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Inventory of the Ichthyological Biodiversity of the Congo River at Kindu (Lualaba Section)

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ABSTRACT

*This study was conducted with the aim of identifying the different fish species inhabiting the Congo River at Kindu, specifically in the Lualaba section. To collect the data, several fishing gears were used, including hooks, baited traps, cast nets, and gillnets. A total of two hundred and sixty (260) specimens belonging to 13 families and 28 species were identified. The most abundant species were *Distichodus sexfasciatus* (9.6%), *Labeo senegalensis* and *Auchenoglanis occidentalis* (8% each), *Citharinus latus* (7.3%), *Marcusenius mento* and *Distichodus rostratus* (7% each), *Cyphomyrus psittacus* (5.8%), and *Oreochromis niloticus* (5%). The calculated Shannon index indicates that Station 1 was more diverse (3.043), whereas Station 2 was moderately diverse (2.718). Pielou's evenness index was high at Station 1 (0.94) and relatively low at Station 2 (0.92). These calculated indices confirm that the Congo River, in its section at Kindu, is rich in fish biodiversity.*

Keywords : Diversity, fish, ecosystem, index, Congo River, Lualaba



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INTRODUCTION

Currently, there are at least 11,952 known freshwater fish species worldwide, representing approximately one quarter of known vertebrates (Nelson, 2006), and African freshwater and brackish waters alone harbor nearly 3,200 species (Leveque and Paugy, 2006; Froese and Pauly, 2013). This number remains provisional because inventories and descriptions of new species are still frequent in Africa, particularly with the development of new identification methods based notably on multivariate analyses and molecular biology (Leveque and Paugy, 2006).

Fish constitute a renewable natural resource (Boden et al., 2004; Leveque and Paugy, 2006), serving as a banner under which studies of aquatic biodiversity can be conducted, given their high species richness and the continuous discovery of new species (Boden et al., 2004; Leveque and Paugy, 2006).

With regard to the Congo Basin itself, taxonomic studies are less extensive. During the first half of the 20th century, notable contributions were made by Boulenger (1901), Nichols and Griscam (1917), and Poll (1938). This is why various studies (Gosse, 1963; Poll and Gosse, 1963; Matthes, 1964; Nyongombe, 1993; Wembodinga et al., 2014; Manga, 2015) have attempted to define and clarify this ichthyological diversity, among other reasons, in order to ensure its protection when necessary. Indeed, how can this multitude of species be conserved if it is not known? According to Lundberg et al. (2000), imperfect knowledge of fish species makes any decision-making for their conservation difficult.

