International Journal of Zoology Studies
ISSN: 2455-7269; Impact Factor: RJIF 5.14
www.zoologyjournals.com
Volume 2; Issue 1; January 2017; Page No. 75-82

Inventory of fish in the Congo Basin: Case of Mukwamboli and Ngene-Ngene rivers, Kisangani, Democratic of the Congo

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Abstract
Fish capture was carried out for a period of 5 months between January and May 2016. Three different capture techniques were used including a battery of six monofilament net of large mesh (8, 10, 12, 15, 20 and 30 mm) and each net was 30 m long and 1.5 m high. The aim of this study was to list fish in different affluents of Tshopo River in order to bring out recent data on the specific diversity of fish fauna and to compare fish specific diversity of these two rivers for a rational and sustainable management. In Makwamboli river, 1 258 specimens of fish distributed in 5 orders, 11 families, 19 genera and 25 species were inventoried and 601 specimens of fish were captured in Ngene-Ngene River are distributed in 5 orders, 10 families, 17 genera and 19 species. The same species found in both rivers show the resemblance between the fish fauna of Mukwamboli and Ngene-Ngene rivers which both are sub-affluents of Tshopo Rivers. Among species inventoried in both rivers during our research, 18 species are listed as a minor concern and two insufficient data in the red list of IUCN (2016).

Keywords: inventory, fish, mukwamboli, ngene-ngene, congo basin, kisangani

1. Introduction

Nowadays, approximately 10 000 species of strictly fresh water fish are known worldwide and 227 species of diadromous fish frequent the fresh water at a certain term of their lives [1] and the situation of fresh water fish is of a great concern [2]. In fact, one third of known species would have disappeared or would be seriously threatened, and approximately 3 to 5% are shortlisted in UICN red list of endangered animals. Among others, the main causes of this decline are namely the destruction and anthropisation of fish habitats which are identified factors causing the immediate loss of aquatic ecosystems [4, 5].

Few decades ago, knowing the fish diversity of African rivers worried scientists and development officials in some African countries for a responsible and sustainable management of biological resources [6]. This phenomenon of degradation of aquatic degradation seems to hasten the process of climate change and habitats as well as to amplify the unavailability of aquatic resources [7]. Presently, the Congo Basin as other African river basins and elsewhere is facing the current problems of climate change [8, 9]. The Democratic Republic of the Congo owns the largest hydrographic network of Africa and its slope covers 3 457 402 km^2.

Unfortunately, the fish fauna is still poorly known and little studied [10] and those available are from Boulenger [11-16, 18]. Considering the problems related to the overexploitation of natural resources, deforestation, pollution, climatic hazards and scarcity of collection products, aquatic environments are one of the last resources that can be used for food production and fight against poverty. However, for their rational, cost-effective, profitable and sustainable exploitation, the role of research is paramount [19]. Nowadays, the overexploitation of aquatic ecosystems is widely recognized globally as well as at the African or national level. It is particularly reflected in a situation of a strong regression of fish captures despite the increase in the fishing gear used [20, 21]. Capture fishery resources are traditionally taken into account, exploited and managed by stock. They suffer the negative consequences of fishing and other polluting and harmful economic activities. The state of aquatic resources is of concern now because since 1990, about 25% of the stocks are more or less severely overexploited. The aquatic ecosystem is poorly known, but probably equally worrying in most regions [22]. In this context, a better understanding of the dynamics of aquatic ecosystems is essential to predict and manage the consequence of environmental variability and anthropogenic impacts, such as those induced by fishing [23].

As Mukwamboli and Ngene-Ngene rivers are not spared from the concern rose above, that's why a study on fish inventory in the Tshopo River affluents was carried out in order to make available recent data on the specific diversity of fish fauna of both rivers for a rational and sustainable management. The objectives of this study are to establish an inventory of the fish fauna Mukwamboli and Ngene-Ngene Rivers from a bibliographic summary and their conservation status according to the IUCN Red List and compare the species diversity of Mukwamboli and Ngene-Ngene rivers.

