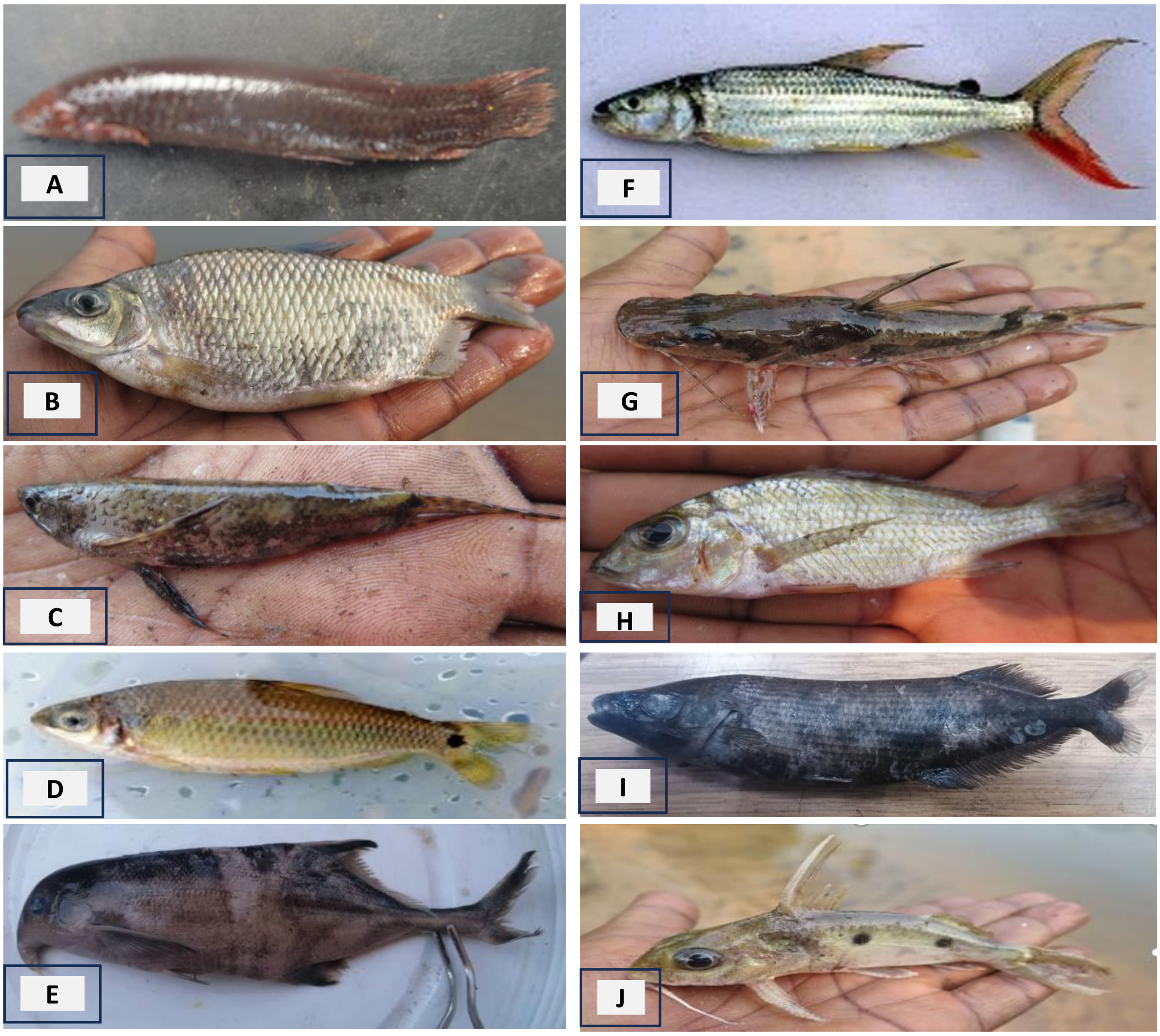

Figure 3. Some lesser-known species in the Inzia river basin: A. *Phractolaemus ansorgii* (Boulenger, 1901) ; B. *Distichodus affinis* (Günther, 1873) ; C.*Pantodon buchholzi* (Peters, 1876) ;D.*Distichodus decemmaculatus* (Pellegrin, 1926) ; E. *Campylomormyrus mirus* (Boulenger, 1898) ; F. *Hydrocynus vittatus (*Castelnau, 1861) ; G. *Chrysichthys ornatus* (Boulenger, 1902);H.*Tylochromis lateralis* (Boulenger, 1898) ;I.*Mormyrops nigricans* (Boulenger, 1899) ;J.*Synodontis congicus* (Poll, 1971).

Data analysis

Using the R.4.4.3 and Past 0.2 software, several diversity indices were calculated to characterize the fish population structure during the first sampling campaign in the Inzia basin:

(i) The relative abundance of a species in an ecosystem is given by the relationship: ni/N; ni: number of individuals of species i and N: total number of individuals harvested (Dajoz, 1996).

(ii) The specific richness (S) of a community is the simplest measure of diversity. It is expressed by the total number of species observed (in absolute value or per unit area or volume);

(iii) Simpson's diversity index represented by 1-D, with maximum diversity represented by the value 1, and minimum diversity by the value 0 (Kathryn Morris et al., 2014). D =Σ fi^2 Where: fi = ni/N; ni: number of individuals of the given species; N: total number of individuals;

(iv) The Shannon-Weaver index (H'), which is a measure of diversity that takes into account not only species richness, but also the proportion represented by each species within the community.

$$\mathrm{H}' = -\sum_{i=1}^{s} \left(\frac{ni}{N}\right) \ln \left(\frac{ni}{N}\right)$$

Where: (S) is the total number of species present; (ni) the number of species i in the sample and (N) the total number of species. H' varies between 0 (in the case where the stand consists of a single species) and H' maximum (H'max = log2.S) in the case where all species are present with equivalent abundance (Sisa et al., 2018; Ibala, 2010).

(v) JACCARD similarity index, which measures the degree of similarity between stands. Its formula is:

$$J = \frac{Nc}{Nx + Ny + Nc}$$

With Nc: number of taxa common to both stations; Nx and Ny: number of taxa present at stations x and y respectively. The JACCARD similarity index ranges from 0 to 1 (Dajoz, 1996; Ibala, 2010; Sisa et al, 2018).

(vi)Piélou equitability index: The Shannon index is rarely used alone. It is often accompanied by the Piélou equitability index, which measures the distribution of individuals within a species. This more rigorous parameter is very useful for comparing potential dominance between sites, as it is independent of species richness. It reflects the degree of diversity achieved by a stand and is calculated as follows:

$$J = \frac{H}{H_{max}}$$

The value of Piélou's equitability index (J) therefore varies between 0 and 1, where 0 corresponds to the dominance of one species and 1 to the equi-repartition of individuals between the different species. Where: ***H*** corresponds to the Shannon index; $\boldsymbol{H_{max}}$ corresponds to the value of maximum theoretical diversity ($\boldsymbol{log_b\ S}$); ***S*** is the species richness (Beisel at al., 2003). The influences of Environmental Variables-Stations-Species were analyzed using Canoco software for Windons 4.5 software, and the Adobe Photoshop 2024 software was used to plot the longitudinal distribution of species in the Inzia basin.

Results

Ichtyofauna diversity defined by orders, families, and species caught

In total, 17 187 fish were caught of which 92.3% (n= 15 861) individuals were captured by static nets, 4.0% (n = 695) by hawks, 1.7% (n = 293) by hooks, 1.7% (291) by scooped fish, and 0.3% (n = 47) found by local fishermen (Table 2). These results showed that 91 fish species identified belonged to 25 families and 12 orders. However, 7 adult specimens were unidentified. The relative abundance (Table 2) of fish families in the Inzia basin was dominated by Mormyridae (13.18%, with n = 12 species), followed by Alestidae (12.08%, n =11), Disichodontidae and Mochokidae (8.72%, n = 8 each one), and Cichlidae (7.62%; n = 5). Other captured families are less well represented. Based on the environmental variables collected, the presence of Mormyridae at the top of the captured fish families was likely due to the availability of lentic water areas rich in dead leaves in most of the habitats studied. In terms of fish resource orders, Siluriformes were in the lead with 27.47% of species, followed by Characiformes (23.07%), Osteoglossiformes (17.58%), Cypriniformes and Cichliformes (7.69% per order).

In terms of species caught, *Synodontis nigriventris* was the most abundant (13.14%), followed by *Rhabdalestes rhodesiensis* (10.11%), *Phenacogrammus interruptus* (9.53%), *Petrocephalus christyi* (8.20%), *Brycinus imberi* (7.29%), *Schilbe marmoratus* (6.58%), *Micralestes humilis* (5.28%), *Enteromius miolepis* (4.64%), *Brachypetersius altus* (2.83%) and *Clypeobarbus congicus* (1.71%). Other species are relatively poorly represented (Table ii).

This abundance was dominated by small species, reflecting the impact of anthropogenic pressure on the fishery resources in the area studied.

Table 2. Species identified by station. A to V were the fished stations.

