

Ichthyofauna of Okpara Stream, a Tributary of Oueme River, Benin, West-Africa

Rachad Sidi Imorou¹, Alphonse Adite¹✍,
Hamidou Arame¹, Antoine Chikou², Nambil Kayode Adjibade¹,
Stanislas Pejanos Sonon¹

¹Laboratoire d'Ecologie et de Management des Ecosystèmes Aquatiques (LEMEA), Département de Zoologie, Faculté des Sciences et Techniques, Université d'Abomey-Calavi, BP 526 Cotonou, Benin

²Laboratoire d'Hydrobiologie et d'Aquaculture, Faculté des Sciences Agronomiques, Université d'Abomey-Calavi, BP 526 Cotonou, Benin

Abstract: In tropical Africa, and particularly in Benin, running waters dwell a high and valuable fish fauna that are almost unknown, but under severe degradation. The current study inventoried the fish biodiversity of the Okpara stream, the main tributary of the Oueme River (the largest in Benin), in order to fill the gap of ichthyological data and to improve habitat protection, species conservation and valorization. During 18 months, fish samplings were made monthly with various fishing gears on five (5) locations. A total of 53 fish species belonging to 30 genera, 14 families and 7 orders were recorded among a total of 9552 individual fish collected. The most representative families were Mormyridae with 9 species and Cichlidae with 8 species, then follow Mockokidae, Clariidae, Cyprinidae and Alestidae with 6, 6, 6, 4 species, respectively. Families such as Anabantidae, Bagridae, Claroteidae, Malapteruridae, Polypteridae and Schilbeidae were less represented and individually included 2 species. The Hepsetidae and Aplocheilidae were represented by one (1) species, respectively the African pike, *Hepsetus odoe* and *Epiplatys bifasciatus*. A holistic scheme of ecosystem management and species conservation requires a complete knowledge on the fish community structure, eco-toxicology and species ecological status.

Keywords: Cichlidae, Dam, Degradation, Eco-Toxicology, Ichthyofauna, Management, Mormyridae, Oueme River

Introduction

Notwithstanding the economic and commercial importance of the fish resources in Africa, and particularly in the Sub-Saharan Africa, the fish biodiversity remains poorly known in most inland waters (rivers, streams, lakes, lagoons, floodplains etc.), and even in marine coastal systems (Aboua *et al.*, 2015; Sanogo *et al.*, 2015). Meanwhile, these aquatic habitats are being seriously degraded by multiple uses that cause profound modifications of the environmental quality leading to habitat fragmentations and an increase of endangered and threatened species. As reported by the International Union for Conservation of Nature (IUCN, 2010), about 21% of known African fish species are threatened.

In West Africa, and particularly in Benin, fishery is among the foremost ancestral activities that provides sustainable and substantial financial resources to grassroots (Adite, 1995; Laleye, 2003; Gbaguidi *et al.*, 2016). Annual fish production was estimated at about 40 metric tons (Direction des Pêches, 1999) from which about 70% accounted for the Oueme River (the longest river in Benin) and its associated lakes, floodplains and tributaries. Among the

tributaries of the Oueme River, the Okpara stream is the biggest one that provides an important commercial fish resources for the Northern Region of Benin. Despite the fisheries importance in the Okpara stream and the multiple cases of habitat degradations occurring in this geographic region, little is known about the fish biodiversity. Indeed, since a half of century (year 1969), the Okpara stream is subjected to a permanent water withdrawal by a Water Company (SONEB) that withdraws and treats the stream water to satisfy domestic needs (Zogo *et al.*, 2008). Likewise, water withdrawal for irrigations, the use of chemical fertilizers and pesticides for agriculture, the overfishing caused by the utilization of devastating fishing gears were the major threats recorded on this stream. Currently, the introduction of the invasive non-native fish species, the Nile Tilapia, *Oreochromis niloticus*, and the invasion of a floating plant, the water hyacinth (*Echhornia crassipes*), constitute an ecological disaster that seriously affect the environmental quality of the stream and leading to habitat fragmentations, species replacement with an increase of the number of threatened fish species (Gourene *et al.*, 1999; Laleye *et al.*, 2004; Adite *et al.*, 2013). As reported by MEPN (2009), more than 43 fish species are

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Alphonse Adite (Correspondence)

+(229) 95808249

currently threatened in Benin. Consequently, habitat restoration and protection, and species conservation and valorization require a perfect knowledge of the fish diversity and their status in order warrant a sustainable exploitation.

The current study aimed to assess the fish biodiversity of the Okpara stream, and data obtained from this survey will serve as documentation to contribute to habitat protection, species conservation and valorization and an ecological follow-up of this stream.