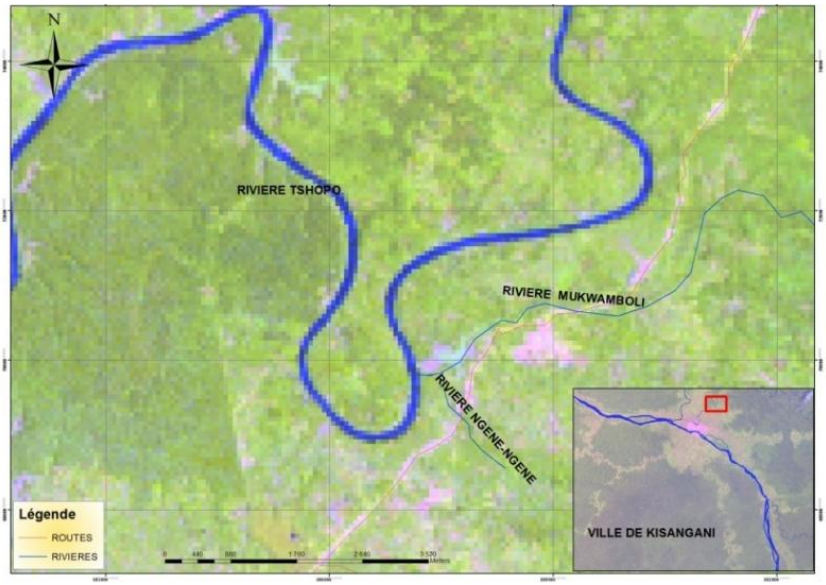
2. Materials and methods

2.1 Materials

2.1.1 Description of study area

Mukwamboli River originates behind the Bangboka International Airport and flows into Tshopo River and has a length of 15 km. Ngene-Ngene River is located at eighteen kilometers from the north-east of Kisangani city, on the former Buta road in Magima village. After being supplied by a dozen streams and rivulets, this river joins Mukwamboli River which in turn flows into Tshopo River. Ngene-Ngene river has a length of 7 km [25].

This study was carried out in Kisangani precisely in Mukwamboli and Ngene-Ngene rivers. Kisangani is included in the climatic zone of Equatorial type. The coordinates that locate it at the city center are 0° 31'N and 25° 11'E and the altitude fluctuates between 376 and 460. Kisangani is characterized by a small annual variation in temperature, with abundant rainfall and persistent moisture throughout the year. The annual average temperature is about 24.3 °C and the average precipitation is high throughout the year which is of 1728.4 mm (minimum; 1417.5 mm and maximum: 1915.4 mm) interrupted by two small sub-dry seasons characterized by a decrease in precipitation between December and January as well as between June and July which correspond to two small dry seasons of low rainfall. The two rainy periods are between September and November and the second rainy season is between mid-March and May. The average rainfall in the driest month is around 60 mm and the average annual relative humidity is 82% [26].



Source: Satellite Landsat in 2015

Fig 1: Location of two collection sites in relation to the city of Kisangani

Along Mukwamboli River, fish were captured at around 20 km far from Kisangani city on the old road linking Kisangani to Buta at Basandjasili village. The vegetation around the sampling area consisted mainly of the following species: *Bambusa vulgaris* (Poaceae), *Alchornea cordifolia* (Euphorbiaceae), *Elaeis guineensis* (Arecaceae), *Atroxima afzeliana* (Polygonaceae) *Leersia hexandra* (Poaceae) and *Dichactanthera corymbosa* (Melastomataceae).

The vegetation around the sampling site along Ngene-Ngene River consisted mainly of the following species: *Alchornea cordifolia* (Euphorbiaceae), *Nymphaea lotus* (Nymphaeaceae), *Azolla pinatta* (Azollaceae), *Ludwigia erecta* (Onagraceae), *Ludwigia abyssinica* (Onagraceae), *Frachrynium craunianum* (Marantaceae), *Marantochloa purpurea* (Marantaceae), *Halopegia azurea* (Marantaceae) and *Mitragyna stipulosa* (Rubiaceae).

2.2 Methods

2.2.1 Capture techniques

Fish capture was carried out for a period of 5 months between January and May 2016. In each river, six sites were selected for sampling, and these sites were chosen based on their accessibility, type of substrates and micro-habitats. At each site, sampling was carried out over a distance of about 500 m and a total of 30 samplings were carried out in each river and site. Three different capture techniques were used, including a battery of six monofilament threads of mesh (8; 10; 12; 15; 20 and 30 mm) and each gill net is 30 m long and 1.5 m high and hooks size 18 and 20. At each sampling, these fishing techniques were installed between 3 pm and 6 pm in the afternoons and recorded between 6 am and 9 am in the following mornings. The captured fish were preserved in plastic buckets containing 10% formaldehyde solution. The identification of the fish was carried out at Centre de Surveillance de la Biodiversité of University of Kisangani (CSB) precisely at the Department of Ecology and Aquatic Resource Biodiversity using identification keys [27-30].

