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Length-weight relationships and condition factors of Mormyridae (Teleostei: Osteglossiformes) from Niger River at Northern Benin: needs for ecosystem restoration and species management

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Abstract

Length-weight patterns and condition factors of eleven (11) Mormyrid fishes have been examined in Niger River in Northern Benin to evaluate the plumpness of the fishes in this riverine habitat. Fishing gears such as gill net, cast net and seine have been used for monthly samplings and a total of 6825 Mormyrid individuals has been collected from February 2015 to July 2016. Mormyrid abundance varied from 09 individuals for *Mormyrus hasselquisti* to 2,985 for *Marcusenius senegalensis*. The size structure showed unimodal standard length distribution for eight (8) species and revealed that juveniles were mostly exploited. Length-weight models displayed allometric coefficients (*b*) varying between 2.2469 and 3.632 indicating positive and negative allometric growth with determination coefficients (r^2) ranging between 0.71 and 0.99. Condition factor varied with habitats and seasons and the highest K=4.94 was recorded for *Brienomyrus niger* and the lowest K=0.42 was recorded for the dominant species, *Marcusenius senegalensis*. These data constitute valuable fisheries documentation that will contribute to Mormyrids management and conservation in order to assure a sustainable exploitation of elephant fishes in Niger River.

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Introduction

With more than 228 described species belonging to 22 genera, the Mormyridae is the most speciose family of freshwater fishes endemic to African inland waters where they consistently appeared in artisanal fisheries (Hopkins *et al.*, 2007; Rich *et al.*, 2017; Adjibade *et al.*, 2019a). Also called elephant fishes, Mormyrids are mostly found in riverine and in some lacustrine habitats all over the continent, except in Southern Sahara, Northern Mahgreb and Southern Cap provinces (Hopkins *et al.*, 2007). Mormyrids reached their highest diversity in the river systems of Central and West Africa with more than 100 species that made 16.2% of the total species richness. Numerically, Mormyrids were often among the most abundant fishes in running waters (Roberts, 1975; Harder, 2000).

As common taxonomic characteristics, the species belonging to Mormyridae display elongate and laterally compressed bodies covered with small cycloid scales (Hopkins *et al.*, 2007). The shapes of the head are highly variable and their mouths, sometimes tubular, are small, non-protrusible and vary in form (Scheffel and Kramer, 1997; Olopade, 2013). Both parasphenoid and tongue are toothed and eyes are usually small and covered by skin. Paired and unpaired fins are present. The caudal peduncle is narrow and cylindrical, but carries an electric organ and two paired sets of specialized Gemminger's bones, one dorsal and one ventral. The caudal fin is deeply forked and the dorsal and anal fins show 12-91 rays and 20-70 rays, respectively (Hopkins *et al.*, 2007). Mormyrids possess an active electric sense that generates weak electric discharges used for orientation, prey detection and communication (Toerring and Moller, 1984; Moller, 1995; Schugardt and Kirschbaum, 2004; Arnegard and Carlson, 2005; Lévêque *et al.*, 2005). Elephant fishes usually live in group and display a schooling behavior in a trouble or dark water, and the majority of the species occurs in running habitats with swift current (Nzeh and Lawal, 2012). They are crepuscular or nocturnal fishes and leave in the bottom. Although Mormyrids are intolerant to pollution, some species like *Brienomyrus niger* can live in harsh conditions and breathe atmospheric air (Moritz and Linsenmair, 2007). In general, the species of this taxa are invertivore fishes and forage mainly on aquatic insects, detritus, sand particles, mollusks, crustaceans and phytoplankton (Adjibade *et al.*, 2019b). Mormyrids are highly valued freshwater fishes used in aquarium and aquaculture and are important fisheries component in African riverine waters (Atobatele and Ugwumba, 2011).