N°	TAXON	STATIONS																						TOTAL	Relative Abundance
		Inzia river								Luie				Lukula					Kafi		Pechi	Pombu	Ping Lake		
		A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V		
	CERATODONTIFORMES																								
	Protopteridae (1)																								
01	*Protopterus dolloi* Boulenger, 1900	0	0	0	3	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	5	0,029092
	POLYPTERIFORMES																								
	Polypteridae (2)																								
02	*Polypterus ornatipinnis* Boulenger, 1902	1	0	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0,023273
03	*Polypterus palmas* Ayres, 1850	0	1	4	6	3	0	1	0	2	1	0	0	3	0	1	0	0	3	0	0	0	0	25	0,145459
	OSTEOGLOSSIFORMES																								
	Pantodontidae (1)																								
04	*Pantodon buchholzi* Peters, 1876	3	9	32	43	26	4	7	1	0	3	0	1	4	2	0	0	0	5	0	0	0	0	140	0,814569
	Notopteridae (2)																								
05	*Papyrocranus congoensis* (Nichols & La Monte, 1932)	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0,017455
06	*Xenomystus nigri* (Günther, 1868)	3	17	21	32	24	5	7	0	13	1	1	0	1	13	1	7	0	6	0	0	0	16	168	0,0977483
	Mormyridae (12)																								
07	*Campylomormyrus mirus* (Boulenger, 1898)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	2	0,011637
08	*Cyphomyrus cf psittacus* (Boulenger , 1897)	0	1	6	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	11	0,064002
09	*Gnathonemus petersii* (Günther, 1862)	4	6	19	21	26	3	5	11	8	0	0	0	0	7	1	0	0	1	0	0	13	11	136	0,791296
10	*Marcusenius greshoffii* (Schilthuis, 1891)	0	0	0	6	4	0	0	0	2	0	0	0	0	0	0	0	0	9	0	0	0	0	21	0,122185
11	*Marcusenius fuscus* (Pellegrin, 1901)	0	5	42	9	11	0	8	0	29	0	0	1	0	6	3	0	2	0	1	2	4	0	123	0,715657
12	*Marcusenius moorii* (Günther, 1867)	4	0	16	19	22	0	9	0	11	6	1	0	9	7	7	0	2	0	0	3	0	0	116	0,674929
13	*Marcusenius monteiri* (Günther,1873)	0	2	0	7	6	1	0	0	0	0	0	4	4	0	0	0	2	4	0	0	0	0	30	0,174551
14	*Mormyrops nigricans* Boulenger, 1899	2	2	5	5	3	3	0	0	0	2	4	0	0	0	0	0	0	0	1	0	0	0	27	0,157095
15	*Mormyrops sirenoides* Boulenger, 1898	4	0	3	2	0	3	0	0	4	0	0	0	0	1	0	0	0	2	0	0	0	0	19	0,110549
16	*Mormyrus caballus* Boulenger, 1898	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0,011637
17	*Petrocephalus christyi* Boulenger, 1920	156	109	82	421	317	47	22	6	61	11	46	4	11	39	18	3	36	19	2	0	0	0	1410	8,203875
18	*Stomatorhinus microps* Boulenger, 1898	3	21	24	5	19	0	5	0	0	4	0	0	0	0	0	0	0	2	0	0	0	0	83	0,482923
	Arapaimidae (1)																								
19	*Heterotis niloticus* (Cuvier, 1829)	0	0	0	3	0	0	0	0	6	0	0	0	0	0	0	0	0	0	0	6	0	0	15	0,087275
	CLUPEIFORMES																								
	Dorosomatidae (1)																								
20	*Pellonula leonensis* Boulenger, 1916	0	9	0	6	4	0	1	0	5	0	0	0	0	4	0	0	0	0	0	0	0	0	29	0,168732
	GONORYNCHIFORMES																								
	Phractolaemidae (1)																								
21	*Phractolaemus ansorgii* Boulenger, 1901	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0,011637
	CYPRINIFORMES																								
	Cyprinidae (5)																								
22	*Clypeobarbus congicus* (Boulenger, 1899)	16	31	68	72	61	11	0	0	29	0	0	0	0	1	2	0	0	4	0	0	0	0	295	1,716414
23	*Clypeobarbus matthesi* (Poll & Gosse, 1963)	6	18	0	19	24	6	0	3	0	0	0	0	5	13	4	6	8	1	0	0	0	0	113	0,657474
24	*Enteromius chiumbeensis* (Pellegrin, 1936)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	38	0	38	0,221097

25	*Enteromius miolepis* (Boulenger, 1902)	16	31	189	231	162	26	36	13	64	29	0	0	2	0	0	0	0	0	0	0	0	0	799	4,648863
26	*Labeo lineatus* Boulenger, 1898	0	2	0	3	5	0	1	2	3	0	0	0	11	9	0	0	0	1	3	0	0	0	40	0,232734
	Danionidae (2)																								
27	*Leptocypris lujae* (Boulenger, 1909)	0	3	1	5	1	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	12	0,06982
28	*Raiamas christyi* (Boulenger, 1920)	9	19	31	28	23	4	0	0	0	0	7	3	6	14	1	0	0	5	2	6	59	0	217	1,262582
	CHARACIFORMES																								
	Distichodontidae (8)																								
29	*Distichodus affinis* Günther, 1873	0	5	11	9	6	2	5	2	3	0	4	0	0	0	0	9	0	0	0	0	0	0	56	0,325828
30	*Distichodus decemmaculatus* Pellegrin, 1926	0	3	17	11	8	0	0	2	3	1	3	0	0	0	0	1	4	0	0	0	0	0	53	0,308373
31	*Distichodus fasciolatus* Boulenger, 1898	2	0	15	8	0	0	0	1	0	0	0	0	0	0	3	0	0	0	1	0	0	0	30	0,174551
32	*Distichodus notospilus* Günther, 1867	2	8		42	5	0	4	0	3	5	4	0	0	6	2	4	0	0	0	0	0	0	85	0,49456
33	*Distichodus sexfasciatus* Boulenger, 1897	0	4	6	2	11	0	4	0	7	2	0	0	0	0	0	0	0	0	0	0	0	0	36	0,209461
34	*Eugnathichthys macroterolepis* Boulenger, 1899	4	11	10	18	13	4	0	0	8	0	6	0	4	9	5	0	1	0	1	0	0	0	94	0,546925
35	*Neolebias trilineatus* Boulenger, 1899	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0,017455
36	*Phago boulengeri* Schilthuis, 1891	12	7	2	16	11	3	0	0	10	0	0	0	4	9	0	5	3	2	4	0	0	0	88	0,512015
	Citharinidae (1)																								
37	*Citharinus gibbosus* Boulenger, 1899	2	11	17	29	24	0	13	0	0	0	6	0	0	4	2	0	1	3	0	0	0	0	112	0,651655
	Alestidae (11)																								
38	*Alestes liebrechtsii* Boulenger, 1898	2	9	0	18	13	0	0	0	0	0	9	0	6	46	59	122	0	2	3	0	0	0	289	1,681503
39	*Brachypetersius altus* (Boulenger, 1899)	9	47	74	96	109	0	16	0	0	7	13	0	0	39	15	0	59	3	0	0	0	0	487	2,833537
40	*Brycinus imberi* (Peters, 1852)	33	104	198	152	183	69	104	55	78	31	0	0	109	49	28	21	8	0	32	0	0	0	1254	7,296212
41	*Brycinus grandisquamis* (Boulenger, 1899)	0	0	12	0	17	0	0	0	15	10	0	0	34	11	0	0	0	0	0	0	0	0	99	0,576017
42	*Brycinus macrolepidotus* Valenciennes, 1850	3	0	7	13	9	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	37	0,215279
43	*Bryconaethiops boulengeri* Pellegrin, 1900	0	13	7	0	12	0	6	0	2	4	6	0	0	0	2	0	1	2	0	4	9	0	68	0,395848
44	*Bryconaethiops microstoma* Günther, 1873	0	9	18	0	0	0	0	0	9	0	0	0	0	0	7	0	0	0	0	0	0	0	43	0,250189
45	*Hydrocynus vittatus* Castelnau, 1861	3	0	16	11	0	2	6	0	0	0	0	0	0	0	9	4	0	11	0	0	0	0	62	0,360738
46	*Micralestes humilis* Boulenger, 1899	17	54	109	142	164	0	22	17	0	0	10	0	0	216	38	0	30	87	3	0	0	0	909	5,288881
47	*Phenacogrammus interruptus* (Boulenger, 1899)	24	103	261	264	233	19	64	16	49	0	37	0	31	134	92	171	39	1	0	0	0	0	1638	9,530459
48	*Rhabdalestes rhodesiensis* (Ricardo-Bertram, 1943)	42	267	307	543	219	0	58	0	19	36	39	0	29	117	38	13	3	6	2	0	0	0	1738	10,11229
	***Hepsetidae* (1)**																								
49	*Hepsetus microlepis* (Boulenger, 1901)	0	10	9	7	57	0	3	0	19	2	3	0	5	15	7	2	0	0	0	0	0	0	139	0,808751
	SILURIFORMES																								
	Amphilidae (3)																								
50	*Trachyglanis cf ineac* (Poll, 1954)	0	0	0	0	0	0	0	0	0	0	0	7	0	0	0	0	0	0	0	0	0	0	7	0,040728
51	*Doumea typica* Sauvage, 1879	0	9	0	16	17	3	5	7	4	5	4	0	0	3	0	0	0	0	0	0	0	0	73	0,42474
52	*Belonoglanis tenuis* Boulenger, 1902	6	0	2	0	9	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	21	0,122185
	Malapteruridae (2)																								
53	*Malapterurus electricus* (Gmelin, 1789)	0	1	3	0	2	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	8	0,046547
54	*Malapterurus monsembeensis* Roberts, 2000	1	0	0	3	0	0	0	0	2	1	0	0	0	0	0	0	0	0	0	0	0	0	7	0,040728
	Mochokidae (8)																								
55	*Synodontis congicus* Poll, 1971	0	4	6	5	7	3	4	9	5	0	8	0	0	7	6	4	6	3	0	0	0	0	77	0,448013
56	*Synodontis contractus* Vinciguerra, 1928	27	96	154	132	121	0	23	4	37	28	0	0	18	11	0	2	9	36	0	0	0	0	698	4,061209
57	*Synodontis greshoffi* Schilthuis, 1891	0	0	0	2	0	0	0	9	0	0	3	0	4	0	1	3	1	0	0	0	0	0	23	0,133822
58	*Synodontis flavitaeniatus* Boulenger, 1919	0	0	2	0	3	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10	0,058184
59	*Synodontis nigriventris* David, 1936	36	70	392	693	607	0	61	52	10	0	93	0	16	124	5	26	53	21	0	0	0	0	2259	13,14366
60	*Synodontis pleurops* Boulenger, 1897	0	0	0	0	0	0	0	3	0	0	2	0	0	4	0	0	0	0	0	0	0	0	9	0,052365