Materiel and Methods

Study area

The study area is the Okpara stream, the longest tributary of the Oueme River. This stream belongs to the northern hydrographic system and goes through two biggest regions of Benin, Borgou and Zou provinces. The Okpara stream is located between 8°14'-9°45' North and 2°35'-3°25' East and extended on about 200 Km. The Oueme River originated from the Southwest of Nikki city at an altitude of 450 m (Laleye *et al.*, 2004). The climate is tropical with three main seasons: the dry season (November - April), the wet season (May - August) and the flood period (September - October). The annual average temperature is 26.6 °C and lower temperatures were recorded in December and January. The annual mean rainfall is about 1200 mm with a peak (1300 mm) recorded in July, August or September (Kora, 2006; INSAE, 2004). Most of the soils are ferruginous and alluvial (from deposits of sediments left by the stream) (Dossou-Yovo, 2009; Ogouwale, 2013). In general, the soil is covered by a

wooded savanna characterized by the presence of *Parkia biglobosa*, *Khaya senegalensis* and *Vitellaria paradoxa*. Also, the vegetation included marshy meadows, bamboo and fallow bushes. Multi-species and commercial fisheries occur in the Okpara stream that appears to be the main source of fish resources for the surrounding populations and even for most cities of the northern region of Benin. The Okpara stream provides water for irrigated agriculture and supply the surrounding populations with drinking water from a dam built by the Benin water company, the SONEB.

Sampling sites

For this study, five (05) sampling locations were selected (Figure 1). These sites were chosen according to localities, accessibility, fisheries importance and levels of sites degradation.

- Site 1: This site is situated in Perere Township at Okpara up stream;
- Site 2: It is localized in Parakou Township at Gadela village (Okpara up stream), about 2 km from SONEB dam;
- Site 3: This site is located at Kpassa village where a dam was built to serve as a source of drinking water for the populations of Tchaourou and Parakou Townships and surrounding villages;
- Site 4: It is situated around Okpara downstream at Yarimarou village (Tchaourou Township) where the dam withdraws its water;
- Site 5: This site is also located around Okpara downstream at Sui village (Tchaourou Township).

Table 1: Geographic coordinates of the sampling sites in the Okpara stream

Sampling site	Village	Latitude	Longitude
Site 1	Perere	2°44'35.034''E	9°24'25.754''N
Site 2	Gadela	2°44'13.016''E	9°18'45.925''N
Site 3	Kpassa	2°44'4.987''E	9°17'15.432''N
Site 4	Yarimarou	2°45'36.214''E	9°13'50.399''N
Site 5	Sui	2°47'11.483''E	9°9'43.134''N

At all sites, samplings were performed in the “aquatic vegetation habitat”, at the edge of the stream and in the “open water habitat” characterized by a high depth and exempt of vegetation.