In Benin, elephant fishes are of high economic and commercial importances and constitute a valuable component of the artisanal fisheries in most running waters. As reported by the Benin Fisheries Department, yearly catches approximated 248 metric tons that valued nearly 250,000,000 F CFA. Particularly, in Niger River, Mormyrids made 12.65% of the commercial catches and appeared to be the second family most abundant in this northern ecosystem after cichlids (Koba, 2005; Adjibade *et al.*, 2019a). Notwithstanding their high economic, commercial and fisheries importances in Niger River, little is known about growth patterns, size distributions, length-weight relationships and condition factors of Mormyrids in this degrading regional riverine ecosystem (Nwani *et al.*, 2006). Currently, the Niger River in Benin is under deadly anthropogenic disturbances such as dumpings of domestic garbage, the uses of chemical fertilizers and pesticides in adjacent agriculture, the use of prohibited and detrimental fishing gears, the proliferation of floating vegetation, the introduction of invading fishes such as the Nile Tilapia, *Oreochromis niloticus* etc. These environmental mal-practices negatively affect the fish community structure and in particular the growth patterns of the fishes (Laë *et al.*, 2004; Hauber, 2011).

Length-weight models and condition factors are useful fisheries management tools that evaluate the well-being of fishes. As reported by Gbaguidi and Adite (2016), length-weight trends and condition factors are robust predictors of fish physiological conditions such as gonad maturation, fecundity, spawning, survival and growth (Bagenal and Tesch, 1978; Abowei, 2010). In addition these indices depict

the ecological health of the ecosystem and constitute some powerful tools for management decision (Deekae and Abowei, 2010).

This fisheries survey documents size structures, length-weight relationships and condition factors of Mormyrids from Niger River in Northern Benin in order to evaluate the plumpness of the fishes and to contribute to fisheries management, habitat protection and sustainable exploitation of these fishes.

Materials and methods

Study location

The current study was conducted in Niger River (at Malanville township), the most important running water in Northern Benin. Located at latitude 11°52'216"N, longitude 3°21'111"E, the Niger River stands as frontier between Benin and Niger Republics. The region shows a soudano-sahelian climate characterized by a dry season from October to April, a rainy season from May to July and a flood season covering August and September. Annual rainfall averaged 750 mm with a peak around 1000 mm (PDC Malanville, 2006; Aboubacar and Humphrey, 2007). Ambient temperatures reached 41°C in March, but may depleted up to 16°C during harmattan, the dominant wind that blows between November-January (PDC Malanville, 2006; Hauber, 2011). The Niger River is composed of a vast floodplain covering about 300 ha that stood as a spawning grounds (Moritz *et al.*, 2006). The region shows argilo sandy and ferruginous soils that are composed of gneiss. In Niger River in Benin, the plant community included floating and bottom-rooted vegetation as well as submerged and terrestrial species (Hauber, 2011). The river at Malanville town showed depths varying between 130-410cm and transparencies between 0-66cm. Dissolved oxygen concentration ranged between 3.8-9.17mg/l with percentages of dissolved oxygen saturation varying between 47-211.14%. Water temperatures ranged between 21.6-35.6°C, pHs and conductivities between 6.2-8.7 and 100-400µ/cm, respectively (Adjibade *et al.*, 2019a).

Sampling sites

In the current fisheries survey, five (5) sampling locations were selected. Site1 and Site2 were located on Sota stream, a tributary of the Niger River. Degrading human activities occurred at Site1 that was covered by dense vegetation. At Site2 (Tounga), in addition to rice farming that occurred at the adjacent wetlands, bathings, clothe washings and dishes were directly done in the water. Site3 was situated on the main channel of the River at Gaya Village in Niger Republic. Compared to Site1 and Site2, Site3 was less degraded. Also less degraded, Site4 was located on the main channel of Niger River. Site5 was located under Benin-Niger bridge, but under anthropogenic disturbances such as pollution and proliferation of floating plants (Fig. 1).

