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Biodiversity of Mochokidae (Pisces: Teleostei: Siluriformes) fishes from Niger River, Northern Benin, West Africa: Threats and management perspectives

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Abstract

Though commercially and economically important in artisanal fisheries of Niger River in Benin, the diversity of Mochokidae is poorly known. The current ichthyological research documents Mochokidae fishes of the Niger River in Benin in order to contribute to management. Fish samplings were performed monthly for 18 months using gillnets, castnets, longlines and seines. Overall, 14 species belonging to one genus, *Synodontis*, were inventoried. Spatially, less degraded sites, Money and Tounga in Benin, and Gaya in Niger Republic, were more speciose and comprised 12, 12 and 11 species, respectively, while 3 species, *Synodontis schall*, *Synodontis membranaceus*, and *Synodontis clarias* were recorded in the disturbed site. Seasonally, the dry season was the most speciose period where all the 14 species occurred. Currently, the Niger River is under severe degradation factors that affect the fish resources. Further investigation on the Mochokidae community structure is required to implement a community-based approach of species management.

Keywords: anthropogenic disturbances, benin, management, mochokidae, niger river, *Synodontis*

Introduction

Among the African catfish, the Mochokidae is one of the most speciose families and widely distributed in African riverine waters such as Koumba (Guinée), Ofin (Ghana), Sassandra (Ivory Coast), Oueme (Benin), Mungo (Cameroun), Cross (Nigeria), Bagbe (Sierra Leone) and Niger River that are permanently exploited for artisanal fisheries (Levêque *et al.*, 1992)^[1]. Overall, the Mochokidae comprises ten (10) genera for more than 170 described species (Ferraris, 2007)^[2]. Among them, five (5) genera and 48 species are known in West Africa and comprised *Chiloglanis* (8 species), *Mochokus* (2 species), *Microsynodontis* (1 species), *Mochokiella* (1 species) and *Synodontis* (36 species) (Paugy and Roberts, 2004)^[3]. In West and Central Africa, Mochokidae fishes showed a wide distribution and are present in the Volta and Pra basins in Ghana, Bénoué and Sassandra basins in Ivory Coast, Little Scarcies and Jong basins in Sierra Leone, Konkouré, Gbin, Kolente and Cavally basins in Guinée, the basins of Kribi, Lobe, Sanaga, Wouri, Cross and Mungo in Cameroon, the basins of Senegal and Gambie, Opoba, Enyong and Cross basins in Nigeria, the Coastal basins from Ghana to Gabon, the basins of Géba in Guinee Bissau, the Mono and Oueme Rivers in Benin etc. In particular, the Mochokidae fishes are widely distributed in the great African freshwater basins and rivers such as the Nile, Chad, Niger and much of the West African region (Paugy and Roberts, 1992)^[4].

In general, species belonging to Mochokidae show a naked body without scales. Mochokidae lack nasal barbels, but possess three (3) mental pairs of barbels comprising a pair of maxillary barbels and two (2) pairs of mandibular barbels, except in some fishes where the lips are modified in an adhesive disk, a sucker. The first dorsal fin is rayed and shows a spine at the anterior part, the second is an adipose dorsal fin that is sometimes rayed. The first ray of the pectoral fin is spiny and denticulated.

In Benin, the species of Mochokidae are widespread in the rivers and associated tributary basins such as Mono, Oueme, Sô, Niger and at a lower level in lacustrine waters where they appeared to be an important commercial fishery resource. In Benin, annual production of Mochokidae reached 600 metric tons (Direction des Pêches du Bénin, 1999)^[5]. Particularly, in the Benin part of the Niger River, Koba (2004)^[6] reported that the Mochokidae represented

10.80 % of the total catches and constituted one of the foremost species in the fish market of Malanville town (personal observation). In Niger River, the Mochokidae has been represented by thirty-three (33) species belonging to three (3) genera, the genus *Synodontis* with 28 species, the genus *Chiloglanis* with 4 species and the genus *Mochokus* with 1 species (Paugy and Levêque, 2004) [7].