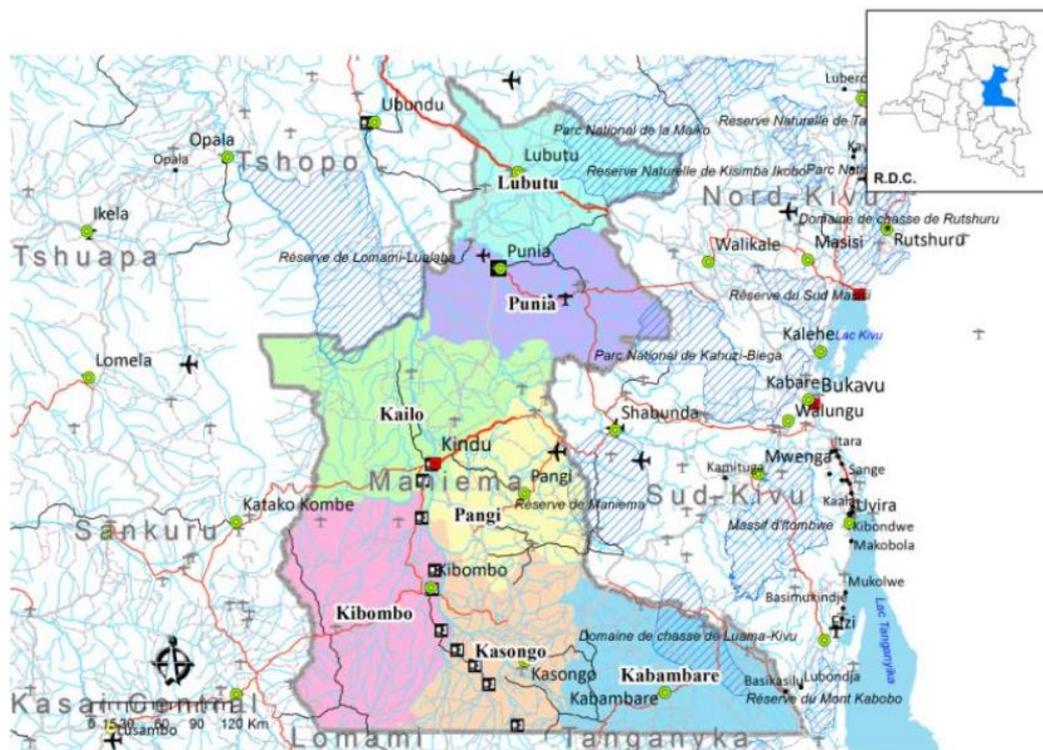


Figure 1. Map indicating the city of Kindu (red dot) in Maniema Province Source: CAID (Cellule d'Analyse des Indicateurs du Développement)

RESEARCH METHODS

MATERIALS AND METHODS

Description of the Study Area

The city of Kindu (Figure 1) is located between 2°56'37'' South latitude and 25°55'20'' East longitude, at an altitude of 497 m. It covers an area of 110 km². Kindu experiences a humid tropical climate of the Aw4 type, with two seasons (rainy and dry seasons). Annual temperatures range between 23°C and 35°C, with an average of 27°C. Annual rainfall is about 1,600 mm. Average precipitation of 30 mm makes June the driest month, while an average of 222 mm is recorded in November, which has the highest rainfall (Anonyme, 2017).

Specifically, the fish species studied were collected from two selected stations, namely Beach Central and Beach Basoko, with geographic coordinates of 2°9'49'' South latitude and 25°9'19'' East longitude; and 2°9'42'' South latitude and 25°9'22'' East longitude, respectively.

The choice of these two stations was motivated by the high presence of fishermen, which indicates the existence of fish diversity. In addition, these two stations constitute focal landing points for fishermen coming from upstream and downstream of Kindu.

Capture Techniques and Sampling

Fish were captured from January to June 2015. Seven sampling campaigns were conducted using hooks (No. 16, 18, and 20), baited traps, cast nets, and gillnets with mesh sizes of 12, 25, and 30 mm.

Experimental fishing was organized at two stations, namely Beach Central and Beach Basoko. The study population consisted of all captured specimens. The captured specimens were first removed from the nets, grouped, counted according to stations, dated, and placed in jars containing 10% formaldehyde, which were hermetically sealed for laboratory analysis.

Fish Identification

Each fish specimen was identified using identification keys or guides proposed by Ricois (1991), Leveque et al. (1992), and Stiassny et al. (2007).

Data Analysis

The composition of ichthyological communities of the Congo River (upstream and downstream of Kindu) was evaluated using analysis of variance to detect differences between the two sampled stations. Thus, five indices were calculated, namely abundance, species richness, Shannon diversity index, Fisher alpha index, and evenness.

The relative abundance of fish species at the two stations was calculated using the following formula: $n / N \times 100$. where n represents the abundance of the species and N represents the total number of specimens collected (Dajoz, 1996).