Collection of Mormyrid fishes

Mormyrid individuals were sampled monthly from February 2015 to July 2016 at all sampling sites in aquatic vegetation and in open water habitats using seine (6.15m × 2m, 16mm-mesh), cast nets (6m-diameter, 20mm-mesh), experimental gill net (50m × 1m, 40mm-mesh; 50 × 1m, 30mm-mesh; 50m × 1m, 20mm-mesh) and traps. Seines were used in aquatic vegetation, and cast nets and gillnets were used in open water (Winemiller and Adite, 1997). To supplement experimental collections, samplings were also made in artisanal catches of local fishermen. After samplings, fish individuals were identified in situ using identification keys such as Paugy *et al.* (2003), Nelson (2006) and Van Thielen *et al.* (1987). Fish individuals were then preserved in 10% formalin and latter in 70% ethanol and conveyed to the Laboratory of Ecology and Aquatic Ecosystems Management of the Faculty of Sciences to confirm identifications.

Data Analysis

In the laboratory, identified fishes species were confirmed with Fishbase (http://www.fishbase.org) and total abundances of each species were recorded by site. Fishes were then weighed to the nearest 0.1 g and total length (TL) and standard length (SL) were measured to the nearest 0.1cm. The length-weight relationship (LWR) of each Mormyrid species was established for the eleven (11) species using the power model:

$$W = a\,TL^{b}$$ (Le Cren, 1951)

and its log-linear form is :

$$\text{Log } W = \text{Log } a + b \text{ Log TL}$$

where TL is the Total Length, W is the individual Weight, "a" is the intercept and "b" is the allometry coefficient (Le Cren, 1951). The value of "b" was compared with b=3 (isometry) using the student's t-test (Sokal and Rohlf, 1995). The frequency histograms (size structures) of standard length (SL) intervals were constructed for each Mormyrid species. The plumpness of the fishes was evaluated using Tesch's (1978) condition factor (K):

$$K = (W/TL^b) \times 100$$

Where, K is the condition factor, W is the total weight (g) and TL the total length (cm). According to Barnham and Baxter (1998), if K = 1.00, the condition of the fish is poor and the individual is long and thin. A 1.20 value of K indicates that the fish is of moderate condition and acceptable to many anglers. A good and well-proportioned fish would have a K value that is approximately 1.40 and higher.