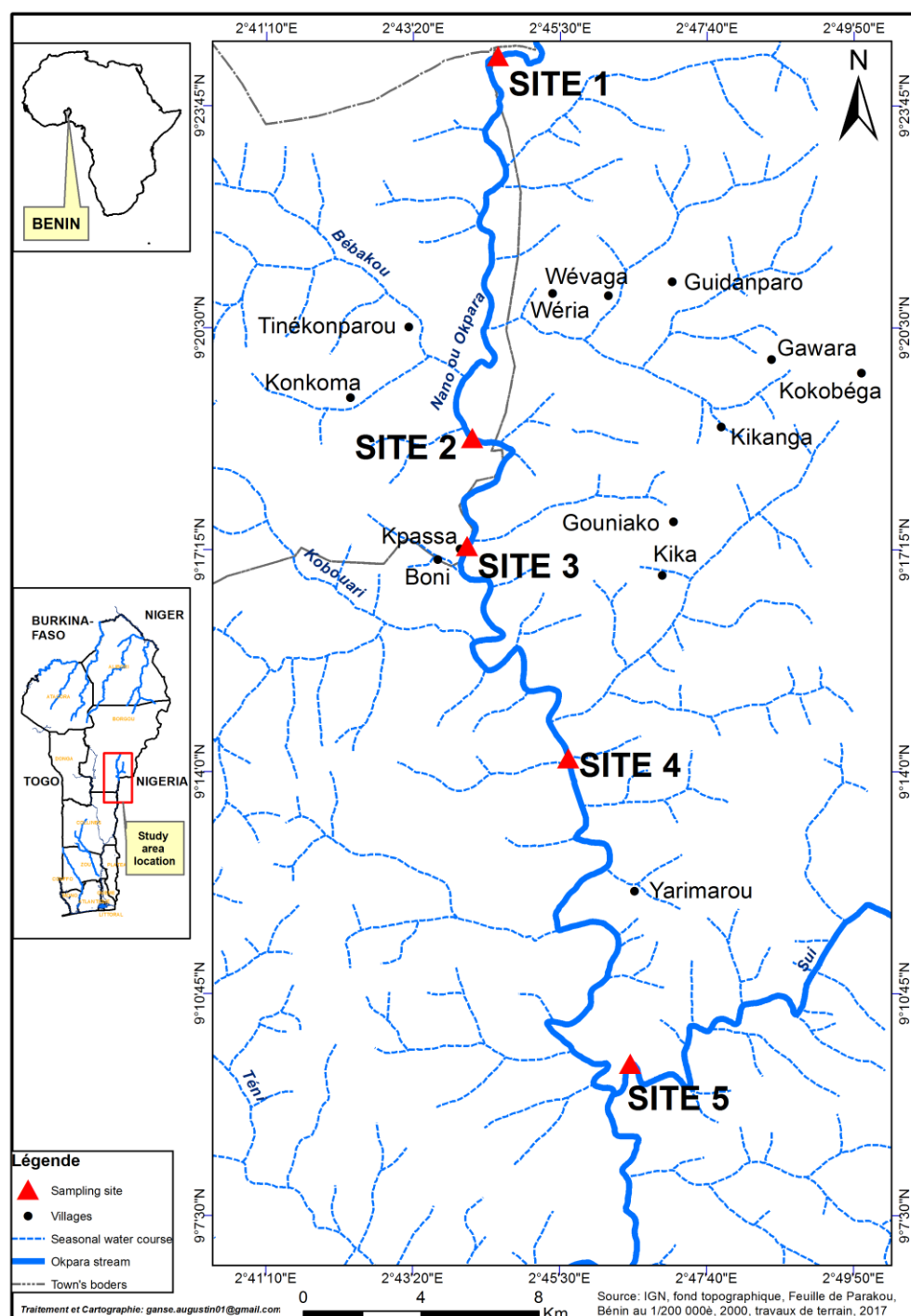


Figure 1: Okpara stream and sampling sites. Site 1= Perere Township, Site 2 = Gadela village (Parakou Township), Site 3= Kpassa village (Tchaourou Township), Site 4= Yarimarou village (Tchaourou Township), Site 5 = Sui village (Tchaourou Township)

Evaluation of water characteristics

The quality of the different habitats (aquatic vegetation, open water) was assessed in situ at each sampling site. The depth was measured to the nearest 1 cm using a graduated rope attached to a water sampler. The temperature and the dissolved oxygen

were measured respectively to the nearest 0.1 °C and 0.1 mg.l⁻¹ using a digital multi-probe (HANNA model 9150 waterproof). pHs were measured to the nearest 0.1 using a pH meter "model 3150 waterproof". Turbidities were measured to the nearest 1 cm using a Secchi disc.

Fish collection

Fish samplings were done once a month for eighteen (18) months in all habitats. At each sampling site, experimental fishing have been done in the open water with an experimental gill net (25 m x 1.30 m, 30 mm-mesh; 25 m x 1.30 m, 15 mm-mesh) and in marginal aquatic vegetation with a seine (4.20 m-length, 2 m – width, 5 mm-mesh) (Adite *et al.*, 2013). In addition, fish samplings were directly made in the fishermen artisanal captures. Thus, one third of each fisherman catches was sampled, but including all uncommon or rare species (Okpeicha, 2011). Fishing gears such as gillnets, seines, cast nets, hooks, and traps were used by the fishermen to collect the fishes. After collection, the fish samples were first identified in situ using fish identification references such as Reed *et al.*, (1967), Lowe McConnell (1975, 1987), Van Thielen *et al.*, (1987), Skelton (1993), Paugy *et al.*, (2004), Lévêque and Paugy (2006), Lévêque *et al.*, (1990-1992). The fish assemblages were preserved in a cooler and then transported to the Laboratory of Ecology and Management of Aquatic Ecosystem (LEMEA) to confirm the identifications. The valid scientific names of the fish species have been confirmed on the website of www.Fishbase.org (Froese and Pauly, 2018). In the lab, each fish individual was measured, weighted and preserved in 10% formalin and latter in 70% ethanol to make easier other biological observations such as stomach content analysis and aspects of reproductive biology (Schreck and Moyle, 1990; Murphy and Willis, 1996).

Results

Water Characteristics

In Okpara stream, temperatures were relatively moderate and ranged between 25 to 30.1 °C, the depths varied from 17 to 1080 cm and transparencies were low and ranged between 10 and 78.1 cm. The dissolved oxygen concentrations ranged between 0.44

and 5.66 mg/l and the percentage of saturation were moderate to low and varied from 6.37 to 75.3%. The water was acid or alkaline with pHs ranging between 6.4 to 8.1. As results, and based on the physicochemical features recorded, the Okpara stream display a relatively adequate water quality that is suitable for a high primary production and the prominence of the fish fauna.