2.3 Data analysis

The diversity indices (Shannon, Simpson, Equitability and Fisher alpha) were used to assess fish diversity in both rivers. The similarity index was calculated in order to classify the stations according to their taxonomic abundance by sampling technique. The Past software was used to make this similarity.

3 Results and discussion

3.1 Inventory of fish fauna of Mukwamboli and Ngene-Ngene rivers in Kisangani city.

A total of 1 258 specimens of fish belonging to 5 orders, 11 families, 19 genera and 25 species were captured in Mukwamboli River and 601 specimens of fish were captured

Ngene-Ngene River are distributed in 5 orders, 10 families, 17 genera and 19 species. The list of captured fish along with their abundances from Mukwamboli and Ngene-Ngene rivers with their status on the UICN red list, 2016 is given in Table 1 below.

Table 1: Captured fish species and their abundances from Mukwamboli and Ngene-Ngene Rivers with their status on the IUCN Red List, 2016

Families / Species	Mukwamboli River			Ngene-Ngene River			IUCN red list
Mormyridae	**Diversity**	**Total No.**	**Ar (%)**	**Diversity**	**Total No.**	**Ar (%)**	
Gnathonemus petersii Günther, 1862	+	35	2.78	+	55	9.15	LC
Petrocephalus microphthalmus Pellegrin, 1909	+	212	16.85	+	152	25.50	LC
Stomathorhinus sp Boulenger, 1898	+	5	0.40	+	15	2.50	
Cyprinidae							
Enteromius brazzai Pellegrin, 1901	+	73	5.80	-	0	0	
Enteromius miolepis Boulenger, 1902	+	93	7.39	+	60	9.98	
Clypeobarbus congicus Boulenger, 1899	+	3	0.24	+	40	6.65	LC
Opsaridium ubangiense Pellegrin, 1901	-	0	0	+	1	0.17	LC
Alestidae							
Brachypetersius altus Boulenger, 1899	+	75	5.96	-	0	0	
Micralestes stormsi Boulenger, 1899	+	61	4.85	+	62	10.32	LC
Micralestes acutidens Pites, 1852	+	32	2.54	-	0	2.54	LC
Bryconaethiops boulengeri Pellegrin, 1900	+	20	1.59	-	0	0	LC
Distichodontidae							
Mesoborus crocodilus Pellegrin, 1900	+	20	1.59	-	0	0	LC
Nannocharax brevis Boulenger, 1902	+	1	0.08	-	0	0	LC
Eugnathichthys macroterolepis Boulenger, 1899	-	0	0	+	13	2.16	LC
Amphiliidae							
Phractura fasciata Boulenger, 1920	+	1	0.08	+	1	0.17	DD
Clariidae							
Clarias angolensis Steindachner, 1866	+	102	8.11	+	25	4.16	LC
Clarias camerunensis Lonnberg, 1822	+	10	0.79	-	0	0.79	LC
Clarias buthupogon Sauvage, 1879	+	14	1.11	+	35	5.82	LC
Clarias gariepinus Burchell, 1822	+	4	0.32	-	0	0	LC
Clarias sp	+	12	0.95	+	14	2.33	
Channallabes apus Günther, 1873	-	0	0	+	7	1.17	
Claroteidae							
Parauchenoglanis punctatus Boulenger, 1902	+	12	0.95	-	0	0	LC
Schilbeidae							
Pareutropius debauwi Boulenger, 1900	+	291	23.13	+	11	1.83	LC
Anabantidae							
Microctenopoma ansorgii Boulenger, 1912	+	3	0.24	+	1	0.17	LC
Cichlidae							
Congochromis pugnatus	+	31	2.46	+	3	0.50	DD
Coptodon rendalli Boulenger, 1897	+	2	0.16	+	8	1.33	
Hemichromis fasciatus Peters, 1857	+	118	9.38	+	70	11.65	LC
Channidae							
Parachanna obscura Sauvage, 1884	+	28	2.23	+	28	4.66	
Total	25	1258	100	19	601	100	

(DD: Insufficient Data, LC: Minor Concern). Ar: Relative Abundance, (+): Present and (-): Absent