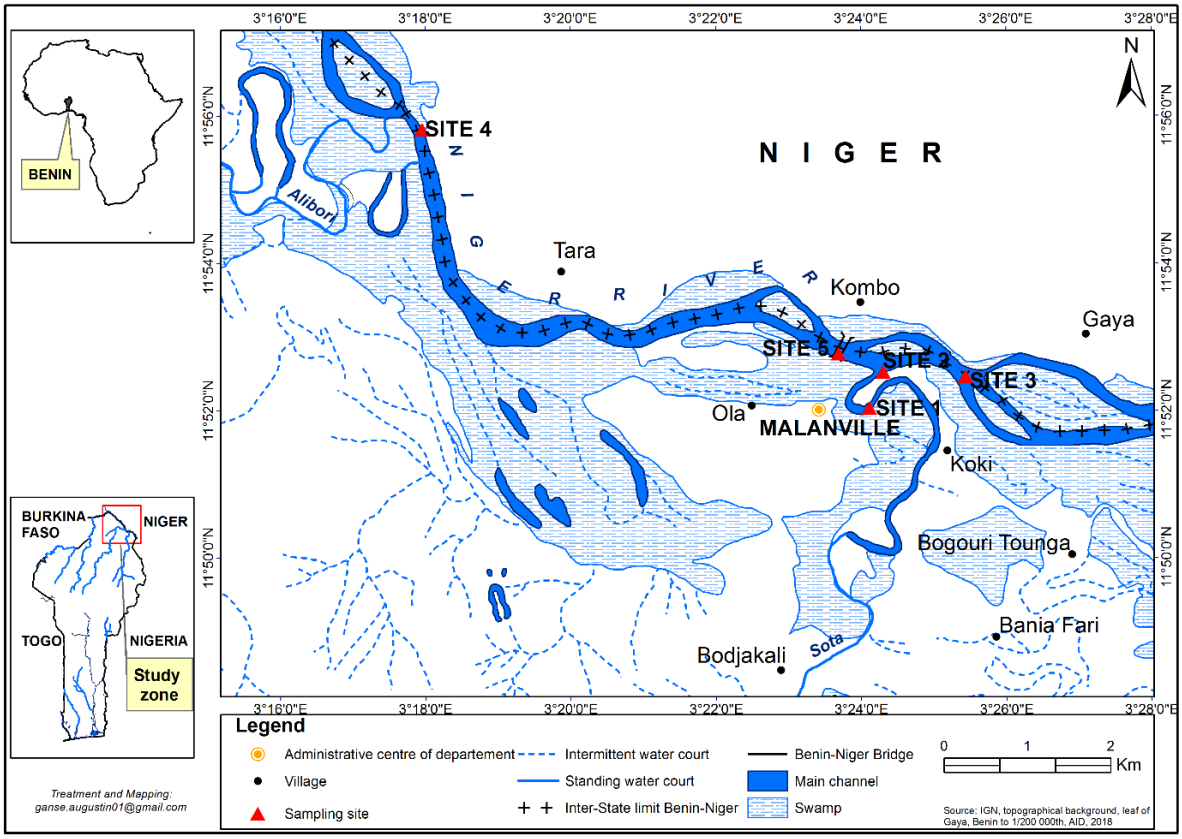

Fig. 1. Map showing Niger River (Northern Benin) and the five study locations : 1= Sota Stream, 2= Tounga, 3= Gaya (Niger Country), 4=Money, 5= Under Benin-Niger Bridge.

Results

Relative abundances and size structures

During the eighteen (18) months of fish survey, eleven (11) mormyrid species were inventoried in Niger River at the northern Benin. Numerically, dominant species were *Marcusenius senegalensis* making 43.74% of the Mormyrid sub-community, *Mormyrus macrophthalmus* (14.87%), *Hyperopisus bebe* (11.43%), *Petrocephalus bovei* (11.21%), *Mormyrus rume* (8.54%) and *Hippopotamyrus pssittacus* (4.69%) (Adjibade *et al.*, 2019a). The five (5) remaining species, *Pollimyrus isidori*, *Mormyrops anguilloides*, *Campylomormyrus tamandua*, *Mormyrus hasselquisti* and *Brienomyrus niger* accounted numerically for only 5.51%. With regards to sizes, total length (TL) of Mormyrid assemblages ranged between 4.6cm (*Pollimyrus isidori*) and 48.5cm (*Mormyrops anguilloides*). Mormyrids with large sizes were *Mormyrops anguilloides* exhibiting TL ranging between 8.9cm and 48.5cm, *Mormyrus*

rume (TL: 47.7cm), *Hyperopisus bebe* (TL: 39.5cm), *Campylomormyrus tamandua* (TL: 27.8cm), *Marcusenius senegalensis* (TL: 27.4cm), *Mormyrus macrophthalmus* (TL : 25cm) and *Mormyrus hasselquisti* (TL: 23.5cm). Standard length frequency histograms (Fig. 2 (a-k)) established for all Mormyrid species showed unimodal size distributions except *Brienomyrus niger*, *Mormyrus hasselquisti* and *Mormyrops anguilloides* that presented a bimodal size distribution.