Fish species composition

During our study, a total of 9552 fish individual were sampled. Overall, fifty three (53) fish species belonging to 30 genera and 14 families (Table 2) were inventoried. The sampling site with the highest species number was Gadela village (Site 2) totalizing 41 species. The lowest species numbers were recorded at Yarimarou village (Site 4) and Sui village (Site 5) totalizing 26 and 24 species, respectively. With regards to fish taxon, the most speciose families recorded were Mormyridae with 9 species and Cichlidae with 8 species. Then follow the Mockokidae, Clariidae, Cyprinidae and Alestidae with 6, 6, 6, 4 species, respectively. The families Alestidae, Anabantidae, Bagridae, Claroteidae, Malapteruridae, Polypteridae and Schilbeidae were represented only by 2 species (Table 2). The African pike (*Hepsetus odoe*) was the only species representing the Hepsetidae family. Among the fourteen families recorded, only 6, Cichlidae, Mormyridae Mockokidae, Clariidae, Cyprinidae and Alestidae totalized about the 2/3 (38 species) of the fish fauna. The remaining eight (8) families gathered not more than 15 species. Also, with regards to seasons, the dry period (November – April), and the wet season (May – August) exhibited the highest species richness with 46 and 40 species recorded, respectively. During the flood period (September - October), the water volume and pulse was very high and dynamic reducing fish concentration and catch per unit of effort (CPUE) (Table 3).

Table 2: Fish species inventoried in Okpara Stream (Oueme River) from December 2015 to May 2017.

Orders	Families	Species	Site 1	Site 2	Site 3	Site 4	Site 5
Characiformes	Alestidae	<i>Brycinus macrolepidotus</i> Valenciennes, 1850	+	+	+	+	+
		<i>Brycinus longipinnis</i> (Günther, 1864)	+	+			
		<i>Brycinus leuciscus</i> (Günther, 1867)	+	+			
		<i>Micralestes occidentalis</i> (Günther, 1899)	+				
	Hepsetidae	<i>Hepsetus odoe</i> (Bloch, 1794)	+	+	+	+	+
Cypriniformes	Cyprinidae	<i>Labeo parvus</i> Boulenger, 1902	+	+	+	+	+
		<i>Labeo senegalensis</i> Valenciennes, 1842	+				
		<i>Enteromius macrops</i> (Boulenger, 1911)		+			
		<i>Enteromius callipterus</i> (Boulenger, 1907)		+	+	+	
		<i>Enteromius chlorotaenia</i> (Boulenger, 1911)				+	+

		<i>Raiamas senegalensis</i> (Steindachner, 1870)							+
Cyprinodontiformes	Aplocheilidae	<i>Epiplatys bifasciatus</i> (Steindachner, 1881)	+	+	+				
Osteoglossiformes	Mormyridae	<i>Hyperopisius bebe</i> (Lacépède, 1803)	+	+	+	+	+		+
		<i>Marcusenius senegalensis</i> (Steindachner, 1870)	+	+	+	+	+		+
		<i>Mormyrops anguilloides</i> (Linnaeus, 1758)	+	+			+		+
		<i>Mormyrus rume</i> Valenciennes, 1846	+	+	+				
		<i>Petrocephalus pallidomaculatus</i> Bigorne and Paugy, 1990					+		
		<i>Petrocephalus soudannensis</i> Bigorne and Paugy, 1990			+	+			
		<i>Petrocephalus pellegrini</i> Poll, 1941	+	+	+				
		<i>Petrocephalus bovei</i> (Valenciennes, 1847)			+	+			
		<i>Brienomyrus niger</i> (Günther, 1866)	+	+					
Perciformes	Anabantidae	<i>Ctenopoma kingsleyae</i> Günther, 1896	+	+					
		<i>Ctenopoma petherici</i> Günther, 1864	+	+	+	+	+		+
	Cichlidae	<i>Oreochromis niloticus</i> (Linnaeus, 1758)	+	+	+	+	+		+
		<i>Hemichromis fasciatus</i> Peters, 1857	+	+	+				+
		<i>Chromidotilapia guntheri</i> (Sauvage, 1882)			+	+	+	+	+
		<i>Sarotherodon galileus mutifasciatus</i> (Günther, 1903)	+	+	+	+			
		<i>Coptodon guineensis</i> (Bleeker in Günther, 1862)	+	+	+	+	+		+
		<i>Coptodon zilli</i> (Gervais, 1848)	+	+	+	+	+		+
		<i>Sarotherodon caudomarginatus</i> (Boulenger, 1916)	+	+	+				
		<i>Pelmatolapia mariae</i> (Boulenger, 1899)	+	+	+	+			
Polypteriformes	Polypteridae	<i>Polypterus ansorgii</i> Boulenger, 1910	+	+	+				
		<i>Polypterus endlicheri endlicheri</i> Heckel, 1849			+	+	+	+	+
Siluriformes	Bagridae	<i>Bagrus bajad</i> (Forskål, 1775)						+	+
		<i>Bagrus docmak</i> (Forskål, 1775)						+	+
	Clariidae	<i>Clarias agboyiensis</i> Sydenham, 1980	+						
		<i>Clarias ebriensis</i> Pellegrin, 1920	+	+	+				
		<i>Clarias gariepinus</i> (Burchell, 1822)	+	+	+	+	+		+
		<i>Clarias pachymena</i> Boulenger, 1903	+	+					
		<i>Gymnalabes typus</i> Günther, 1867				+	+		
		<i>Heterobranchus longifilis</i> Valenciennes, 1840	+	+	+	+	+		+
	Claroteidae	<i>Chrysischtys nigrodigitatus</i> (Lacépède, 1803)	+	+	+	+	+		+
		<i>Chrysischtys auratus</i> (Geoffroy Saint-Hilaire, 1808)	+	+					+
	Malapteruridae	<i>Malapterurus beninensis</i> Murray, 1855			+				
		<i>Malapterurus electricus</i> (Gmelin, 1789)			+	+	+		
	Mockokidae	<i>Synodontis macrophthalmus</i> Poll, 1971	+						
		<i>Synodontis melanopterus</i> Boulenger, 1903	+	+					
		<i>Synodontis nigrita</i> Valenciennes, 1840			+	+	+	+	+
		<i>Synodontis schall</i> (Bloch and Schneider, 1801)	+	+	+	+	+		+