The Shannon diversity index is a biotic measure of multidimensional information (Legendre and Legendre, 1984). This index reflects changes in community structure and visualizes their spatial variations (Evrard, 1996). The analysis of the Shannon diversity index theoretically allows one to determine whether a mature biocenosis (high diversity) or a young community (low diversity) is present (Diouf, 1996). It is expressed by the following equation:

$$H' = -\sum \left(\frac{n}{N}\right) \ln\left(\frac{n}{N}\right)$$

With:

- (1) H' = Shannon index
- (2) n = number of individuals of the taxon
- (3) N = total number of individuals in the population

Fisher alpha indicates the number of species coexisting in a uniform habitat of fixed size. In other words, it represents species richness within a local ecosystem. This diversity is measured through components of heterogeneity/evenness, which combine the measurements into a single index.

Evenness is defined as the ratio of actual diversity to maximum diversity. It is obtained by dividing the Shannon diversity index by the base-2 logarithm of species richness (Pielou, 1969), in order to determine whether the station or living conditions are optimal for the different species. Consequently, the formula used was as follows (Dajoz, 1996):

$$E = \frac{H'}{\log_2 S}$$

Where:

- (1) E = evenness
- (2) H' = Shannon & Weaver diversity index (1949)
- (3) S = species richness

Evenness varies between 0 and 1. The closer it is to 1, the more the structure of the observed community reflects the progressive adjustments of different species to the constraints resulting from their biotic and abiotic environment. Cancela da Fonseca (1968), Daget (1979), and Hermi and Aissa (2002) estimate that values below 0.8 indicate low structural stability of communities.

Table 1. Taxonomy of captured fish and their relative abundance

Families	Species	Number	%
1. Cyprinidae	<i>Labeo senegalensis</i>	21	8
	<i>Labeo roseopunctatus</i>	5	2
	<i>Labeo parvus</i>	6	2.3
	<i>Leptocypris guineensis</i>	3	1.1
2. Mormyridae	<i>Mormyrops engystoma</i>	4	1.5
	<i>Cyphomyrus psittacus</i>	15	5.8
	<i>Gnathonemus petersii</i>	8	3
	<i>Marcusenius mento</i>	18	7
3. Alestiidae	<i>Brycinus luteus</i>	7	2.7
4. Citharinidae	<i>Citharinus latus</i>	19	7.3
5. Channidae	<i>Channa</i> sp.	3	1.1
6. Distichodontidae	<i>Distichodus rostratus</i>	18	7
	<i>Distichodus sexfasciatus</i>	25	9.6
	<i>Nannocharax lineomaculatus</i>	5	2

Families	Species	Number	%
	<i>Nannocharax occidentalis</i>	4	1.5
7. Mochokidae	<i>Synodontis budgetti</i>	6	2.3
	<i>Synodontis pleurops</i>	5	2
	<i>Synodontis decorus</i>	6	2.3
8. Malapteruridae	<i>Malapterurus electricus</i>	4	1.5
9. Cichlidae	<i>Oreochromis niloticus</i>	13	5
	<i>Tilapia dageti</i>	11	4.2
	<i>Sarotherodon galileus</i>	6	2.3
10. Clupeidae	<i>Pellonula leonensis</i>	2	1
11. Claroteidae	<i>Chrysichthys nigrodigitatus</i>	8	3
12. Clariidae	<i>Clarias gariepinus</i>	5	2
	<i>Heterobranchus longifilis</i>	4	1.5
13. Bagridae	<i>Auchenoglanis occidentalis</i>	21	8
	<i>Clarotes macrocephalus</i>	8	3
Total		28	260

The study of variations in the diversity index and evenness within an environment across different seasons or in different geographic regions containing comparable communities can provide valuable information on the evolution of communities (Dajoz, 1996). The different indices were evaluated using the PAST software (version 3.1.2).

RESULTS AND DISCUSSION

Qualitative inventory of the ichthyofauna and relative abundance

Table 1 presents the families, fish species collected, and their respective numbers. Analysis of Table 1 shows that a total of 260 fish specimens were captured and distributed among 13 families and 28 species. The families Cyprinidae, Mormyridae, and Distichodontidae were the most represented, with four species each, whereas the least represented families were Citharinidae, Alestiidae, Channidae, Malapteruridae, Clupeidae, and Claroteidae, each represented by a single species.