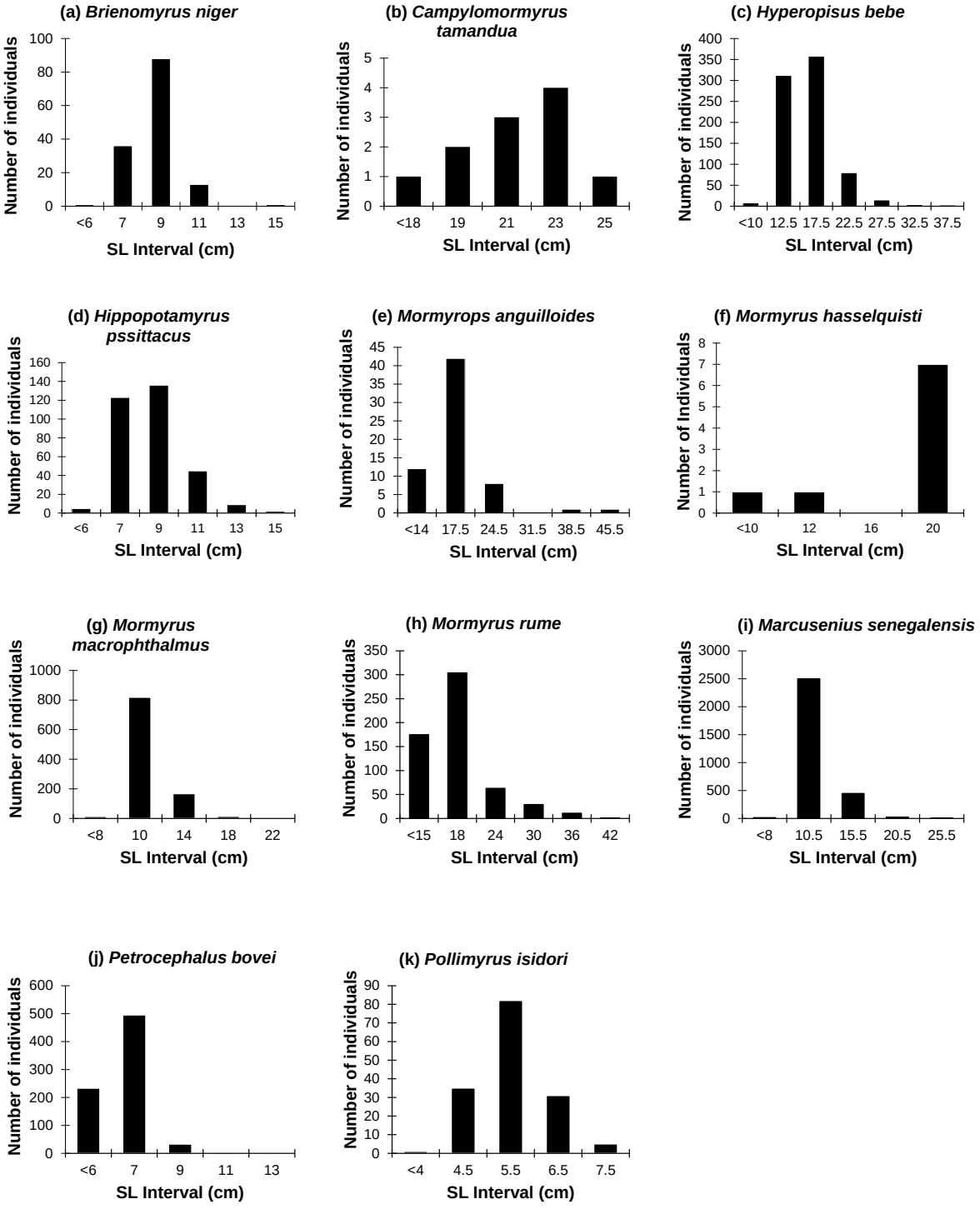

Fig. 2. (**a-k**) Size structures of Mormyridae fishes collected in Niger River in Northern Benin from February 2015 to July 2016.

Length-weight relationships (LWR)

Descriptive statistics such as sample sizes, standard length and weight ranges of the 11 Mormyrid species are presented in Table 1. Also, the matrix of outputs such as "a", the constant, "b", the slope or allometric coefficient and r^2, the determination coefficient of the length - weight regression equations are given in Table 1. Overall, allometric coefficients b were relatively high and ranged between 2.2469 and 3.632 for *Brienomyrus niger* and *Mormyrus hasselquisti*, respectively (Table 1). Six (6) Mormyrids, *Brienomyrus niger*, *Campylomormyrus tamandua*, *Mormyrops anguilloides*, *Mormyrus macrophthalmus*, *Petrocephalus bovei* and *Pollimyrus isidori* showed significant negative allometric growth (b <3; p <0.05). In contrast, five (5) species, *Hyperopisus bebe*, *Mormyrus rume*, *Hippopotamyrus pssittacus*, *Marcusenius senegalensis* and *Mormyrus hasselquisti* exhibited significant positive allometric growth (b >3; p <0.05) (Table 1). The regression equations showed significant (p <0.05) determination coefficients (r^2) ranging between 0.71 (*Mormyrus hasselquisti*) and 0.99 (*Petrocephalus bovei*) (Table 1 & Fig.3 (l-v)).