Schileidae	<i>Synogontis budgetti</i> Boulenger, 1911	+	+			
	<i>Synodontis sorex</i> Günther, 1864	+				
	<i>Schilbe intermedius</i> Rüppell, 1832	+	+	+	+	+
	<i>Schilbe mystus</i> (Linnaeus, 1758)	+				
	Number of genera	24	26	24	22	20
	Number of species	38	41	32	26	24

Total number of species: 53

Total number of genera: 30

Total number of families: 14

Total number of orders: 07



Brycinus macrolepidotus



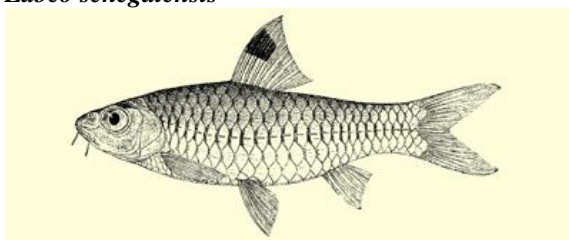
Brycinus leuciscus



Hepsetus odoe



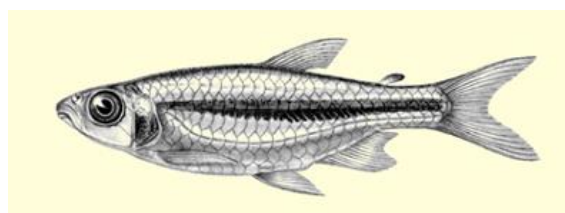
Labeo senegalensis



Enteromius callipterus (source : Leveque et Paugy, 2004)



Brycinus longipinnis



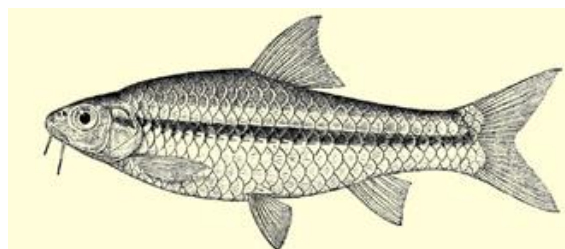
Micralestes Occidentalis (source : Leveque et Paugy, 2004)



Labeo parvus



Enteromius macrops



Enteromius chlorotaenia (source : Leveque et Paugy, 2004)



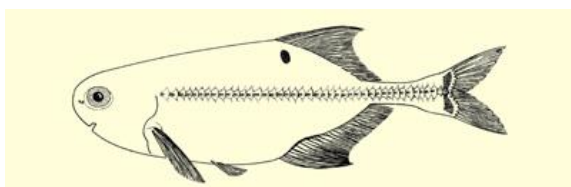
Raiamas senegalensis (www.fishbase.org)



Hyperopisius bebe



Mormyrops anguilloides (Specimen in a bad condition)



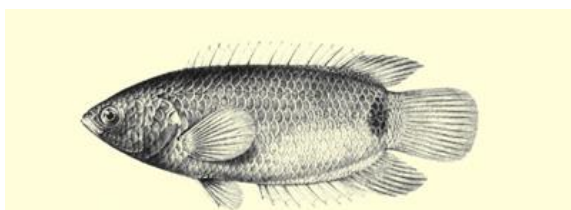
Petrocephalus pallidomaculatus (source : Leveque et Paugy, 2004)



Petrocephalus pelegriini



Brienomyrus niger



Ctenopoma petherici (source : Leveque et Paugy, 2004)