However, the most abundant species were *Distichodus sexfasciatus* (9.6%), *Labeo senegalensis* and *Auchenoglanis occidentalis* (8% each), *Citharinus latus* (7.3%), *Marcusenius mento* and *Distichodus rostratus* (7% each), *Cyphomyrus psittacus* (5.8%), and *Oreochromis niloticus* (5%). *Tilapia dageti* (4.2%), *Gnathonemus petersii*, *Chrysichthys nigrodigitatus*, and *Clarotes macrocephalus* (3% each) were moderately abundant. The other species were less abundant, with percentages below 3 (*Labeo roseopunctatus*, *Labeo parvus*, *Leptocypris guineensis*, *Mormyrops engystoma*, *Brycinus luteus*, *Channa* sp., *Nannocharax lineomaculatus*, *Nannocharax occidentalis*, *Synodontis budgetti*, *Synodontis pleurops*, *Synodontis decorus*, *Malapterurus electricus*, *Sarotherodon galileus*, *Pellonula leonensis*, *Heterobranchus longifilis*, and *Clarias anguillaris*). Figure 2 presents the data related to the analysis of variance of the two stations. Based on Figure 2, the analysis of variance calculated to compare the mean values of the two stations does not indicate a significant difference at the 5% level ($P = 0.39$).

Diversity indices

Data on diversity indices (species richness, Shannon index, Fisher alpha index, and evenness) of the two sampled stations are presented in Table 2 in order to characterize biodiversity.

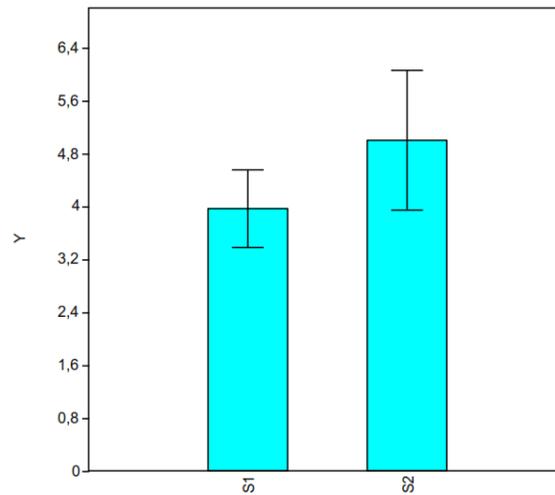


Figure 2. Comparison of the mean values of the number of fish captured at S1 (Beach Central) and S2 (Beach Basoko) (ANOVA, P-value = 0.39).

Table 2. Calculated diversity indices

Diversity indices	S1	S2
Species	25	19
Number of specimens	115	145
Shannon_H	3.043	2.718
Fisher_alpha	9.84	5.845
Evenness_J	0.94	0.92

From the analysis of Table 2, it appears that a total of 260 specimens were captured during the surveys, with 115 specimens recorded at Station 1, represented by 25 species, compared to 145 specimens at Station 2, which comprised 19 species.

The calculated Shannon index also shows variation between the two stations. Diversity was higher at Station 1 (3.043), whereas Station 2 was moderately diverse (2.718). The Shannon index calculated for both stations combined was 3.066, indicating that the Congo River possesses high ichthyological diversity.

A similar trend was observed for the Fisher_alpha index, which was higher at Station 1 than at Station 2, with respective values of 9.84 and 5.84. The evenness index was high at Station 1 (0.94) and relatively low at Station 2 (0.92). For both stations combined, species were evenly distributed, with an evenness index of 0.91.

DISCUSSION

The present study was initiated to determine the ichthyological richness of the Congo River in its Lualaba section located at Kindu. Twenty-eight (28) different fish species were collected and identified in this part of the river.