61	*Synodontis schoutedeni* David, 1936	0	0	0	1	0	0	0	2	0	0	3	0	0	0	0	0	0	0	0	0	0	0	6	0,03491
62	*Synodontis vaillanti* Boulenger, 1897	0	3	6	5	3	2	0	4	3	4	0	0	0	0	0	2	0	0	0	0	0	0	32	0,186187
	Schilbeidae (3)																								
63	*Schilbe grenfelli* (Boulenger, 1900)	2	7	6	11	9	0	0	2	7	6	1	0	4	0	6	0	0	9	0	0	0	0	70	0,407285
64	*Schilbe marmoratus* Boulenger, 1911	58	287	106	111	253	7	47	24	0	64	30	0	19	72	23	20	5	6	0	0	0	0	1132	6,586373
65	*Pareutropius debauwi* (Boulenger, 1900)	0	2	7	13	0	0	3	0	0	0	11	0	24	0	9	4	122	0	1	0	0	0	169	1,140397
	Claroteidae (4)																								
66	*Auchenoglanis occidentalis* (Valenciennes, 1840)	0	0	2	0	0	5	3	5	1	0	0	0	0	0	0	0	0	0	0	0	0	0	16	0,093094
67	*Chrysichthys ornatus* Boulenger, 1902	3	4	9	0	7	0	0	2	3	0	0	0	6	4	2	2	0	0	0	0	0	0	42	0,244371
68	*Chrysichthys habereri* Steindachner, 1912	2	1	3	2	1	0	0	8	5	0	0	0	0	4	4	0	0	0	0	0	0	0	30	0,174551
69	*Chrysichthys punctatus* Boulenger, 1899	0	1	0	3	0	0	2	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0	10	0,058184
	Clariidae (5)																								
70	*Channallabes apus* (Günther, 1873)	0	0	2	6	0	0	0	0	0	0	0	0	3	5	0	0	0	0	0	3	0	0	19	0,110549
71	*Clarias camerunensis* Lönnberg, 1895	0	6	4	9	3	0	0	0	0	8	14	0	0	0	0	0	0	0	0	8	14	0	66	0,384011
72	*Clarias gabonensis* Günther, 1867	4	3	9	17	13	0	3	0	4	3	6	0	2	0	0	0	0	3	0	3	6	0	16	0,442195
73	*Parauchenoglanis balayi* (Sauvage, 1879)	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7	13	0	15	0,0877275
74	*Parauchenoglanis punctatus* (Boulenger, 1902)	0	6	5	7	9	4	3	3	2	0	0	0	0	3	0	3	0	0	0	24	17	0	88	0,512015
	CICHLIFORMES																								
	Cichlidae (7)																								
75	*Coptodon tholloni* (Sauvage, 1884)	3	7	13	19	17	0	9	2	6	8	11	19	0	6	3	6	0	4	0	8	11	19	171	0,994938
76	*Hemichromis elongatus* (Guichenot, 1861)	1	9	9	11	8	2	5	0	0	3	9	17	3	6	2	1	0	2	0	3	9	17	117	0,680747
77	*Lamprologus congoensis* Schilthuis, 1891	0	2	11	9	0	0	7	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	32	0,186187
78	*Oreochromis niloticus* (Linnaeus, 1758)	4	0	0	6	8	0	13	6	1	0	5	0	0	5	2	0	0	5	11	0	5	14	85	0,49456
79	*Rubricatochromis stellifer* (Loiselle, 1979)	7	13	9	14	18	5	9	0	1	4	19	38	1	17	0	0	0	4	0	38	4	19	220	1,280037
80	*Tylochromis lateralis* (Boulenger, 1898)	3	3	6	4	9	3	0	0	5	7	0	0	4	0	0	0	0	0	11	7	0	22	84	0,488741
81	*Tylochromis variabilis* Stiassny, 1989	0	0	0	0	0	0	4	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6	0,03491
	SYNBRANCHIFORMES																								
	Mastacembelidae (2)																								
82	*Mastacembelus congicus* Boulenger, 1896	0	4	6	3	7	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	25	0,145459
83	*Mastacembelus niger* Sauvage, 1879	0	2	5	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	7	0,040728
	ANABANTIFORMES																								
	Anabantidae (4)																								
84	*Ctenopoma ocellatum* Pellegrin, 1899	2	36	8	17	6	0	0	3	5	0	4	0	1	0	4	2	0	0	3	0	4	7	102	0,593472
85	*Ctenopoma gabonense* Günther, 1896	0	4	0	7	3	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	15	0,087275
86	*Ctenopoma nigropannosum* Reichenow, 1875	2	5	7	0	4	3	0	0	5	0	0	0	0	6	2	0	0	0	0	0	0	0	34	0,197824
87	*Ctenopoma weeksii* Boulenger, 1896	0	9	7	5	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	24	0,13964
	***Channidae* (2)**																								
88	*Parachanna insignis* (Sauvage, 1884)	1	3	7	4	4	0	2	0	3	1	0	0	0	5	0	1	0	2	0	0	2	0	35	0,203642
89	*Parachanna obscura* (Günther, 1861)	0	5	1	0	0	2	0	1	0	0	0	0	2	0	0	0	0	0	0	0	0	0	11	0,064002
	TETRAODONTIFORMES																								
	Tetraodontidae (2)																								
90	*Tetraodon miurus* Boulenger, 1902	4	2	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7	0,040728
91	*Tetraodon mbu* Boulenger, 1899	1	3	2	1	0	2	0	0	4	0	1	0	0	2	0	0	0	1	0	0	0	0	17	0,098912
																								17.187	100

Calculated biodiversity indexes

Based on the biodiversity index calculations from the ichthyofauna diversity matrix of 22 stations in the study basin, the Shannon index showed high diversity (3.20) at station I (Teba), followed by C (3.04 at Kimbi nsayala), and G (3.01 at Port Ipaki). Regarding the Piélou Index, a species dominance of 0.60 was observed at station P (Mbanzamwanga), 0.67 at D (Misimbidi-Mukwala), 0.71 at E (Dunda), 0.72 at B (Port Macurmbiem) and 0.75 at N (Dondo) (Fig. 4). In terms of Simpson's index, the most abundant species were clearly observed at station I (0.93), G (0.92), and E, B and K (0.91). However, the difference was less between several other stations. Specific richness, on the other hand, was higher at stations D (70), B (66), C (64), E (62), I (49) and N (44), which corroborated with the result of Principal Component Analysis (PCA) derived from the station-species matrix. The Jaccard Similarity Index expressed by the Cluster dendrogram (Fig. 5) revealed 4 groups of fish populations in the Inzia basin. The first was made up of species present at station D, the second included those of two stations, C and E, the third included 17 stations (O, P, U, S, V, L, T, J, M, F, H, G, I, A, Q, K and R). The last one included the species from stations B and N.

Although located downstream of the main river Inzia, which was on average 106.6 m wide, the presence of swamps and the outlets of two other rivers (Lwale in the Mansasayi sector and Ebwi in Kwilu Ntobere), on averaging 10 m wide and 2 m deep, give some sites at Station B characteristics similar to those at Station N (tributary streams, swamps, etc.).

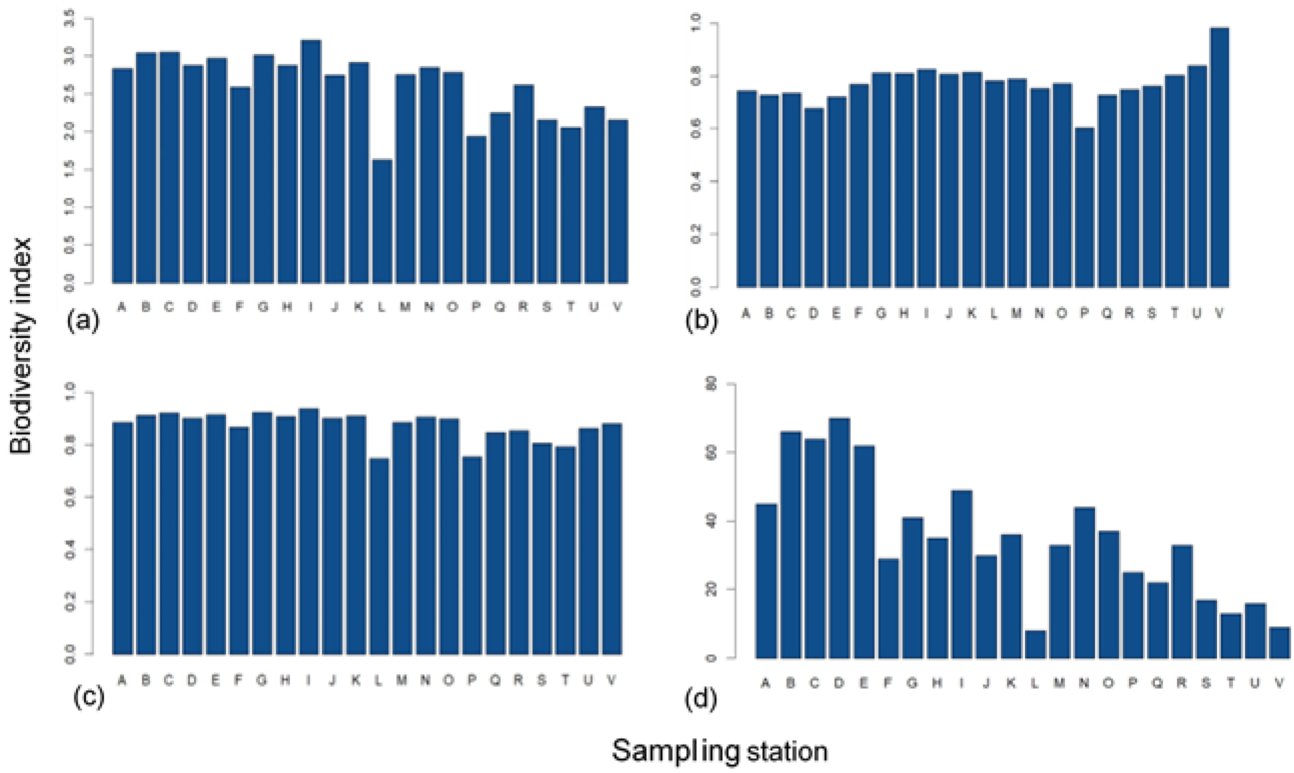

Figure 4. Biodiversity indices calculated for the 22 sampled stations (A to V): (a)Shannon's diversity index, (b) Piélou's equitability index, (c) Simpson's diversity index, and (d) Taxa (S).

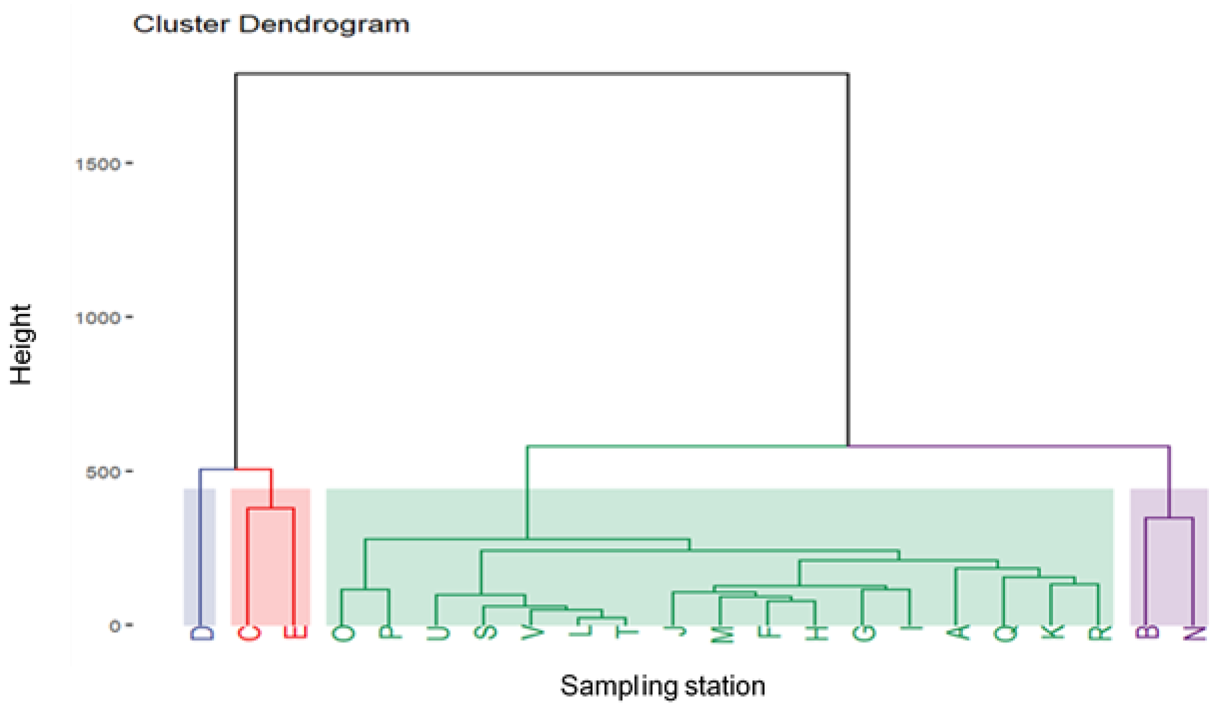

Figure 5. Jaccard Similarity Level between the sampled stations (A to V). The first community in blue is represented by fish from station D, the second in red groups stations C and E, the third in green has 17 stations (O, P, U, S, V, L, T, J, M, F, H, G, I, A, Q, K and R), and the last community in purple) by stations B and N.