Epiplatys bifasciatus



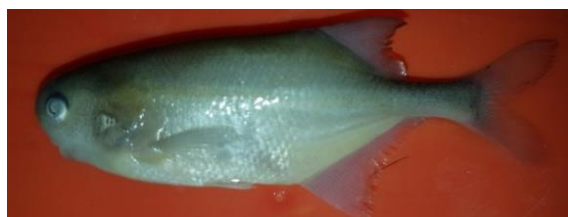
Marcusenius senegalensis



Mormyrus rume



Petrocephalus soudanensis



Petrocephalus bovei



Ctenopoma kingsleyae



Oreochromis niloticus



Hemichromis fasciatus



Chromidotilapia guntheri (source : Leveque et Paugy, 2004)



Sarotherodon galilaeus multifasciatus



Coptodon guineensis



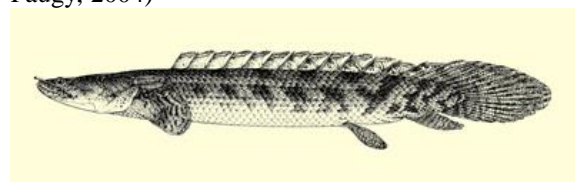
Coptodon zillii



Sarotherodon caudomarginatus (source : Leveque et Paugy, 2004)



Pelmatolapia mariae (Formalin-preserved specimen)



Polypterus ansorgii (source : Leveque et Paugy, 2004)



Polypterus endlicheri



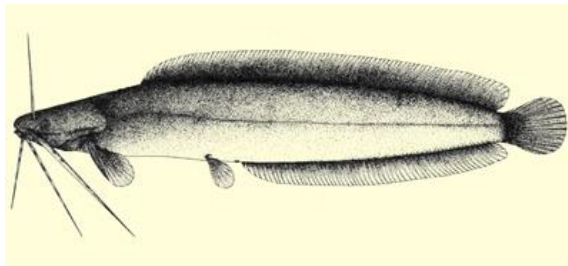
Bagrus bajad



Bagrus docmak



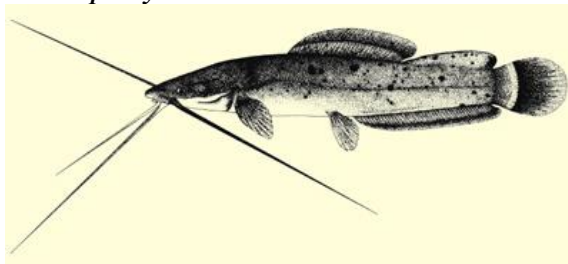
Clarias abgoyensis



Clarias ebriensis (source : Leveque et Paugy, 2004)



Clarias pachymena



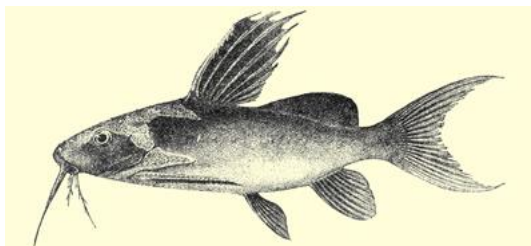
Heterobranchus longifilis (source : Leveque et Paugy, 2004)



Chrysischtys auratus



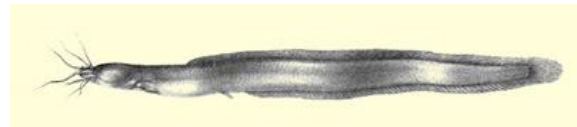
Malapterurus electricus



Synodontis melanopterus (source : Leveque et Paugy, 2004)



Clarias gariepinus



Gymnalabes typus (source : Leveque et Paugy, 2004)



Chrysischtys nigrodigitatus



Malapterurus benineensis



Synodontis macrophtalmus



Synodontis nigrita



Synodontis schall



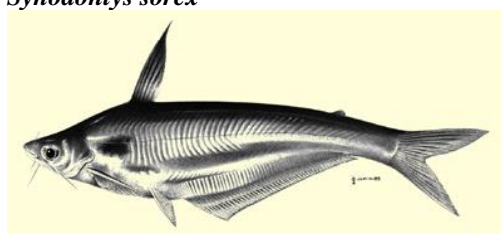
Synodontis budgetti (dorsal and pectoral fins were broken by the fishermen)



Synodontis sorex



Schilbe intermedius



Schilbe mystus (source : Leveque et Paugy, 2004)

Figure 2: Photos of the 53 fish species inventoried in the Okpara stream (Oueme River) from December 2015 to May 2017.

Table 3: Fish species inventoried in Okpara Stream (Oueme River) by season from December 2015 to May 2017.