From the table above, it may be noticed that For Mukwamboli River, Siluriformes order has 4 families followed by Perciformes with 3 families and Characiformes with 2 families and at last Osteoglossiformes and Cypriniformes each has only one 1 family. Alestidae and Clariidae families have more species followed by Cichlidae, Cyprinidae and Mormyridae, each with 3 species. The family of Distichodontidae and Claroteidae possess 2 species and finally that of Amphiliidae, Schilbeidae, Channidae and Anabantidae each have a single species. *Pareutropius debauwi* was the most abundant fish species (23.13%), followed by *Petrocephalus microphthalmus* (16.85%). *Hemichromis fasciatus* (9.38%), *Clarias angolensis* (8.11%), *Enteromius miolepis* (7.39%), *Brachypetersius altus* (5.96%) and *Enteromius brazzai* (5.80) were relatively less abundant. For Ngene-Ngene River, the order of Suliriformes and Perciformes are richer with 3 families each followed by the order of Characiformes with 2 families. Osteoglossiformes and Cypriniformes have one family each. The family of Clariidae is more abundant in species with 4 species followed by Mormyridae, Cyprinidae and Cichlidae with 3 species. *Petrocephalus microphthalmus* is the most abundant (25.29%), followed by *Hemichromis fasciatus* (11.65%) and *Micralestes stormsi* (10.32%). Among the species inventoried on the two rivers during our research, eighteen are listed as a minor concern and two insufficient data on the IUCN Red List.

This difference would probably be explained by the fact that we have carried out non-selective captures in order to grant the same chance to all species to be captured. The low rate or absence of some species is also due to the fact that they are difficult to capture or they escape the capture techniques used: *Nannocharax brevis* (0.08%), *Phractura fasciata* (0.08), *Microctenopoma ansorgii* (0.17%) and *Opsaridium ubangiense* (0.17%).

The comparative diversity of the fish fauna of these two rivers

with that of the rivers studied on the left bank of the Congo River by Danadu [31] indicates that out of 49 inventoried species, 9 species are found in Mukwamboli and Ngene-Ngene rivers among which 1 is common in 4 rivers as follows: Mukwamboli, Ngene-Ngene, Bitubu and Romée. However, 16 species are found either in Mukwamboli or in Ngene-Ngene.

Mukwamboli River is full of many species of fish and this is justified by the fact that Mukwamboli River has a large area than Ngene-Ngene River and is supplied by several streams or rivulets. This shows that Mukwamboli River is fishier than Ngene-Ngene River in which there is no great human activity around this river. On the other hand, Ngene-Ngene River suffers great deforestation and overexploitation of fisheries by local fishermen that is why the distribution and abundance of species are not the same.

3.2 Assessment of biodiversity in Mukwamboli and Ngene-Ngene rivers

3.2.1 Index of fish diversity observed in both rivers

The biological diversity for both rivers is presented in table 2.

Table 2: Diversity of fish observed in both rivers

	Mukwamboli	Ngene-Ngene
Taxa_S	25	19
Individuals	1258	601
Shannon_H	2.507	2.406
Simpson_1-D	0.8847	0.8794
Equitability_J	0.7787	0.8171
Fisher_alpha	4.421	3.735

Table 2 shows that species richness is higher in Mukwamboli River (S = 25) while in Ngene-Ngene River (S = 19) is the least diverse. The Simpson index shows that the probability of a fish species being observed at two different sites is very high (tending towards 1). The equitability and Shannon indices show a strong structuring of the fish populations observed in both rivers, Mukwamboli (E = 0.7787> 0.5 and H = 2.507) and Ngene-Ngene (E = 0.8171> 0.5 and H = 2.406) respectively.

The calculated ecological indices evaluated the fish diversity for both rivers. Shannon index showed values greater than 1 in all captures sites and this shows that our two rivers are diverse. It confirmed the allegations that a value of less than 1 indicates that the site is less diverse and a value equal to or greater than 1 means that the site is diversified. Regarding Simpson index, all values tended to 1, the high value of the Simpson index results into a great diversity in the area [32]. Concerning the Equitability Index, the values range between 0.7787 and 0.8171 and these values were greater than 0.5 and tend towards 1 that explains that numbers are more or less equitably distributed in all the prospected areas. As for the Fisher alpha index, values change between 3.735 and 4.421 and this explains why the two sites are much more remote.

3.2.2 Euclidean similarity index and bray curtys distance

Figure 2 shows the degree of similarity between Mukwamboli and Ngene-Ngene rivers.