Influences of environmental variables on the ichthyofauna distribution

The Principal Component Analysis (PCA) derived from the station-species matrix (Fig. 6a) revealed a species similarity of 70.1% on axis 1 in four stations (D, followed by B, E, and N). The species *Hemichromis elongatus*, *Marcusenius monteiri, Parachanna insignis, Pantodon buchholzi*, *Cyphomyrus psittacus*, *Mormyrops nigricans*, *Synodontis contractus*, *Enteromius miolepis*, *Raiamas christyi*, *Phago boulengeri*, *Eugnathichthys macroterolepis*, *Rubricatochromis stellifer*, *Marcusenius moorii*, *Clypeobarbus congicus*, *Citharinus gibbosus*, *Xenomystus nigri*, *Ctenopoma ocellatum*, *Labeo lineatus,* and *Distichodus decemmaculatus* were more present in the first three stations located in the Inzia river. In contrast, *Synodontis congicus*, *Synodontis vaillanti*, *Oreochromis niloticus*, *Distichodus affinis*, *Brycinus grandisquamis*, *Chrysichthys ornatus*, Brachypetersius altus, *Synodontis nigriventris*, *Phenacogrammus interruptus*, *Brycinus imberi*, *Schilbe grenfelli*, *Rhabdalestes rhodesiensis*, *Schilbe marmoratus* and *Micralestes humilis* exerted more influence on the last station of the

Lukula River (Test of significance of first canonical axis: eigenvalue = 0.183, F-ratio = 0.000, P-value = 1.0000).

The PCA from the station-environmental variable matrix (Fig. 6b) showed 84.7% convergence on axis 1 for the same stations. Canopy height, distance from source, percentage of sandy substrate, water temperature, station width, bank constitution, TDS and proportion of dead leaves would explain this convergence, as also revealed by the overall similarity of 71.1% observed in terms of ichthyofauna diversity in these biotopes. Canonical redundancy analysis (CRA) also confirmed that the main environmental variables influencing up to 70.1% (Fig. 6c) of species distribution at the different stations in the Inzia basin were indeed those mentioned above. Finally, the analysis of significant environmental variables - Species (Fig. 6d) revealed three determining variables for species distribution in the first four stations rich in fish diversity, which included TDS, sandy substrate and canopy height. Canonical redundancy analysis (CRA) also confirmed that the main environmental variables influencing up to 70.1% (Fig. 6c) of species distribution at the different stations in the Inzia basin were indeed those mentioned above. Finally, the analysis of significant environmental variables - Species (Fig. 6d) revealed three determining variables for species distribution in the first four stations rich in fish diversity, which included TDS, sandy substrate and canopy height.

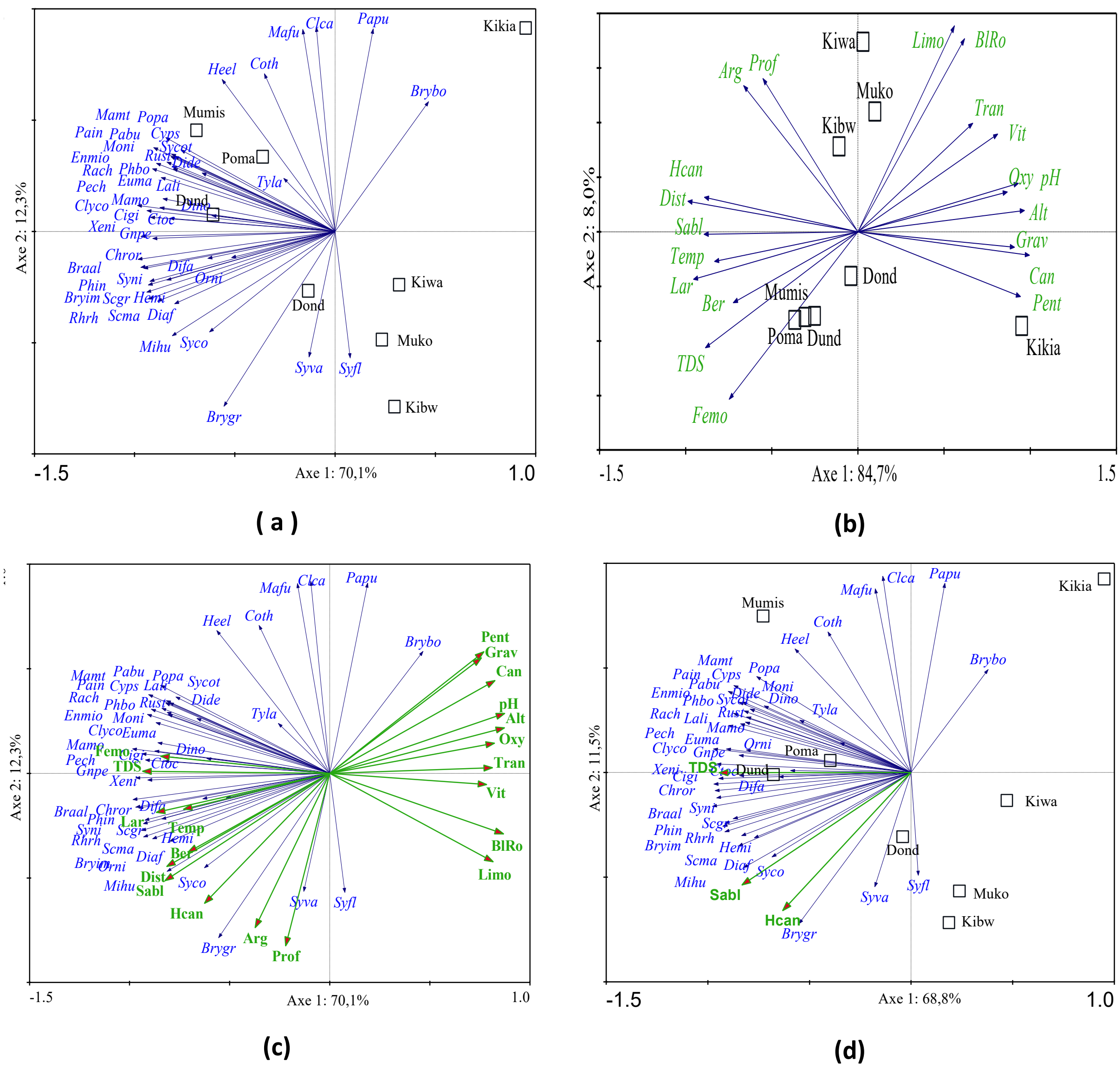

Figure 6. Analysis of the influence of environmental variables on the species distribution within the Inzia basin: (a) Principal Component Analysis (PCA) Stations - Species; (b) PCA Stations - Environmental variables; (c) Canonical Redundancy Analysis (RCA) Environmental variables - Species; (d) RCA Significant environmental variables – Species. Stations were Poma (Port Macurmbien - B), Mumis (Misimbidi - D), Dund (Dunda - E), Kibw (Kibwila - T), Kiwa (Kiwawa - J), Dond (Dondo - N), Muko (Mukomo - O) and Kikia (Pechi Kikiadi - T) ; Species were: Popa (*Polypterus palmas*), Pabu (*Pantodon buchholzi*), Xeni (*Xenomystus nigri*), Cyps (*Cyphomyrus psittacus*), Gnpe (*Gnathonemus petersii*), Mafu (*Marcusenius fuscus*), Mamo (*Marcusenius moorii*), Mamt (*Marcusenius monteiri*), Moni (*Mormyrops nigricans*), Pech (*Petrocephalus christyi*), Clyco (*Clypeobarbus congicus*), Enmio (*Enteromius miolepis*), Lali (*Labeo lineatus*), Rach. (*Raiamas christyi*), Diaf. (*Distichodus affinis*), Dide. (*Distichodus decemmaculatus*), Difa (*Distichodus fasciolatus*), Dino (*Distichodus notospilus*), Euma (*Eugnathichthys macroterolepis*), Phbo (*Phago boulengeri*), Cigi (*Citharinus gibbosus*), Braal. (*Brachypetersius altus*), Bryim. (*Brycinus imberi*), Brygr. (*Brycinus grandisquamis*), Brybo. (*Bryconaethiops boulengeri*), Mihu. (*Micralestes humilis*), Phin. (*Phenacogrammus interruptus*), Rhrh. (*Rhabdalestes rhodesiensis*), Hemi. (*Hepsetus microlepis*), Syco. (*Synodontis congicus*), Sycot. (*Synodontis contractus*), Syfl. (*Synodontis flavitaeniatus*), Syni. (*Synodontis nigriventris*), Syva. (*Synodontis vaillanti*), Scgr. (*Schilbe grenfelli*), Scma. (*Schilbe marmoratus*), Chror. (*Chrysichthys ornatus*), Clca. (*Clarias camerunensis*), Papu.

Parauchenoglanis punctatus), Coth. (*Coptodon tholloni*), Heel. (*Hemichromis elongatus*), Orni. (*Oreochromis niloticus*), Rust. (*Rubricatochromis stellifer*), Tyla. (*Tylochromis lateralis*), Ctoc. (*Ctenopoma ocellatum*, and Pain. (*Parachanna insignis*); Environmental variables were: Lar. (Width, in m), Prof (Depth, m), Dist. (Distance from source, Km), Alt (Elevation, m), Pent. (Slope, m/Km), Hcan. (Canopy height, m), Can. (Canopy cover, %, Temp. (water temperature, °C), Oxy. (Oxygen, mg/l), pH, Vit. (Water speed, m/s), TDS. (Dissolved Subsistency Rate, ppm), Tran. (Transparency, m). Substratum: Grav. (Gravel), Sabl. (Sand), Limo. (Loam), Arg. (Clay), Femo. (Dead leaves), BlRo. (Boulder, presence/absence) and Ber. (Bank, tree/grass) (in relative abundance). (Percentages of species, environmental variables and station representation on the first two axes).