Condition factors

In Niger River, condition factors of Mormyrids significantly (p <0.05) varied with species. *Brienomyrus niger* exhibited the highest condition indice (K=4.94) whereas the lowest condition indice (K=0.11) was recorded for *Mormyrus hasselquisti* (Table 2). Only four (4) Mormyrids, *Brienomyrus niger, Campylomormyrus tamandua, Pollimyrus isidori* and *Petrocephalus bovei* showed relatively higher condition factors ranging between K=1.91 and K=4.94. Inversely, the seven (7) remaining species, *Mormyrus hasselquisti, Hippopotamyrus pssittacus, Marcusenius senegalensis, Mormyrops anguilloides, Mormyrus macrophthalmus, Hippopotamyrus pssittacus* and *Hyperopisus bebe* exhibited lower K values less than 1.

Spatially, condition factors of Mormyrids significantly (p<0.05) varied with habitat. Indeed, in the open water, species such as *Hyperopisus bebe, Hippopotamyrus pssittacus, Mormyrops anguilloides, Marcusenius senegalensis* and *Pollimyrus isidori* showed higher K varying between 0.42 and 4.34. Inversely, *Brienomyrus niger, Campylomormyrus tamandua, Mormyrus macrophthalmus, Mormyrus rume and Petrocephalus bovei* exhibited higher K in the aquatic vegetation habitat with values between 0.64 - 9.36 (Table 3 and 4). Also, significant (p<0.05) seasonal variations of K were recorded. Indeed, species such as *Brienomyrus niger* and *Pollimyrus isidori* exhibited higher condition indices during the dry season with K between 3.03 and 4.38. In contrast, *Hippopotamyrus pssittacus, Mormyrus macrophthalmus, Petrocephalus bovei and Pollimyrus isidori* showed higher K (1.29-3.99) in the wet periods and Mormyrids such as *Mormyrops anguilloides, Mormyrus rume and Petrocephalus bovei* exhibited higher condition indices during the flood season with K ranging between 0.74 to 12.94.

Table 1. Length-weight regression equations of the eleven (11) Mormyrid fishes collected in Niger River in Northern Benin from February 2015 to July 2016. a : Regression equation intercept ; b±SE : Regression equation slope, r^2 : coefficient of determination.

Species	Abundance	SL mean±SE	a	b±SE (slope)	r^2	Growth trends
Brienomyrus niger	139	8.58±1.13	0.0488	2.25±0.7	0.7563	A-
Campylomormyrus tamandua	11	21.25±2.2	0.0394	2.44±0.02	0.9419	A-
Hyperopisus bebe	780	16.16±3.70	0.0045	3.05±0.07	0.9115	A+
Hippopotamyrus pssittacus	320	8.56±1.59	0.0066	3.10±0.07	0.9147	A+
Mormyrops anguilloides	64	17.88±5.70	0.0082	2.93±0.05	0.9676	A-
Mormyrus hasselquisti	9	17.68±4.41	0.0011	3.63±0.04	0.9862	A+
Mormyrus macrophthalmus	1015	10.75±1.80	0.009	2.84±0.05	0.9251	A-
Mormyrus rume	583	17.83±5.00	0.0044	3.10±0.05	0.9609	A+
Marcusenius senegalensis	2985	11.28±1.89	0.0041	3.22±0.06	0.8981	A+
Petrocephalus bovei	765	6.45±0.92	0.0186	2.69±0.11	0.7146	A-
Pollimyrus isidori	154	5.46±0.67	0.0308	2.39±0.03	0.97	A-