Notwithstanding their great importance in fisheries in the Benin part of the Niger River that currently is under severe environmental degradation pressure, the Mochokidae fishes of the Niger River at Malanville Township in Benin are poorly documented. Major factor of environmental disturbances were overfishing, utilization of controversial fishing gears, floating plant invasions, domestic waste dumpings, introduction of invasive fishes such the Nile tilapia *Oreochromis niloticus* etc. Successful ecosystem management and biological resource conservation and valorization require a complete knowledge of inhabiting fishes and status.

The current ichthyological investigation aimed to document the Mochokidae fish fauna in the Niger River at Northern Benin in order to contribute to ecosystem management and fish biodiversity conservation and valorization.

Materials and Methods

Study region

The study area is the Niger River around the municipality of Malanville (Benin) that covers 3.016 km² with an average altitude of 200 m. Malanville is located in the extreme North-East of Benin Republic between 11°5' and 12° North latitude and between 2°45' and 3°40' East longitude and where Niger River stands as border between the two neighbor countries, Benin and Niger Republics. This municipality is limited to the North, South, West, and East by the Niger Republic, Kandi/Ségbana town, Karimama town and Nigeria, respectively. The study region displayed a Sudano-Sahelian climate marked by a dry season from November-April and a wet season from May-October. Harmattan is the dominant wind blowing from November to January in all directions with temperatures varying between 16 and 25 °C and average annual rainfall was about 750 mm (Adjovi, 2006) [8].

In Benin, the Niger River comprised three (3) tributaries, Alibori (338 Km), Sota (250 Km) and Mékrou (410 km) that

were flooded during August and September. Almost every year, the Niger River caused a severe inundation covering 275 Km² at peak flood (Welcomme, 1985) [9]. Also, in its lower reaches, on the border of Niger and Benin countries, the Niger River displayed a vast wetland, covering about 300 ha that constitutes an important spawning and nursery grounds for the fish community (Moritz *et al.*, 2006) [10]. The soils in Malanville were gneissic for most part of the territory while the Niger valley and its tributaries were sandy-clayish and ferruginous. Alluvial, sandy loamy, and muddy soils were sometimes found during the rainy season on the high terraces and covered with a grassy savanna dominated by trees such as *Adansonia digitata* and *Borassus aethiopum*. Malanville comprised some protected forests such as those of Goungoun, Boïffo (Guéné locality) and a hunting area that extended from Djona to Torozougou villages. Aquatic vegetation in Niger River included floating, bottom-rooted and submerged plants such as *Pistia stratiotes*, *Echhornia crassipes*, *Nymphaea* spp, *Marsilea* sp, *Ipomoea aquatic*, *Ludwigia* spp, *Echinochloa colona* and *Typha domingensis* (Hauber, 2011) [11]. Fish resources were heavily exploited by ethnic groups such as Dendi, Fulfuldé, Monkolé, Derma, Haoussa, Nago, Yoruba, Bariba and Kotocoli. Other important ethnic groups from Southern Benin were Mina, Adja, Goun, Fon exerting a high fishing pressure on the river. Caught fishes including Mochokidae species were debarked and commercialized in Malanville fish market.

Sampling sites

Fish collection sites (Figure 1) were selected in Niger River according to the importance of fishing activities and accessibility to locations. Overall, the Mochokidae species were sampled on four (4) stations. In the first two sites, "Tounga village (11°52'216"N, 3°23'907"E)" and "Behind Dry Port (11°52'112"N, 3°23'672"E)" under anthropogenic disturbances, fishing activities were moderate. The third site "Money village (11°52'987"N, 3°20'819"E)" was less polluted and fishing activities were highly developed. "Gaya village (11°52'675"N, 3°25'329"E)" is the only site from Niger country. This site was deeper, less degraded with highly developed fishing activities.