Discussion

Thanks to systematic sampling of fish resources and environmental variable study performed in 8 different rivers, using the analysis of biodiversity indices and environmental variables, we were able to assess fish biodiversity and determine the environmental variables influencing species dispersal. This study significantly contributed to the first knowledge's of the ichthyofauna diversity of the Inzia watershed, as well as the parameters influencing fish distribution in the different habitats of the studied environment.

In a single fish inventory carried out in 2022, our study identified in the Inzia basin an ichthyofauna composed of 91 species belonging to 57genera, 25 families and 12 orders. In other tropical aquatic ecosystems in the DRC, particularly in the Inkisi River, Wamuini et al. (2010) observed and identified in two sampling campaigns 61 species grouped into 37 genera belonging to 15 families.

Katemo et al. (2023) studied the fish diversity in the Upemba National Park (PNU) in the DRC, and counted 248 species, 78 genera belonging to 26 families and 15 orders, during two fish inventory campaigns. Ekyamba et al. (2023) observed an ichthyofauna composed of 129 species, 54 genera belonging to 20 families and 8 orders, in Lomami National Park (LNP) in the DRC. Mbimbi and Stiassny (2011) studied the fish diversity of the Kwilu River, the outlet of the Inzia, and identified 113 species, 45 genera grouped within 21 families. Monsembula et al. (2013) reported after two fish inventory campaigns a ichthyofauna diversity in the N'sele River located in the Malebo Pool in the DRC a ichthyofauna diversity composed of 148 species, 64 genera belonging to 27 families.

The number of species, genera, families and orders observed varying between tropical aquatic ecosystems in the DRC would be attributed to the difference in the habitats studied, the types and selectivity of capture gear and the fishing season. The results of our study were carried out in a dry season using gear and capture methods that would be selective. This could mean that the number of fish and species could be higher than the reported values. It should also be noted that the Inzia basin does not have protected areas like in the PNU and PNL parks, and is therefore the subject of intense human activities.

Our results also show that some species are more present at certain stations than at others, and that TDS, sandy substrate and canopy height are the determining environmental variables in the distribution of these fish species in the Inzia River and its tributaries. Furthermore, Wamuini et al. (2010) mentioned above, revealed that species distribution varied from station to station, and that grassy banks, the presence of large boulders, station width and the presence of plant debris seemed to influence species distribution in the study environment. These results are similar to our own, the slightest differences being linked to the choice of ecological stations, which in our environment are essentially located in forested areas, and above all, Inzia superior was not sampled.

Ward et al. (1999) have shown that many fish species, although not highly migratory, move between different units of the hydrosystem, and occupy different habitats at different stages of their life cycle. The establishment and development of fish populations and populations in large rivers are conditioned by the diversity of environments offered by the hydrosystem and, above all, by the accessibility of these environments to fish. This is consistent with the results of our research, which found 4 groups of fish populations populating the environment under study: (i) species present at station D, (ii) those at stations C and E, (iii) species at stations O, P, U, S, V, L, T, J, M, F, H, G, I, A, Q, K and R; and (iv) those at stations B and N. The presence of the first stand (station D) can be explained by the location of its habitat in the least disturbed forest environment, close to large marshy areas. The second is due to habitats located in transition zones between undisturbed and disturbed forest environments, at the junction of large rivers (Inzia-Luie, Inzia-Lukula). The particularity of the last locality (B, N) may be linked to certain habitat similarities, associated with anthropogenic pressure at B (influence of an active port as well as several fishing camps in the town of Bagata and surrounding villages). According to our knowledge of the terrain, the presence of station N near to B is due to the stagnant arms of the river, as well as the presence of swamps located from the Makala tributary up to its confluence with the Lukula on the left bank, and those located towards Kikongo on the right bank, which give limnophilic species the possibility of proliferating easily alongside the rheophilic species of the main watercourse.

The concept of the river continuum is an important milestone in river ecology, as it allows a comprehensive assessment of the structure and function of lotic ecosystems. This theory, which links physical and geomorphological attributes of streams to biodiversity patterns, functional traits and metabolic dynamics, describes downstream and upstream gradients in community composition and ecosystem processes (Doretto et al., 2020). Along the Inzia basin (Fig. 7), the middle course contains 76 species, 53 of which are perceptible at altitudes ranging from 363 to 449 m and at an interval of 138 to 190 Km as the crow flies from the basin's confluence with the Kwilu River. Sixteen species are present at altitudes between 541 and 662 m and between 190 and 220 Km from the Inzia River outlet, beyond the falls (Lipens and Pechi).

This reduction in the number of species upstream of the waterfalls also reflects the influence of physical barriers on fish distribution in our studied environment, which could favour genetic differentiation due to altitude. This would be amplified by the presence of different barriers that reduce or block the upstream dispersal of fish species (Boizard, 2008; Fanny Arnaud, 2012; Piégay et al., 2022).

According to Katemo et al. (2023), the role of waterfalls and rapids as barriers to upstream fish dispersal and isolation of fish has already been observed in the DRC in the Luanza River basin (a left-bank sub-tributary of the Middle Luapula River in the Upper Congo basin). The Kundelungu Plateau (1310-1690 m altitude) and the mountainous areas (995-1300 m altitude) are endemic zones, colonized by a poor ichthyofauna composed of torrential species. The number of species increases considerably in the lowlands (975-995 m altitude). In these lands, the highland ichthyofauna is replaced by that characteristic of the lowland ichthyofauna.

Dispersal barriers are therefore a component of connectivity that may be a more important determinant of fish species dispersal than the distance by waterway between two rivers (Poissant et al., 2005). Their influence on species dispersal and migration is reflected both in the specific composition of communities and the genetic structure of populations. The presence of certain fish species in watercourses is more dependent on the presence or absence of barriers than on the presence of favourable habitat (Spens et al. 2007).

Dispersal barriers will generally not prevent the downstream dispersal of individuals (Adams et al. 2001), but they will isolate upstream populations from the influx of migrants from the network downstream of the barriers (Knaepkens et al., 2004; Crispo et al., 2006). Gene flow will become unidirectional, from upstream to downstream. This isolation will lead to greater differentiation of populations upstream of impassable barriers, and often to a reduction in their genetic diversity compared with other populations in the river system (Taylor et al., 2003; Habicht et al., 2004; Knaepkens et al., 2004; Poissant et al., 2005). The role of barriers is therefore crucial in the study of fish species dispersal.

The results of this research show, in particular, that of the 89 species identified in Inzia inferior , only 53 are present in the three stations (F, J, S) located along National Route 1. According to Lévêque and Paugy (2006a), the consequences of human activities, amplified today by population growth and ever-increasing pressure on natural resources, are endangering fish fauna almost everywhere in the world. Africa, which has long been spared, is now suffering these impacts. These comments corroborate with our results, which show the anthropogenic pressure linked to the significant human traffic along this route N°1 negatively impacted on the diversity of ichthyofauna un the Inzia basin.

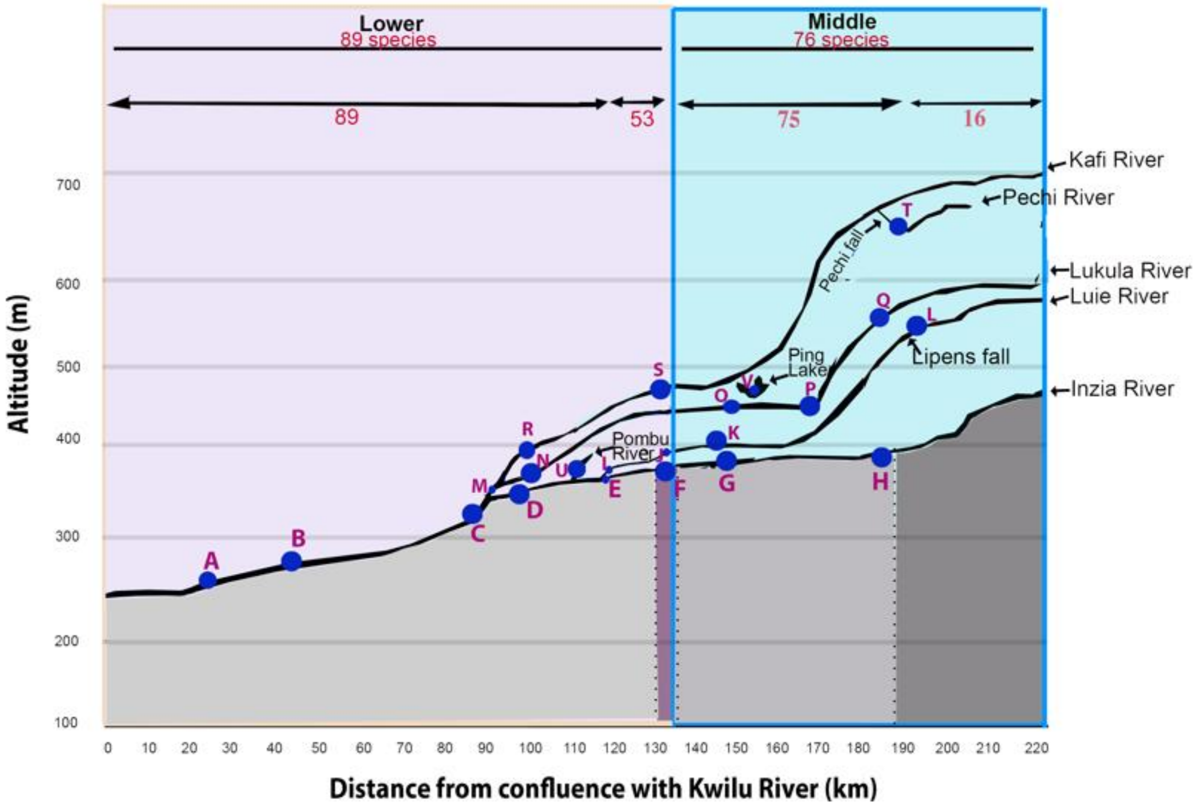

Figure 7. Longitudinal distribution of species in the Inza basin according to distance from the Inza mouth and altitude. Sampling stations are A to V.

Conclusion

The aim of this study, which contributes to improving our knowledge of fish in the Inzia basin in the Middle Congo, was to assess the biodiversity of the ichthyofauna, the relative abundance of species and the environmental variables that influence of fish dispersal in this little-studied environment. Given that the part of the basin sampled is essentially located in a forest environment, we recorded an abundance of Mormyridae (13.18%), followed by Alestidae (12.02%), Mochokidae (8.79%) and Claridae (5.49%).

For species expected to have larger populations, we observed that the specimens were generally small. Similar to the presence of the Alestidae in this group, a family dominated by small-bodied species would indirectly reflect the anthropogenic pressure (Laë et al., 2004) to which the local fish resources are subject.

regarding environmental variables, although we observed a decrease in the number of species in the field at stations where the water current was relatively high and the substrate dominated by boulders, data analysis showed that these variables were not more decisive in the distribution of species in the studied environment (see Fig. 4d).