The results obtained are consistent with those of Manga (2015) in the Congo River at Kindu (upper course), using gillnets, cast nets, and traps, who inventoried 34 fish species; however, only six species (*Clarias gariepinus*, *Chrysichthys nigrodigitatus*, *Oreochromis niloticus*, *Sarotherodon galileus*, *Distichodus rostratus*, and *Malapterurus electricus*) are common to the present study. Wembodinga et al. (2014) identified 69 fish species captured using hooks, traps, and gillnets in the Lomami River (a tributary of the Congo River), but the species common to this study are *Oreochromis niloticus* and *Clarias gariepinus*. Finally, Nyembo and Muanza (2017) inventoried 25 fish species in the Lubilanji River (a tributary of the Kasai River) using fishing gears such as gillnets, traps, and cast nets; only *Clarias gariepinus*, *Malapterurus electricus*, and *Oreochromis niloticus* are common with the results of the present study. It appears evident that these fish species have adapted to the prevailing ecological conditions in these regions, which would favor their dispersion from one region to another.

The difference in the number of species among the various collections may probably be due to the fishing techniques used and the size of the sampling stations, which did not allow exploration of all habitats, since it is known that the number of species present in a given biotope depends on habitat diversity (Williamson, 1988; Teugels and Guegan, 1994). This difference may also be due to the season of capture. Indeed, rivers in the Congo Basin are influenced by two seasons (dry season and rainy season), with periods of flooding and recession, which could explain the presence of certain fish species at a given period of the year and their absence at another period (Lowe-Macconnell, 1988).

The Shannon diversity index ranges from 2.718 to 3.043. The lowest value was observed at Station 2, while the highest value was recorded at Station 1. Evenness ranges from 0.92 to 0.94, with the lower value observed at Station 2 and the higher value at Station 1. Station 2 exhibits low diversity. This situation could be explained by habitat quality and the shallow depth of the station, which affects species richness (Hugueny, 1990).

An opposite trend, with higher diversity values ranging from 3.59 to 5.18, was reported by Monsembula (2018) in the N'Sele River basin, in the Pool Malebo. Regarding evenness, the values obtained in this study are largely above 0.8, indicating a balanced distribution of individuals among species at these stations. Similar results were reported by Monsembula (2018), who observed evenness values greater than 0.8 for the ichthyological fauna of the N'Sele River basin in its main course. In contrast, the results of Ibala (2010) on fish fauna of the Luki and Lefini rivers (Congo Basin) revealed values below 0.8.

CONCLUSION

The present study aimed to inventory the fish species inhabiting the ecosystem of the Congo River in its Lualaba section at Kindu. Experimental fishing conducted during the rainy season from January to June 2015, using hooks, traps, cast nets, and gillnets, made it possible to sample 260 fish specimens belonging to 13 families and 28 species at the two stations. *Distichodus sexfasciatus* (9.6%), *Labeo senegalensis* and *Auchenoglanis occidentalis* (8% each), *Citharinus latus* (7.3%), *Marcusenius mento* and *Distichodus rostratus* (7% each), *Cyphomyrus psittacus* (5.8%), and *Oreochromis niloticus* (5%) were the most abundant species.

Regarding the analysis of variance, the mean values of the two stations did not indicate a significant difference at the 5% level ($P = 0.39$). With respect to diversity indices, the calculated Shannon index indicates that Station 1 is more diverse (3.043), whereas Station 2 is moderately diverse (2.718). Pielou's evenness index is high at Station 1 (0.94) and relatively low at Station 2 (0.92). These calculated indices confirm that the Congo River, in its Kindu section, is rich in ichthyological biodiversity.

The results of this investigation will serve as reference data on the ichthyofauna of the study area and will enrich the national inventory of ichthyofauna of the Democratic Republic of the Congo. However, it is important to conduct continuous monitoring of the status of ichthyological fauna in the Congo River in order to develop appropriate measures to prevent changes in community structure or even the disappearance of certain fish species.

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