Orders	Families	Species	Dry	Wet	Flood
Characiformes	Alestidae	<i>Brycinus macrolepidotus</i> Valenciennes, 1850	+	+	+
		<i>Brycinus longipinnis</i> (Günther, 1864)	+	+	
		<i>Brycinus leuciscus</i> (Günther, 1867)		+	
		<i>Micralestes occidentalis</i> (Günther, 1899)	+		
	Hepsetidae	<i>Hepsetus odoe</i> (Bloch, 1794)	+	+	+
Cypriniformes	Cyprinidae	<i>Labeo parvus</i> Boulenger, 1902	+	+	+
		<i>Labeo senegalensis</i> Valenciennes, 1842		+	
		<i>Enteromius macrops</i> (Boulenger, 1911)	+	+	+
		<i>Enteromius callipterus</i> (Boulenger, 1907)		+	+
		<i>Enteromius chlorotaenia</i> (Boulenger, 1911)	+		
		<i>Raiamas senegalensis</i> (Steindachner, 1870)		+	
Cyprinodontiformes	Aplocheilidae	<i>Epiplatys bifasciatus</i> (Steindachner, 1881)	+	+	
Osteoglossiformes	Mormyridae	<i>Hyperopisius bebe</i> (Lacépède, 1803)	+	+	
		<i>Marcusenius senegalensis</i> (Steindachner, 1870)	+	+	+
		<i>Mormyrops anguilloides</i> (Linnaeus, 1758)	+	+	

		1758)			
		<i>Mormyrus rume</i> Valenciennes, 1846	+	+	
		<i>Petrocephalus pallidomaculatus</i> Bigorne and Paugy, 1990	+		+
		<i>Petrocephalus soudannensis</i> Bigorne and Paugy, 1990	+		+
		<i>Petrocephalus pellegrini</i> Poll, 1941	+	+	
		<i>Petrocephalus bovei</i> (Valenciennes, 1847)	+	+	
		<i>Brienomyrus niger</i> (Günther, 1866)	+	+	
Perciformes	Anabantidae	<i>Ctenopoma kingsleyae</i> Günther, 1896	+		
		<i>Ctenopoma petherici</i> Günther, 1864	+	+	+
	Cichlidae	<i>Oreochromis niloticus</i> (Linnaeus, 1758)	+	+	+
		<i>Hemichromis fasciatus</i> Peters, 1857	+	+	+
		<i>Chromidotilapia guntheri</i> (Sauvage, 1882)	+	+	+
		<i>Sarotherodon galileus mutifasciatus</i> (Günther, 1903)	+	+	+
		<i>Coptodon guineensis</i> (Bleeker in Günther, 1862)	+	+	
		<i>Coptodon zilli</i> (Gervais, 1848)	+	+	
		<i>Sarotherodon caudomarginatus</i> (Boulenger, 1916)	+		
		<i>Pelmatolapia mariae</i> (Boulenger, 1899)	+	+	
Polypteriformes	Polypteridae	<i>Polypterus ansorgii</i> Boulenger, 1910		+	
		<i>Polypterus endlicheri endlicheri</i> Heckel, 1849		+	+
Siluriformes	Bagridae	<i>Bagrus bajad</i> (Forskål, 1775)	+		
		<i>Bagrus docmak</i> (Forskål, 1775)	+		
	Clariidae	<i>Clarias agboyiensis</i> Sydenham, 1980		+	+
		<i>Clarias ebriensis</i> Pellegrin, 1920	+	+	
		<i>Clarias gariepinus</i> (Burchell, 1822)	+	+	+
		<i>Clarias pachymena</i> Boulenger, 1903		+	
		<i>Gymnalabes typus</i> Günther, 1867	+	+	
		<i>Heterobranchus longifilis</i> Valenciennes, 1840	+		+
	Claroteidae	<i>Chrysischtys nigrodigitatus</i> (Lacépède, 1803)	+	+	+
		<i>Chrysischtys auratus</i> (Geoffroy Saint-Hilaire, 1808)	+	+	
	Malapteruridae	<i>Malapterurus beninensis</i> Murray, 1855	+	+	
		<i>Malapterurus electricus</i> (Gmelin, 1789)	+		
	Mockokidae	<i>Synodontis macrophtalmus</i> Poll, 1971	+	+	+
		<i>Synodontis melanopterus</i> Boulenger, 1903		+	+
		<i>Synodontis nigrita</i> Valenciennes, 1840	+	+	
		<i>Synodontis schall</i> (Bloch and Schneider, 1801)	+	+	+
		<i>Synodontis budgetti</i> Boulenger, 1911	+	+	+
		<i>Synodontis sorex</i> Günther, 1864	+		
	Schilbeidae	<i>Schilbe intermedius</i> Rüppell, 1832	+	+	+
		<i>Schilbe mystus</i> (Linnaeus, 1758)	+		
		Number of genera	28	25	16
		Number of species	46	40	21