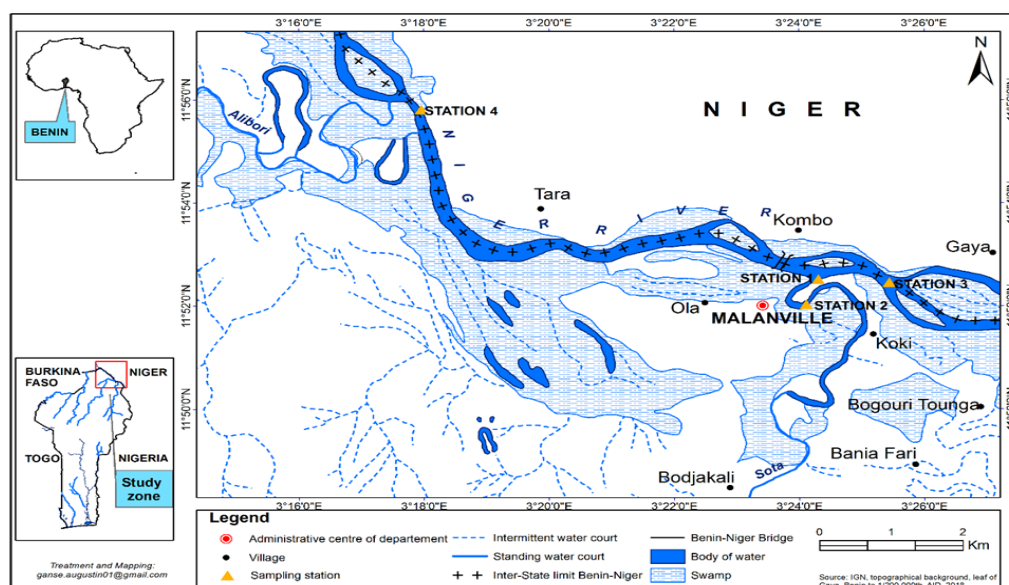


Fig 1: Study region and Sampling Stations, Station 1 = Tounga, Station 2 = Behind dry port, Station 3 = Gaya, Station 4 = Money.

Table 1: Geographic coordinates of the different sampling stations

Stations	Latitude	Longitude
Tounga	11°52'216"N	3°23'907"E
Behind dry port	11°52'112"N	3°23'672"E
Gaya	11°52'675"N	3°25'329"E
Money	11°52'987"N	3°20'819"E

Fish sampling and identification

Fish collections were done monthly at the four sites from February 2015 to July 2016. At each site, fish samplings were performed both in the open water habitat and in the adjacent aquatic vegetation habitat. To approximate the whole diversity of Mochokidae and to ensure the representativeness of fishes in the collection, samplings were done both from fisherman artisanal fisheries and from experimental captures using many types of fishing gears and fishing methods. Fishing gears and techniques used in artisanal fisheries were cast nets (6 m-diameter, 20 mm-mesh), gillnets (50 m × 1 m, 40 mm-mesh; 50 × 1 m, 30 mm-mesh; 50 m × 1 m, 20 mm-mesh), experimental gill net (3000 m × 500 m, 1 m² mesh), laboratory seine (6.15 m × 2 m, 16 mm-mesh) and longlines. Samplings from artisanal fisheries were performed on the basis of 1/3 of the total number of species individuals when these latter exceed 50 specimens. When the total number of individuals was less than 50 for a given species, all individuals of this species were included in the sample (Kakpo, 2011; Okpeicha, 2011) [12, 13]. Experimental captures were supplemented using a laboratory seine of length = 6.15 m, width = 2 m and mesh = 16mm. At each sampling station, eight to ten seine hauls on about 10 meters were made.

After collection, Mochokidae individuals were identified in situ using taxonomic identification guides and references of Van Thielen et al. (1987) [14], Levêque et al. (1990;1992), Paugy et al. (2003a, b), Paugy et al. (2004) and Lévêque and Paugy (2006) [15-18]. Collected fish specimens were then preserved in 10% formalin and transported to the "Laboratoire d'Ecologie et de Management des Ecosystèmes Aquatiques (LEMEA)" of the Faculty of Sciences and Technics of Abomey-Calavi University. The specimens were then removed from the formalin and transferred to 70 % ethanol to facilitate subsequent observations, such as measurements, stomach contents analysis etc. Fish names were confirmed using <http://www.fishbase.org> (Schreck, 1990; Murphy and Willis, 1996; Adite et al., 2017) [19-21]. After identifications, the total length (TL) and the standard length (SL) of each specimen were measured to the nearest 0.1 cm using an ichthyometer, and the individual weight (W) was measured to the nearest 0.01g using an electronic scale

(CAMRY 0.1g / 500g; AWS).