Our results confirm the abundant biodiversity of fish species in tropical ecosystems, regardless of anthropogenic pressure on fishery resources. Seven individuals remained unidentified and will be identified by DNA analysis in specialized laboratories in Belgium. These unidentified individuals are likely to be new species. It would be interesting to conduct regular fish monitoring in our study area in the future, combining the effect of seasonal capture and habitat exploitation behavior. A mapping of spawning areas would be important to establish for the implementation of species restoration and conservation measures through the delimitation of species protection zones and where fishing would be prohibited in order to promote sustainable management of ichthyofauna in the Inzia basin.

Acknowledgements

We would firstly like to thank the European Union for the funding implemented by the European Alliance in the Field of Agricultural Knowledge for Development, European Economic Interest Grouping (AGRINATURA- EEIG) and the Regional Post-Graduate School of Integrated Management of Tropical Forests and Territories (ERAIFT), through the project « Capacity building for biodiversitý practitioners, scientists and policy makers for the sustainable management of protected areas and forest ecosystems in Africa ». We would also like to thank the members of the Aquatic Resources Management and Aquaculture Unit, University of Liège, as well as the administrative and academic staff of ERAIFT, for facilitating and supervising this study. Our thanks also go to Mr Yanick Kulungu Akedio, and to assistants Cowhain Manana, Idriss Mungongo, and Jerith Kikay for their unfailing support during data collection in the field.

References

Alberto Doretto, Elena Piano, & Courtney E. Larson. (2020). The River Continuum Concept: lessons from the past and perspectives for the future. *Canadian Journal of Fisheries and Aquatic Sciences.* 77 :1853-1864. https://cdnsciencepub.com/doi/full/10.1139/cjfas-2020-0039

Banque Mondial (2021). Rapport de cartographie des sites hydroélectriques et solaires photovoltaïques potentiels (Tâche 1). Activités de priorisation et cartographie des sites Hydroélectriques et solaires en RD Congo, Mai 2021. 121 p, inédit. https://www.scribd.com/document/816041364/

Beisel, J.N, Usseglio-Polatera, P., Bachmann, V. & Moreteau (2003). A comparative Analysis of Evenness Index Sensitivity. *International Review of Hydrobiology*, 2023, 3-15.https://doi.org/10.1002/iroh.200390004

Boden, G., Teugels, G.G. & Hopkins C.D. (1997). A systematic revision of the large-scaled Marcusenius with description of a new species from Cameroon (Teleostei: Osteoglos

Boizard, J (2008). La diversité génétique du mulet à cornes dans un contexte de conservation : Rôle des interconnexions et des barrières sur la dispersion des individus. Mémoire de maitrise, Université de Montréal Faculté des études supérieures, 59 p. http://hdl.handle.net/1866/8124

Boulenger, A (1901). Les poisons du bassin du Congo. Bruxelles. *Publications de l'État indépendant du Congo,* 532 p https://www.fishbase.se/references/FBRefSummary.php?ID=1879

Boulenger, A (1909). Catalogue of the fresh-water fishes of Africa in British Museum (Natu-

Boulenger, A (1911). Catalogue of fresh water fishes of Africa. British Museum (Natural History), Print by order of administrations, Vol. 2, London : 529 p. https://www.biodiversitylibrary.org/item/91114

Boulenger, A (1915). Catalogue of the fresh-water fishes of Africa in British Museum (Natural History). *The Trustees*, London, Vol. 3, 526 p. https://fishbase.mnhn.fr/biblio/BiblioSummary.php?id=2989&speccode=3&syncode=1408

Britz, R (2007). Polypteridae. P. 168-173. In M.L.J. Stiassny, GG. Teugels and C.D. Hopkins (eds.) *The fresh and brackish water fishes of Lower Guinea, West-Central Africa*. Volume I. Collection Faune et Flore tropicales 42. Institut de Recherche pour le Développement, Paris, France, Muséum National d'Histoire Naturelle, Paris, France and Musée Royal de l'Afrique Centrale, Tervuren, Belgium. 800 pp. https://www.fishbase.se/references/FBRefSummary.php?id=81628&speccode=4830

Brooks E., Allen J., & Darwell, T (2011). The Status and Distribution of Freshwater Biodiversity in Central Africa. Gland, Switzerland and Cambridge. *IUCN*. 126p. https://portals.iucn.org/library/efiles/documents/RL-67-001.pdff

CGEDD (2019). Sixième rapport de la République Démocratique du Congo à la Convention sur la Diversité Biologique. Ministère de l'Environnement et Développement Durable-RDC, 407 p. https://medd.gouv.cd/wp-content/uploads/2024/01/RD_Congo_6e_Raport_National_Biodiversite.pdf

Conference on Artificial Itelligence for Defense (CAID). https://caid.cd/?page_id=6822

Crispo, E, Bentzen P, Reznick ON. Kinnison MT, Hendry AP (2006) The relative influence of natural selection and geography on gene flow in guppies. *Molecular Ecology*. 15, 49-62. https://onlinelibrary.wiley.com/doi/10.1111/j.1365-294X.2005.02764.x

Daget J., J. P. Gosse & D. F. E. Thys van den Audenaerde. (1984). Checklist of the Freshwater Fishes of Africa. *CLOFFA*. ISNB, Bruxelles, MRAC, Tervuren & ORSTOM ,Paris.Vol. 1,410 p. https://horizon.documentation.ird.fr/exl-doc/pleins_textes/divers13-06/23347.pdf

Daget J., J. P. Gosse & Thys van den Audenaerde D. (1991). Checklist of the Freshwater Fishes

Daget J., J. P. Gosse., & Thys van den Audenaerde, D. (1986). Checklist of the Freshwater Fishes of Africa. *CLOFFA*. ISNB, Bruxelles, MRAC ,Tervuren & ORSTOM, Paris. Vol. 2, 520 p. https://www.fishbase.se/references/FBRefSummary.php?ID=4339

Dajoz R. (1996). Précis d'écologie. *Dunod*, Paris, Ed. 6, 551 p. https://bibliotheques.mnhn.fr/medias/doc/EXPLOITATION/HORIZON/225026/precis-d-ecologie

Debojit M, Ayush B , Sarowar A, Sahil H, and Supriyo D. 2025. Fish diversity and assessment of cypermethrin and use of ichthyotoxic plant-based fishing: an imminent threat to the aquatic diversity of the River Jinari, (Assam, India. *Records af the Zoological Survey of India*.Vol. 125(2)/177-186.

Fanny Arnaud (2012). Approches géomorphologiques historique et expérimentale pour la restauration de la dynamique sédimentaire d'un tronçon fluvial aménagé : le cas du Vieux Rhin entre Kembs et Breisach (France, Allemagne). Thèse de doctorat, l'Université Lumière Lyon 2, Discipline Géographie, Aménagement et Urbanisme. *HAL Openscience*. 280p. https://theses.hal.science/tel-00833042/file/Arnaud_2012_thA_se.pdf

Fermon, Y (1996). Les Haplochromis spp. (Teleostei, Cichlidae) des zones rocheuses du Mwanza Gulf, lac Victoria, Tanzanie : Structure des communautés et écomorphologie. Thèse de doctorat, Muséum National d'Histoire naturelle, Laboratoire d'Ichtyologie Général et Appliquée, 263 p. https://www.researchgate.net/profile/Yves-Fermon/publication/32971790

Ferraris, J., Vari, P & Skelton, P. (2011). A New Genus of African Loach Catfish (*Siluriformes* : *Amphilius*) from the Congo River Basin, the Sister-Group to All Other Genera of the Domain, with the Description of Two New Species. Copeia, *American Society of Ichthyologists and Herpetologists.* .Vol. 4, 477-489. https://www.jstor.org/stable/41416566

FONAREED- RDC (2017). Vers une mobilisation de finance climat pour le développement durable de la RDC, Programme Intégré RDD+ Kwilu. Avec la participation de la CTB, 25 p. https://www.cafi.org/sites/default/files/2021-02/DRC-WorldBank-Gestion%20Durable%20Pygmees%20-Prodoc%20Final_Novembre%202016_0.pdf

Geerinckx, T., D, Adriaens., G.G. Teugels., & W, Verraes. (2004). A systematic revision of the African catfish genus *Parauchenoglanis* (Siluriformes: Claroteidae). *Journal of Natural History.* 38,775-803. https://www.fishbase.se/references/FBRefSummary.php?ID=50834

Gosse, J.-P (1984). Mormyridae. pp. 63-122. In J. Daget, J.-P. Gosse and D.F.E. Thys van den Audenaerde. Check-list of the freshwater fishes of Africa. *CLOFFA*. Royal Belgian Institute of Natural Sciences (ISNB), Bruxelles, Royal Museum for Central Africa

(MRAC), Tervuren & ORSTOM (Paris).Vol. 1,410 p. https://fishbase.mnhn.fr/biblio/BiblioSummary.php?id=3203&speccode=10830&syncode=34176

Gosse, J.-P (1986). Anabantidae. pp. 402-414. In J. Daget, J.-P. Gosse and D.F.E. Thys van den Audenaerde (eds.) Check-list of the freshwater fishes of Africa *CLOFFA*. ISNB, Brussels; MRAC, Tervuren; and ORSTOM, Paris. Vol. 2. https://fishbase.mnhn.fr/references/FBRefSummary.php?ID=6803

Habicht, C., Olsen, J.B., Fair, L. & Seeb, J.E. (2004) Smaller effective population sizes evidenced by loss of microsatellite alleles in tributary-spawning populations of sockeye salmon fram the Kvichak River, Alaska drainage. *Environmental Biology of Fishes*. 69, 51-62. https://link.springer.com/chapter/10.1007/978-94-007-0983-6_5

https://horizon.documentation.ird.fr/exl-doc/pleins_textes/divers13-06/15357.pdf

https://www.tandfonline.com/doi/abs/10.1080/00222939700770881

Ibala, A (2010). Faune des poissons des rivières Luki et Lefini (Bassin du Congo) : Diversité et écologie. Katholieke Universiteit Lzuven, Faculté des Science, Engineering and Technology Group, Department of Biology, Animal Ecology and Systematics Section, Laboratory of Animal Diversity and Systematics, 403 p. https://www.scirp.org/reference/referencespapers?referenceid=3918236

Katemo, B (2020). Ichtyofaune du Parc National de l'Upemba (PNU/RD Congo) : diversité, écologie, conservation et gestion durable. Thèse de doctorat en sciences (biologie), KU Leuven, 401 p.