Discussion

In Benin, running waters inhabit relatively high ichthyodiversity and mostly support an important commercial and subsistence fisheries (FAO, 2003; ICSF, 2002) that improve grassroots revenues and nutritional needs. The current ichthyological exploration on the Okpara stream, the main tributary of the Oueme River, assessed and documented the fish biodiversity in order to contribute to habitat protection, species conservation and overall ecosystem management. Eighteen (18) months of survey revealed that the Okpara stream harbors fifty three (53) fish species belonging to 30 genera, 14 families and 7 orders. Laleye *et al.*, (2004) reported 47 fish species, a lower number compared to the present records. The differences in fishing efforts, fishing gears, sampling sites and sampling durations may explain the differences in the number of species recorded during these two survey periods (Hugueny and Leveque, 1999). As results, species such as *Polypterus ansorgii*, *Bagrus bajad*, *Chrysichthys nigrodigitatus*, *Gymnalabes typus*, *Malapterurus benineensis*, *Synodontis macrophthalmus*, *Synodontis budgetti*, *Synodontis sorex* and *Sarotherodon caudomarginatus* recorded in this study, were not found by Laleye *et al.*, (2004). In contrast, species such as the bonytongue *Heterotis niloticus* (Osteoglossiformes: Osteoglossidae), *Gymnarchus niloticus* (Osteoglossiformes: Gymnarchidae), *Hydrocynus vittatus* (Characiformes: Alestidae) and *Lates niloticus* (Perciformes: Latidae), although reported by Laleye *et al.*, (2004), were not found during the current samplings. The absence of these species in the current fish assemblage may be due to the stock reduction caused by overfishing, habitat disturbances and habitat losses. Indeed, these four species are under a strong fishing pressure because of their high economic and commercial values. Also, environmental degradations such the effects of the dam built at Kpassa village and the water pollution due to the permanent use of chemical fertilizers and pesticides may increase the species vulnerability to death or force them to migrate and to colonize less degraded habitats. Nevertheless, both ichthyological surveys indicated that Cichlidae, Mormyridae, Clariidae, Mochokidae, Cyprinidae, Alestidae were the most speciose families in Okpara stream, a trend globally consistent with the ichthyological composition of most West African running waters (Leveque and Paugy 1999, 2006; Kuela 2002; Paugy *et al.*, 2003 a, b; Kantoussan 2007; Montchowui 2007).

Compared to similar African running waters, the Okpara stream exhibited a relatively high species richness. Indeed, Hazoume (2017) and Montchowui *et al.*, (2007) reported 48 and 43 fish species, respectively in the Sô and Hlan streams, two running waters connected to the Oueme River. In particular, the presence of families such as Eleotridae, Gobiidae,

Clupeidae, Monodactylidae, Mugilidae, Megalopidae, Paralichthyidae and Belonidae found in the Sô stream (Hazoume, 2017) and absent in the Okpara stream from this current assessment is due to the connection of the Sô with Lake Nokoué, a brackish water from which these estuarine and marine species migrate. Likewise, a less species richness (48 fish species) was recorded by Moritz (2010) in the Iguidi running water, a Benin South-East small forest stream, also connected to the Oueme River. Spatially, the study showed high species richness at Okpara up stream while the downstream exhibited a relatively less fish fauna. The great variability of the ichthyofauna from site to site probably indicated differential degradation levels with regards to space. Indeed, Kpassa village (Site 3), a collecting site under severe degradation due to the construction of a dam, showed a relatively reduced fish fauna (32 species) compared to Gadela village (Site 2) that harbored a high number of fish species (41 species). Probably, the water retrieval may cause habitat losses and fragmentations leading to a modification of the fish community structure with an increase of endangered and threatened fish species.

With regards to season, the dry and wet periods concentrated a high number of fishes, 46 and 40 species, respectively. The withdrawal of water by the water company (SONEB) during the dry season could cause fish concentrations, making them more available and more vulnerable to fishing gears. In contrast, the flood season, with its huge water volume and dynamic hydrological regime, reduced the vulnerability of fishes to fishing gears and thus displayed a poor species number (21 species). Moreover, local migrations of fishes for spawning during this flooding period could lessen access to some fish species. In addition, the permanent use of chemical fertilizers and pesticides for adjacent agriculture pollutes and degrades the Okpara stream water quality and the nutritional values of the fishes through deposits of heavy metals in the fish flesh. Indeed, from the Northern Benin agriculture, a huge quantity of fertilizers and pesticides are drained in the stream by runoff and contaminates the fishes. Consequently, a study on the eco-toxicology of Okpara stream is required to assess the contaminations and overall quality of exploited, commercialized and ingested fishes in order to guaranty the health of grassroots and consumers of the Okpara stream fish resources.

Conclusion

The current ichthyological exploration on the Okpara stream indicated that this Oueme River tributary exhibited a high fish species richness (53 species) compared to other associated streams. However, the overfishing, the use of detrimental fishing gears, the use of chemical fertilizers and pesticides and the presence of a dam constructed by the Benin water

company (SONEB), constitute some major threats for the Okpara stream fish biodiversity and even for the whole Oueme River. A study on the fish community structure and on the eco-toxicology of this running water is required to better assess dynamics, ecological status and contaminations of the Okpara stream ichthyofauna and to contribute to species management and sustainable exploitation.

Conflict Of Interest

The authors declare that there is no conflict of interest.

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