Results

Water quality

In the Niger River of Benin, the depths ranged between 110-960 cm and transparencies were low and varied from 0 to 60 cm. Water temperatures were relatively high and ranged between 21 and 34.2°C. The dissolved oxygen concentrations ranged between 2.60-9.36 mg/l and the percentage of saturation varied from 35.1 to 131.7 %. The water was alkaline or acid with pHs ranging between 6.20 to 8.90. These different values of the physicochemical parameters indicated that the Niger River in Benin was globally favorable to primary production, fish survival and fish growth. Nevertheless, the dumping of domestic wastes, the invasion of floating plants, oil spills, the introduction of invasive fish species and the use of chemical fertilizers and pesticides for agriculture could affect the water quality and cause changes in fish community structure.

Spatial and seasonal distribution of fish fauna

The current ichthyological investigation conducted in the Benin part of the Niger River revealed fourteen (14) Mochokidae species belonging to only one genus, *Synodontis*. Mochokidae fishes inventoried were, *S. schall* (Figure 2a), *S. membranaceus* (Figure 2b), *S. nigrita a* (Figure 2c), *S. clarias* (Figure 2d), *S. sorex* (Figure 2e), *S. violaceus* (Figure 2f), *S. melanopterus* (Figure 2g), *S. macrophthalmus* (Figure 2h), *S. ocellifer* (Figure 2i), *S. budjetti* (Figure 2j), *S. nigrita b* (Figure 2k), *S. courteti* (Figure 2l), *S. filamentosus* (Figure 2m) and *S. frontosus* (Figure 2n). Spatially, sites at Money and Tounga villages exhibited the highest species richness with twelve (12) and 12 species, respectively, and followed site Gaya in the Niger country with eleven (11) Mochokidae species. Inversely, only three (3) species, *Synodontis schall*, *Synodontis membranaceus* and *Synodontis clarias* were recorded at the "Dry Port" under severe degradation caused by anthropogenic disturbances. These three (3) species, *S. schall*, *S. membranaceus*, and *S. clarias* were also found at all sampling sites while *S. frontosus* was recorded only in Tounga site (Table 2). Seasonal records indicated that the dry period was the most speciose season during which all the 14 Mochokidae were encountered, followed by the rainy season with 11 species and the flood period with seven (7) species. Fishes such as *Synodontis schall*, *Synodontis membranaceus*, *Synodontis nigrita a*, *Synodontis macrophthalmus* and *Synodontis violaceus* were recorded at all seasons, while *Synodontis frontosus*, an uncommon species, was found only in dry period (Table 3).

Table 2: Spatial distribution of Mochokidae species collected in the Niger River in Benin from February 2015 to July 2016.

Species	Money	Tounga	Behind dry port	Gaya
<i>Synodontis schall</i> (Bloch & Schneider, 1801)	++	++	+	++
<i>Synodontis membranaceus</i> (Boulenger, 1907)	++	+	+	++
<i>Synodontis nigrita a</i> Valenciennes, 1840	++	+		+
<i>Synodontis clarias</i> (Linnaeus, 1758)	+	+	+	+
<i>Synodontis sorex</i> Günther, 1864	+	+		+
<i>Synodontis violaceus</i> Pellegrin, 1919	+	+		+
<i>Synodontis melanopterus</i> Boulenger, 1903	+			+
<i>Synodontis filamentosus</i> Boulenger, 1901	+	+		+
<i>Synodontis ocellifer</i> Boulenger, 1900	+	+		+
<i>Synodontis macrophthalmus</i> Poll, 1971	+	+		
<i>Synodontis budjetti</i> Boulenger, 1911		+		
<i>Synodontis nigrita b</i> Valenciennes, 1840	+	+		+

<i>Synodontis courteti</i> Pellegrin, 1906	+			+
<i>Synodontis frontosus</i> Vaillant, 1895		+		
Total species number	12	12	3	11

++ Abundant species (number of individuals > 50).