A- : Negative allometric growth
A+ : Positive allometric growth

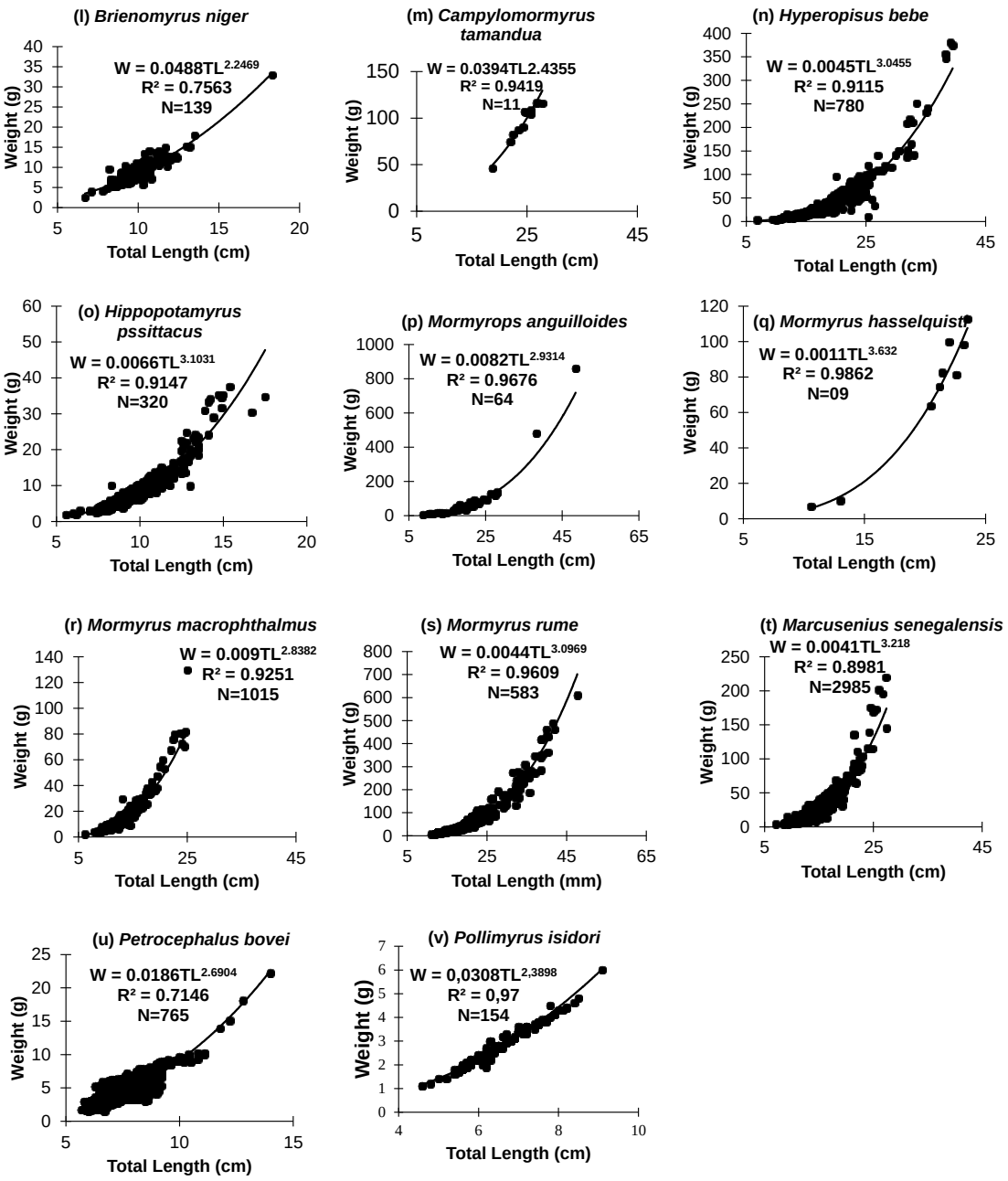

Fig. 3. (**l-v**) Curvilinear relationships between total length (TL) and body weight (W) of Mormyridae fishes collected in Niger River in Northern Benin from February 2015 to July 2016.