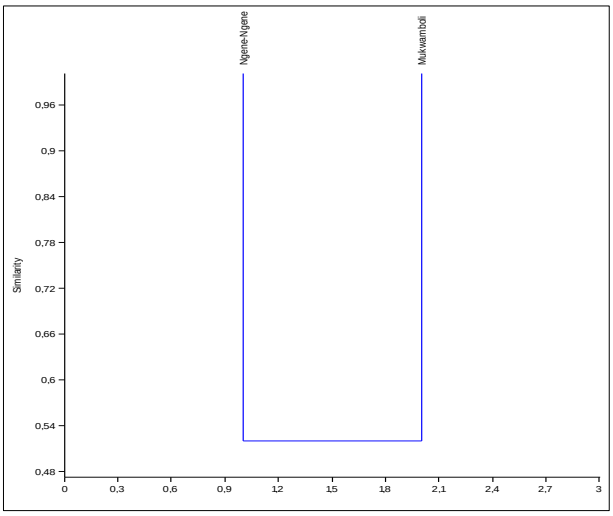


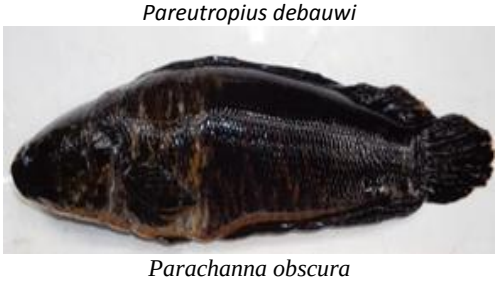
Fig 2: Dendrogram of Euclidean similarity

From figure 2, it should be noticed that the observed similarity between Mukwamboli and Ngene-Ngene is 52%.

The waters of Mukwamboli River are more acidic (pH = 5.83) than those of Ngene-Ngene (pH = 6.89). According to European Union directives (Directives 2006), the observed values of the physicochemical parameters (temperature 23.6 and 24.7 °C., pH 5.83 and 6.89, conductivity 23.6 and 19.2 us/cm and dissolved oxygen 4.15 and 7.68 mg/l of river water indicate good quality water.

Annex 1: Some species of fish captured in the Mukwamboli River

Pareutropius debauwi



Parachanna obscura

Gnathonemus petersii

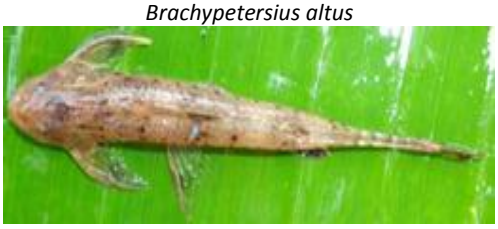
Petrocephalus microphthalmus

Microctenopoma ansorgü

Micralestes acutidens

Brachypetersius altus

Mesoborus crocodilus



Phracthura fisciata

Hemicromis fasciatus

Enteromius miolepis

Enteromius brazzai

Bryconaethiops boulengeri

Nannocharax brevis

Parauchenoglanis punctatus

Annex 2: Some species of fish captured in the Ngene-Ngene River

Hemichromis fasciatus

Microctenopoma ansongii

Micralestes stormsi

Pareutropius debauwi

Enteromius miolopis

Parachanna obscura

Channallabes apus

Gnathonemus petersii

Petrocephalus microphthalmus

Clarias buthupogon

4. Conclusion

This study carried out a fish survey of Mukwamboli and Ngene-Ngene rivers and this inventory is based on sampling performed for a period of 5 months. In Mukwamboli River, 19 genera were inventoried distributed in 25 species and Ngene-Ngene River encompasses 17 genera distributed in 19 species. The fommowing ubiquitous species *Gnathonemus petersii*, *Petrocephalus microphthalmus*, *Stomathorhinus sp*, *Enteromius miolepis*, *Clypeobarbus congicus*, *Micralestes stormsi*, *Phractura fasciata*, *Clarias angolensis*, *Clarias buthupogon*, *Clarias sp*, *Pareutropius debauwi*, *Microctenopoma ansorgii*, *Congochromis pugnatus*, *Coptodon rendalli*, *Hemichromis fasciatus* and *Parachanna obscura* compared to both rivers demonstrate the similarity between the fish fauna ofMukwamboli and Ngene-Ngene rivers sub-affluents of Tshopo River.

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