+ Less abundant species (number of individuals < 50).

Synodontis nigrita a: *Synodontis nigrita* with apparent spots

Synodontis nigrita b: *Synodontis nigrita* with non-apparent spots.

Table 3: Seasonal occurrence of Mochokidae species collected in the Niger River in Benin from February 2015 to July 2016

Species	Dry season	Rainy season	Flood
<i>Synodontis schall</i> (Bloch & Schneider, 1801)	++	++	++
<i>Synodontis membranaceus</i> (Boulenger, 1907)	++	++	++
<i>Synodontis nigrita a</i> Valenciennes, 1840	+	+	+
<i>Synodontis clarias</i> (Linnaeus, 1758)	++	+	
<i>Synodontis sorex</i> Günther, 1864	++	+	
<i>Synodontis violaceus</i> Pellegrin, 1919	+	+	+
<i>Synodontis melanopterus</i> Boulenger, 1903	+	+	
<i>Synodontis filamentosus</i> Boulenger, 1901	+	+	
<i>Synodontis ocellifer</i> Boulenger, 1900	+	+	
<i>Synodontis macropthalmus</i> Poll, 1971	+	+	+
<i>Synodontis budjetti</i> Boulenger, 1911	+	+	
<i>Synodontis nigrita b</i> Valenciennes, 1840	+		+
<i>Synodontis courteti</i> Pellegrin, 1906	+		+
<i>Synodontis frontosus</i> Vaillant, 1895	+		
Total species	14	11	7

++ Abundant species (number of individuals > 50).

+ Less abundant species (number of individuals < 50).

Synodontis nigrita a: *Synodontis nigrita* with apparent spots

Synodontis nigrita b: *Synodontis nigrita* with non-apparent spots.



a) *Synodontis schall* (Bloch & Schneider, 1801)



b) *Synodontis membranaceus* (Boulenger, 1907)



c) *Synodontis nigrita a* Valenciennes, 1840



d) *Synodontis clarias* (Linnaeus, 1758)



e) *Synodontis sorex* (Günther, 1864)



f) *Synodontis violaceus* (Pellegrin, 1919)



g) *Synodontis melanopterus* (Boulenger, 1903)



h) *Synodontis macrophthalmus* (Poll, 1971)



i) *Synodontis ocellifer* (Boulenger, 1900)



j) *Synodontis melanopterus* (Boulenger, 1903)



k) *Synodontis nigrita b* (Valenciennes, 1840)



l) *Synodontis courteti* (Pellegrin, 1906)



m) *Synodontis filamentosus* (Boulenger, 1901)



n) *Synodontis frontosus* (Vaillant, 1895)

Fig 2(a-n): Photos of the 14 Mochokidae species collected in the Niger River at Malanville. (Photo Arame)

Degradation factors

The ecological survey revealed that the Niger River in Benin was under severe degradation mostly generated by anthropogenic factors that modified and degraded the ecosystem. Major degradation factors recorded were:

- **Chemical fertilizers and pesticides used in agriculture:** Farmers used chemical fertilizers and pesticides in the floodplains or on the banks of the river for rice and vegetable production. These fertilizers reached the river either

through percolation, runoff water and soil erosion and constituted a major source of pollution of the aquatic environment during the rainy and the flood season. In addition, the high concentration of population around the Niger River and its tributaries contributed to the degradation of its quality that was also affected by the dumping of garbage and domestic wastes including dirty water from laundry, dishes etc., causing modification of the fish community structure (Figure 3).



Fig 3: Multiple utilizations of the river, (1) men and women are washing their clothes and doing dishes and (2) animals (oxen) are drinking water. (Photo Arame).