Katemo, B., Snoeks, J., Chocha, A., Abwe, E., Mukweze, C., Ilunga, M.K., Kiwele, P., Ngoy, L., & E, Vreven. (2023). The Upemba National Park (Upper Congo Basin, DR Congo) : An Updated Check list Confirming Its Status as an African Fish Biodiversity Hotspot. *Diversity. 2023*, 15966. https://www.mdpi.com/1424-2818/15/9/966

Kathryn, M. E, Caruso, T, Buscot, F.B, Fischer, M, Hancock, C,Tanja, S. M , Meiners, M, Meuller, C , Obermaier, E, Prati, D, Socher, D.S , Sonnemann, I , Weaschke, N, Wubet, T, Wurst, S & Rillig M.C. (2014). Choosing and using diversity indices: insights for ecologicalapplications from the German Biodiversity Exploratories. *Ecology and Evolution*. 3514-3524 https://doi.org/10.1002/ece3.1155

Kisekelwa, T., Isumbisho, M., Ntakimazi, G., & Micha J.-C. (2013). Preliminary assessment of fish diversity in Lowa River. Bulletin scientifique de l'Institut national pour l'environnement *et la conservation de la nature*. 12,17-24.https://www.uerhaispbkv.org/index.php?option=com_content&view=article&id=21&Itemid=163

Knaepkens, G, Verheyen, E, Galbusera, P. & Eens ,M (2004) The use of genetic for the evaluation of a potential migration barrier for the bullhead. Journal of Fish Biology. 64, 1737-1744.

Kouamélan, P., Teugels., N'Douba, V., Gooré Bi, G., & Koné, T. (2003). Fish diversity and its

Laë R., Ecoutin, J.-M., & Kantoussan, J. (2004). The use of biological indicators for monitoring fisheries exploitation: Application to man-made reservoirs in Mali. *Aquatic Living Resources*.17(2):95-105.

Lazard, J., & Lévêque, C. (2009). Introductions et transferts d'espèces de poissons d'eau douce. *Cahiers Agricultures*. 18, 157-163. https://revues.cirad.fr/index.php/cahiers-agricultures/article/view/30784

Lévêque, C (1994). Introduction générale : Biodiversité des poissons africains. *In*: Teugels G. G., J. F. Guégan & J. J. Albatet (éds): Biological diversity of african fresh- and brackish water fishes. *Annales du Musée Royal d'Afrique Centrale. Sciences Zoologiques*. 275, 7-16. https://horizon.documentation.ird.fr/exl-doc/pleins_textes/divers20-07/010021350.pdf

Lévêque, C (1995a). Role and consequences of fish diversity in the functioning of African freshwater ecosystems: a review. Aquatic Living Resources. 8, 59-78.

Lévêque, C., & Daget, J.(1984). Cyprinidae. In J. Daget, J.-P. Gosse and D.F.E. Thys van den Audenaerde (eds.) Check-list of the freshwater fishes of Africa *CLOFFA*. ORSTOM, Paris and MRAC, Tervuren. Vol. 1. 217-342. https://horizon.documentation.ird.fr/exl-doc/pleins_textes/divers13-06/15357.pdf

Lévêque, C., & Paugy, D. (2006a). Caractéristiques générales de la faune ichtyologique. *In* : Lévêque C. & D. Paugy (éds). Les poissons des eaux continentales africaines : diversité, écologie et utilisation par l'homme. *IRD* (Paris). 43-53. https://horizon.documentation.ird.fr/exl-doc/pleins_textes/ed-06-08/010037336.pdf

Louizi, H (2019). Les poissons Cichlidae du Maroc et leurs Cichlidogyrus parasites branchiaux : Statut taxonomique, Phylogénie et Biogéographie. Thèse en vue de l'obtention du doctorat. Centre de recherche : Biotechnologies Végétale et Microbienne, Biodiversité et Environnement, 148 p. https://toubkal.imist.ma/bitstream/handle/123456789/15326/THESE_LOUIZI.pdf?sequence=1

Mahamba, R., Kangela, V., Kankonda, A., Ulyel, J., & Micha, J-C. (2018). Etude des peuplements ichtyologiques des rivières Yoko et Biaro (Réserve de Yoko, Province Tshopo, R.D. Congo). *Revue Scientifique et Technique Forêt et Environnement du Bassin du Congo* Vol. 11, 49-65. https://www.mediaterre.org/docactu,Zm9zdGVyL2RvY3MvcmV2dWVzY2llbnRpZmlxdWVyaWZmZWFjdm9sLTExb25saW5l,9.pdf

Mahamba, R., Ndjaki, J., Kankonda, A ., Ulyelali-Patho, J., & Micha, J.-C. (2017). Caractérisation et écologie des peuplements des Mormyridae dans la réserve de Yoko (Kisangani-RD. Congo*). Journal International of Biological and Chemical Sciences.* 11,(3) :967-999.https://www.semanticscholar.org/paper/Caract%C3%A9risation-et-%C3%A9cologie-des-peuplements-des-la-Byanikiro-Nsila/367bc9a6fbe48bcdce39126f145525424fba3682

Mbega, J. D (2004). Biodiversité des ***poissons*** du ***bassin*** inférieur de l'Ogooué (Gabon). *Press*-es *Universitaires de Namur* : 614 p. http://www.tropicultura.org/text/v22n1/47.pdf

Mbimbi, J., & Stiassny, M. (2011). Fishes of the Kwilu River (Kasai basin, central Africa): A list of species collected in the vicinity of Kikwit, Bandundu Province, Democratic Republic of Congo. *Check List*. 7 (5) : 991-699. https://www.semanticscholar.org/paper/Fishes-of-the-Kwilu-River-(Kasai-basin%2C-central-A-Munene-Stiassny/830fcdb3703544dc539390577d85501094c54b15

Menga, K.D (2018). Utilisation des terres à vocation agricoles dans le Groupement Kingomansala, Secteur Kitoy en RD. Congo. *Editions Universitaires Européennes*. 51 p. https://www.laboutiqueafricavivre.com/livres-specialises/119358-utilisation-des-terres-a-vocation-agricoles-dans-le-groupement-kingomansala-9786138398189.html

Micha J.-C (2019). La pêche continentale malade du paludisme en Afrique centrale. *Tropicultura.* 37,1. https://eujournal.org/index.php/esj/article/view/15894

Micha, J-C (2017). Quel avenir pour les Aires Protégées (AP) aux zones humides oubliées en Afrique continentale ? *Tropicultura*. 4, 235-236. http://www.tropicultura.org/text/v35n4/235.pdf

Micha, J-C (2019). Défis dans la conservation du poisson dans les aires protégées du bassin du Congo. *Nature & Faune*. 32 (2) 69-74. https://m.academicjournals.org/journal/AJEST/article-references/647B05870203

Micha, J-C., & Mbenga, J-D. (2003). Vidéo la biodiversité des poissons du fleuve Ogooué au Gabon. Unité de Recherche en Biologie des Organismes. Une production de CARPE, CENAREST, TOTAL, Inspection provinciale des Eaux et Forêts du Moyen Ogooué, GABON, *FUNDP-Namur*, 2003. https://www.youtube.com/watch?v=fi95fgOaCxc

Monsembula, R., Liyandja, T & Stiassny, M. (2013). Fishes of the N'sele River (Pool Malebo, Congo basin, Central Africa): a list of species collected in the main channel and affluent tributaries, Kinshasa Province, Democratic Republic of Congo. *Check List* 9(5) 941–956. https://checklist.pensoft.net/article/18761/

Montchowui, E., Niyonkuru, C., Ahouansou, S., Chikou, A & Lalèyè, P. (2007). L'ichtyofaune de la rivière Hlan au Bénin (Afrique de l'Ouest). *Cybium* .31(2)173-176. http://aquatres.scientificwebjournals.com/tr/download/article-file/1017176

Mukabo, G., Masirika, J., Muzungu, L., Lubunga, P., Sindayihebura, A., Sibomana, C., Nshombo, V., Micha, J.-C. & Ntakimazi, G. (2020). Les poissons du bassin de la rivière Ulindi, à l'Est de la République Démocratique du Congo : revue de la littérature. *Journal International of Biological and Chemical Sciences*. 14(8): 2928-2940. https://www.ajol.info/index.php/ijbcs/article/view/202072

Mutambwe, S (1992). Le bassin de la Luki (Zaïre) et son aménagement. Systématique, biologie et écologie de sa faune piscicole. Thèse de doctorat : Université Paul Sabatier, Toulouse (France), 335 p. https://www.academia.edu/100541997/Contribution_to_the_knowledge_of_the_ichthyofauna_in_the_Inkisi_River_Lower_Congo_RDC_?uc-sb-sw=80835179

Ndahama, H., Batumike, P., Bagalwa, J-J., Ndegeyi, B., Baluku, J-P., Bahizire, J-L., Matembera, D., & Bugoma, D. (2014). Inventaire de la Biodiversité Aquatique du Bassin du Lac Kivu : Cas Spécifique des Poissons de la Rivière Nyabarongo RD Congo. *International Journal of Innovation and Applied Studies*. Vol. 7 (4)1298-1305. https://issr-journals.org/links/papers.php?journal=ijias&application=pdf&article=IJIAS-14-208-08

Ngoy a Ngoy, C., Doma, A., Mulungo, H., Kitenge, G & Manga, J. (2017). Inventaire de la Biodiversité Ichtyologique du Fleuve Congo à Kindu (Partie Lualaba). *Congo Sciences* 20217. 140-110. https://congosciences.online/wp-content/uploads/2023/05/NGOY_1_2020_Vol_8_N_2_Art_6-1.pdf

of Africa. *CLOFFA*. ISNB, Bruxelles, MRAC, Tervuren & ORSTOM, Paris. Vol. 4, 740 https://horizon.documentation.ird.fr/exl-doc/pleins_textes/divers13-06/15357.pdf

Ovidio M, Philippart J-C. (2002). The impact of small physical obstacles on upstream movements of six species of fish: synthesis of a 5-year telemetry study in the River Meuse basin. Hydrobiologia. 483(1-3):55–69. doi: 10.1023/A:1021398605520.

Ovidio, M., Renardy, S., Dierckx, A., Nzau Matondo, B., & Benitez, J.-P. (2021). Improving Bypass Performance and Passage Success of Atlantic Salmon Smolts at an Old Fish-Hostile Hydroelectric Power Station: A Challenging Task. *Ecological Engineering* 160: 106148.