- **Utilization of prohibited and controversial fishing techniques:** Prohibited fishing gears such as cast nets, small meshes (1-5 mm) gill nets, seines and traps were widely utilized by fishermen. Also, the “Acadja”, a fishing technique

that involve planting of tree branches in shallow waters was very common and was increasingly used in the Niger River (Figure 4).

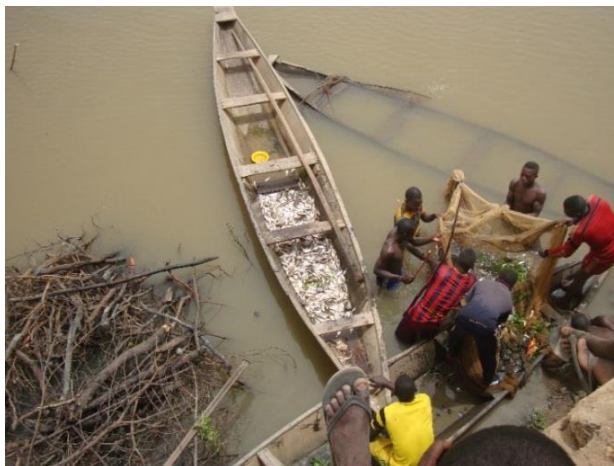


Fig 4: Fisherman catches comprising small fish individuals that indicate overfishing. (Photo Arame).

- **Transportation of petroleum products:** The river was also used by Nigerians, Nigeriens and Beninese for the transportation of fuels (gasoline) and others petroleum products that spilled in the river in case of accidents. Likewise, motorized boats and motor pumps used for irrigation also polluted and degraded the river environment,

loss of the fish biodiversity. As reported by Koba (2004) [6], eight (8) fish species were declared missing from the catch of the Niger River ichthyofauna.

- **Proliferation of invasive plants:** The Niger River was covered by some invasive floating plants such as *Nymphaea* spp and *Echhornia crassipes* that retrieve nutrients from the water, reduce phytoplankton production, modify the water quality and cause changes in fish community structure with

Discussion

Though the water quality of the Niger River appeared to be globally suitable for primary production, in most sites, the various anthropogenic disturbances depicted constituted a threat for uncommon and less tolerant species. Overall, the current fish survey indicated that the Niger River in Benin comprised a relatively high number of Mochokidae fishes

reaching fourteen (14) species belonging to only one genus, *Synodontis*, and dominated by *Synodontis schall*. This record of Mochokidae species was higher than 10 species reported by Hauber (2011) ^[11] in the Niger River at Malanville. Likewise, Koba (2004) ^[6] reported a lower Mochokidae richness (8 species) for two combined towns in Benin, Malanville and Karimama. Indeed, species such *Synodontis membranaceus*, *Synodontis clarias*, *Synodontis violaceus*, *Synodontis melanopterus*, *Synodontis budjetti*, *Synodontis courteti* and *Synodontis frontosus* recorded in the current inventory were absent in Koba (2004) ^[6] records. Inversely, species such as *Synodontis tourei* and *Brachisynodontis batensoda* found by previous research were not recorded in the current fish assemblages. This difference in the species richness could be attributed to differential sampling efforts and sampling strategy and probably, past collections may not have covered the three seasons, dry, wet and flood that in most cases showed differences in species richness (Lalèyè *et al.*, 2004) ^[22]. Probably, the abundances of these two (2) species, *Synodontis tourei* and *Brachisynodontis batensoda*, may have declined because of ecosystem degradation and habitat losses. While comparing with other habitats, findings indicated that the current record was greater than those reported for most rivers from Benin, such the Oueme river basin where only three (3) Mochokidae, *S. Ouemeensis*, *S. nigrita* and *S. Sorex* were recorded (Lalèyè *et al.*, 2004; Musschoot *et al.*, 2008) ^[22, 23], the Sô river with only two (2) species, *S. schall* and *S. nigrita* (Hazoume *et al.*, 2017) ^[24], the Hlan and the Tovè rivers with one species, *Synodontis nigrita* and *Synodontis schall*, respectively (Montchowui *et al.*, 2007; Djidohokpin *et al.*, 2017) ^[25, 26]. In Mali, Sanogo *et al.* (2012) ^[27] reported nine (9) Mochokidae, *S. clarias*, *S. courteti*, *S. filamentosus*, *S. schall*, *S. macrophthalmus*, *S. membranaceus*, *S. nigrita*, *S. ocellifer* and *S. sorex* in Baoulé River of the Niger River basin. In Bagoé River, Sanogo *et al.* (2015) ^[28] identified six (6) species: *S. membranaceus*, *S. clarias*, *S. sorex*, *S. filamentosus*, *S. nigrita*, *S. schall*. Seasonally, the highest Mochokidae richness recorded during the dry and wet periods, 14 and 11, respectively, was due to the fact that fish spawning occurred during the wet season and resulting offspring and juveniles were concentrated and recruited in the dry period during which water volume was reduced. In addition to water evaporation, during the dry season, water withdrawal for rice farming lowered down the water level and concentrated the fishes (Adjibade *et al.*, 2019) ^[29]. With regards to spatial distribution of Mochokidae, the 2 sites, Money and Tounga in Benin exhibited the highest species richness that reached 12 and 12 species, respectively during the survey period. Also, 11 species were recorded in site Gaya of the Niger Republic. These results could be attributed to the fact that sites Money and Tounga communicated respectively with Alibori and Sota tributaries which, because of periodic floodings, showed a great variability of habitats that constituted excellent spawning and nursery grounds where ecological conditions favored high Mochokidae recruitment (Gulland, 1983) ^[30]. These areas also provided refuges for little fishes against predators. Though site Gaya was under heavy fishing pressures from both Beninese and Nigerien fishermen, the species richness was still high in this habitat because located in the main channel of the River. The low species richness (3 species) recorded in site “Behind the Dry Port” was probably due to anthropogenic disturbances such as dumping of domestic wastes and garbage

by grassroots, proliferation of invasive plants, releases of chemical fertilizers and pesticides through adjacent agricultures (rice cultivation), introduction of exotic fishes (*Oreochromis niloticus*) and overfishing. In particular, the overfishing appeared to be one of the major threats to the fish biodiversity of the Niger River and was due to the increase of fishermen population that utilized all kinds of detrimental and controversial fishing gears, cast nets, gillnets, traps constructed with small mesh-nets, hooks and long lines. Welcomme, cited by Scudder and Conelly (1985) ^[31] reported that in year 1970, the overfishing was scant, uncommon and was not a threat to the Niger River fish fauna because of the availability of high fish stocks exploited by a relatively low number of fishermen. According to Koba (2004) ^[6], the increase of skilled fisherman population that originated from all region of Benin (South, Center, North) and from neighbor countries such as Niger, Togo, Burkina Faso, Mali, Ghana and Nigeria, has led to the overexploitation of the fish resources. Indeed, more than 15 ethnic groups, Dendi, Fulfuldé, Monkollé, Djerma, Haoussa, Nago, Yoruba, Bariba, Wla, Pedah, Mina, Adja, Goun, Fon, Kotocoli etc. exerted a high fishing pressure on the river fish fauna (Koba, 2004) ^[6]. As reported by the Institute of Statistics (INSAE, 1992) ^[32], about 6356 active fishermen families have been recorded in Malanville and Karimama towns. Because of the high level of ecosystem disturbance and resource degradation, a successful restoration of the Niger River and resource conservation require a complete survey on the ichthyo-biodiversity and its community structure.

Conclusion and perspectives

The current ichthyological survey indicated that the Niger River in Benin comprised a high Mochokidae richness, 14 species, belonging all to one genus, *Synodontis*. Among them, *Synodontis schall* dominated the Mochokidae sub-community. The dumping of garbage and domestic wastes, the invasion of floating plants, the use of prohibited fishing gears, the introduction of invasive fish species and the use of chemical fertilizers and pesticides in agricultures, were the major threats and degradation factors affecting the Mochokidae fishes of the Niger River in Benin. The current findings, in addition to a survey on the community structure, will serve as reference data and documentation for monitoring and follow-up and will contribute to ecosystem and species management.

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