Paugy, D (1986). Etudes et thèse. Révision systématique des Alestes et Brycinus africains (Pisces, Characidae). *Editions de l'Office de la Recherche Scientifique et Technique d'Outre-Mer* (*ORSTOM*)*,* Paris. 295 p. https://fishbase.mnhn.fr/references/FBRefSummary.php?ID=42019

Paugy, D., & Lévêque, C. 2006). Un model biologique pour les recherches sur la biodiversité. *In* : Lévêque C. & D. Paugy. Les poissons des eaux continentales africaines : diversité, écologie et utilisation par l'homme. *IRD* (Paris): 7-10. https://www.scirp.org/reference/referencespapers?referenceid=2999380

Piégay, H., Radakovitch, O., Morandi, B., Chateauminois, A., & Clémens, A. (2022). 12 années de recherche pour la connaissance et la gestion hydro-sédimentaire du fleuve. Bilans et perspectives scientifiques. Observatoire des Sédiments du Rhône. *HAL Open science*. 77p.https://hal.science/hal-03869998v1/file/OSR_Synthese_12_ans.pdf

PNUD & UNOPS. (1998). Monographie de la province du Bandundu. Programme National de relance du Secteur Agricole et Rural (PNSAR) 1997-2001. Ministères de l'Agriculture et de l'Elevage, du Plan, de l'Education National et de l'Environnement, Conservation de la Nature, Forêts et Pêche. 408 p. https://search.worldcat.org/title/Monographie-de-la-province-du-Bandundu/oclc/1414505657

PNUE (2004). Mise en œuvre de mesures de conservation et gestion durable des ressources halieutiques : le cas du Sénégal. République du Sénégal (Ministère de la pêche), ENDA (Prospectives- Dialogues politiques et PNUE. *PNUE-Pêche et Environnement.* 76 p. https://id.scribd.com/document/656540040/Gestion-Durable-Du-Senegal

Poissant, J, Knight, TW & Ferguson, MM. (2005). Nonequilibrium conditions following landscape rearrangement: the relative contribution of past and current hydrological landscapes on the genetic structure of a stream-dwelling fish. Molecular Ecology.14, 1321-1351. https://pubmed.ncbi.nlm.nih.gov/15813773/

Poll, M (1967b). Contribution à la faune ichtyologique de l'Angola, Museudo Dundo. Lisboa. 381p.https://www.researchgate.net/publication/235701583_A_New_Species_of_Synodontis_Siluriformes_Mochokidae_from_Tributaries_of_the_Kasai_River_in_Northern_Angola_Authors

Poll, M (1971). Révision des Synodontis africains (famille Mochokidae). *Annales du Musée Royal d'Afrique Centrale, Sciences Zoologiques.* (8) 191,1-497.

Poll, M (1973). Nombre et distribution géographique des poissons d'eau douce africains. *Bulletin du Muséum National d'histoire naturelle*. 150 (6) 113-128. https://link.springer.com/chapter/10.1007/978-94-010-1563-9_18

Poll, M. & Gosse, J.P. (1995). Genera des Poissons d'eau douce de l'Afrique. *Académie royale de Belgique*, Bruxelles. 325 p. https://books.google.com/books/about/Genera_des_poissons_d_eau_douce_de_l_Afr.html?id=H5kWAQAAIAAJ

Pwema, V., Madianganu ,V., Manikisa, I., Yaga, C., Munganga, C., Kavumbu, S., & Lusasi W. (2023). Ichthyological Fauna Exploited In The Kwilu River In The City Of Kikwit: Section Between Port Louise And The Kwilu Bridge (D.R. Congo).. *International Journal of Progressive Sciences and Technologies(IJPSAT).* Vol. 40 (1)269-288

ral History). *The Trustees.* London, Vol. 1, 373 p

relationships with environmental variables in a West African basin. *Hydrobiologia*

Retzer, E (2010). Taxonomy of Auchenoglanis Günther 1865 (Siluriformes : Auchenoglanididae). *Zootaxa*. 2655,25–51. https://www.mapress.com/zootaxa/2010/f/z02655p051f.pdf

Risch, L.M (1986). Bagridae. pp. 2-35. In J. Daget, J.-P. Gosse and D.F.E. Thys van den Audenaerde. Check-list of the freshwater fishes of Africa *CLOFFA*. ISNB, Brussels; MRAC, Tervuren; and ORSTOM, Paris. Vol. 2. https://www.fishbase.se/references/FBRefSummary.php?ID=3236

Roberts, R (2003). Systematics and osteology of Leptoglaninae, a new subfamily of the African catfish family Amphiliidae, with descriptions of three new genera and six new species. *California Academy of Sciences*. 54 (5): 81-132. https://www.mindat.org/taxon-2340834.html

Sanogo, Y., Samake, F., Kone, A., & Traore, D. (2015). Diversité du peuplement ichtyologique de la rivière Bagoé (Bassin du Niger, Mali). *Editions Agronomie Africaine.* 27 (1) : 47 – 56. https://www.ajol.info/index.php/aga/article/view/118753/108241

SCDB (2009). Biodiversité, développement et réduction de la pauvreté : reconnaître le rôle de la biodiversité pour le bien-être humain. *Programme des Nations unies pour l'environnement (PNUE)*, Montréal.52 p. https://www.cbd.int/doc/bioday/2010/idb-2010-booklet-fr.pdf

Sisa, E., Mukwita, J., Mutambel, H., & Pwema, V. (2018). Contribution à l'étude de la structure et de la dynamique des peuplements ichthyologiques des cours d'eau de la ville de Kinshasa : Cas de la rivière Lukunga. *International Journal of Innovation and Applied Studies*. Vol. 24 (3) :1357- 1371. https://ijpsat.org/index.php/ijpsat/article/view/4415

Skelton, P.H (1993). A complete guide to the freshwater fishes of southern Africa. *Southern Book Publishers*. 388 p. https://www.ajol.info/index.php/az/article/view/154325/143906

Skelton, P.H., & Teugels G.G. (1986). Amphiliidae. pp. 54-65. In J. Daget, J.-P. Gosse and D.F.E. Thys van den Audenaerde. Check-list of the freshwater fishes of Africa *CLOFFA*. ISNB, Brussels; MRAC, Tervuren; and ORSTOM, Paris. Vol. 2. https://horizon.documentation.ird.fr/exl-doc/pleins_textes/divers13-06/23347.pdf

somorpha: Mormyridae). *Journal of Natural History*. 31 :1645-1682.

Spens, J, Englund, G. & Lundqvist H. (2007). Network connectlvlty and dispersal barriers: using geographical information system (GIS) tools to predict landscape distribution of a key predator (Esox /ucius) among lakes. *Journal of Applied Ecology*. 44, 1127-1137. https://besjournals.onlinelibrary.wiley.com/doi/full/10.1111/j.1365-2664.2007.01382.x

Stiassny, J., Teugels, G., & Hopkins, D. (2007). The Fresh and Brackish Water Fishes of Lower Guinea, West-Central Africa. *IRD Éditions*, Paris .Vol. 1, 806 p.https://horizon.documentation.ird.fr/exl-doc/pleins_textes/ed-06-08/010044384.pdf

Taylor, E.B., Stamford, M.D. & Baxter, J.S. (2003). Population subdivision in westslope cutthroat trout (*Oncorhynchus clarki /ewisi*) at the nonhern periphery of its range: evolutionary inferences and conservation implications. *Molecular Ecology*. 12, 2609-2622. https://onlinelibrary.wiley.com/doi/10.1046/j.1365-294X.2003.01937.x

Teugels, G (1986). A systematic revision of the African species of the genus *Clarias* (Pisces; Clariidae). *Annales du Musée Royal d'Afrique Centrale. Sciences Zoologiques*. 187-192.https://sfi-cybium.fr/sites/default/files/pdfs-cybium/07-AOClarias%5B104%5D372.pdf

Teugels, G., & Guegan, J-F. (1994). Diversité biologique des poissons d'eaux douces de la basse Guinée et de l'Afrique Centrale *in* Teugels *et al.* (eds). Diversité biologique des poissons des eaux douces et saumâtres d'Afrique. Synthèses géographiques. Symposium Paradis. *Annales du Musée Royal d'Afrique Centrale. Sciences Zoologiques*. 275, 67 – 85. https://orbi.uliege.be/bitstream/2268/315041/11/Bibliographie.pdf

Teugels, G., & Thieme, M. (2005). Freshwater Fish Biodiversity in the Congo Basin, pp. 51-53. *In*: Thieme L.M., Abell R., Stiassny M.L.J., Skelton P. et al. Freshwater Ecoregions of Africa and Madagascar. A Conservation Assessment. Island Press, Washington, Cavelo, London. 431 p. https://www.researchgate.net/publication/338061471_The_Cyphomyrus_Myers_1960_Osteoglossiformes_Mormyridae_of_the_Lufira_basin_Upper_Lualaba_DR_Congo_A_generic_reassignment_and_the_description_of_a_new_species

Tshibwabwa, M (1997). Systématique des espèces Africaines du genre Labeo (Teleostei, Cyprinidae) dans les régions ichtyogéographiques de Basse-Guinée et du Congo, Thèse de doctorat, Facultés Universitaires Notre Dame de la Paix, Namur, 512 p. https://researchportal.unamur.be/en/studentTheses/syst%C3%A9matique-des-esp%C3%A8ces-africaines-du-genre-labeo-teleostei-cypr

Tshibwabwa, M., & Teugels, G (1995). Contribution to the systematic revision of the African cyprinid fish genus Labeo: species from the Lower Zaire river system. *Journal of Natural History*.29 (6), 1543- 1579. https://sfi-cybium-d10.scrol.net/sites/default/files/pdfs-cybium/04-Tshibwabwa%255B204%255D359-367%255Dpdf.pdf

Tshibwabwa, M., Stiassny, J., & Schelly, R. (2006). Description of a new species of Labeo (Teleostei: Cyprinidae) from the Lower Congo River. *Zootaxa,* 1224, 33–44. https://www.mapress.com/zootaxa/2006f/zt01224p044.pdf

Van der Zee, J.R., & Sonnenberg, R. (2010). *Aphyosemion teugelsi* (Cyprinodontiformes : Nothobranchiidae), a new species from a remote locality in the southern Democratic Republic of the Congo. *Zootaxa,* 2724,58-68. https://www.mapress.com/zootaxa/2010/f/z02724p068f.pdf

Van der Zee, J.R., & Sonnenberg, R. (2011). *Aphyosemion musafirii* (Cyprinodontiformes: Nothobranchiidae), a new species from the Tshopo Province in the Democratic Republic of Congo, with some notes on the *Aphyosemion* of the Congo Basin. *Bonn Zoological Bulletin.* 60(1):73-87. http://140.109.28.86/References/FBRefSummary.php?id=86918&fishbase=Yes&lang=french

Wamuini, S (2010). Ichtyofaune de l'Inkisi (Bas-Congo / RDC) : Diversité et écologie. Thèse de doctorat, Université de Liège, Faculté des Sciences, Département des Sciences et Gestion de l'Environnement, Laboratoire de Morphologie Fonctionnelle et évolutive, 277p. https://orbi.uliege.be/bitstream/2268/315041/7/Pages-liminaires.pdf

Wamuini, S., Vreven, E., Vandewalle, P., Mutambue, S., & Snoeks, J. (2010). Contribution à la connaissance de l'ichtyofaune de l'Inkisi au Bas-Congo (RD du Congo). *Cybium,* 34(1):83-91

Ward J.V., Tockner K, and Schiemer F. 1999. Biodiversity of floodplain river ecosystems: ecotones and connectivity. *River Research and Applications*, 15, 125-139