Table 2. Mean condition factors (K) of Mormyrid fishes collected in Niger River in Northern Benin from February 2015 to July 2016.

Species	Abundance	Mean condition factor (K±SE)	K range
Brienomyrus niger	139	4.94±0.81	3.02-8.49
Campylomormyrus tamandua	11	3.95±0.26	3.53-4.37
Hyperopisus bebe	780	0.46±0.08	0.06-1.05
Hippopotamyrus pssittacus	320	0.67±0.11	0.35-1.42
Mormyrops anguilloides	64	0.83±0.11	0.49-1.22
Mormyrus hasselquisti	09	0.11±0.01	0.09-0.13
Mormyrus macrophthalmus	1015	0.9±0.12	0.46-1.99
Mormyrus rume	583	0.45±0.07	0.26-0.73
Marcusenius senegalensis	2985	0.42±0.07	0.15-1.18
Petrocephalus bovei	765	1.91±0.45	0.84-3.68
Pollimyrus isidori	154	3.09±0.16	2.61-3.71

Table 3. Seasonal variations mean condition factors (K) of Mormyrid fishes collected in Niger River in Northern Benin from February 2015 to July 2016. b= slope of length-weight regression equations.

Species	DRY		WET		FLOOD	
	Mean K±SE	b	Mean K±SE	b	Mean K±SE	b
Brienomyrus niger	4.38±0.74	2.65	0.79±0.01	3.03	-	-
Hyperopisus bebe	0.30±0.05	3.20	0.63±0.17	2.68	0.13±0.02	3.52
Campylomormyrus tamandua	3.91±0.27	2.44	-	-	-	-
Hippopotamyrus pssittacus	0.50±0.09	3.21	1.29±0.18	2.80	0.48±0.08	3.27
Mormyrops anguilloides	0.84±0.11	2.93	0.47±0.08	3.09	12.94±0.91	2.00
Mormyrus hasselquisti	0.04±0.01	4.00	-	-	-	-
Mormyrus macrophthalmus	1.14±0.14	2.74	1.83±0.16	2.62	1.15±0.13	2.78
Mormyrus rume	0.21±0.03	3.36	0.29±0.05	3.21	0.44±0.06	3.12
Marcusenius senegalensis	0.32±0.05	3.32	0.47±0.08	3.16	0.56±0.07	3.15
Petrocephalus bovei	2.16±0.50	2.62	1.87±0.45	2.71	0.74±0.11	3.11
Pollimyrus isidori	3.03±0.16	2.40	3.99±0.19	2.26	-	-

Table 4. Mean condition factor (K) by Habitat of Mormyrid fishes collected in Niger River in Northern Benin from February 2015 to July 2016. b: slope of length-weight regression equation.

Species	Open water		Aquatic vegetation		Whedo	
	mean K±SE	b	mean K±SE	b	mean K±SE	b
Brienomyrus niger	2.04±0.33	2.612	4.43±0.35	2.34	-	-
Campylomormyrus tamandua	3.3±0.28	2.49	9.36±0.35	2.17	-	-
Hyperopisus bebe	0.44±0.08	3.05	0.20±0.03	3.36	-	-
Hippopotamyrus pssittacus	0.88±0.15	2.99	0.32±0.05	3.4	-	-
Mormyrops anguilloides	0.86±0.14	2.92	0.48±0.06	3.13	-	-
Mormyrus hasselquisti	0.11±0.01	3.63	-	-	-	-
Mormyrus macrophthalmus	0.85±0.10	2.86	1.21±0.15	2.70	-	-
Mormyrus rume	0.25±0.05	3.28	0.64±0.08	2.99	-	-
Marcusenius senegalensis	0.42±0.07	3.21	0.25±0.04	3.44	1.30±0.14	2.78
Petrocephalus bovei	1.47±0.37	2.81	3.36±0.61	2.44	-	-
Pollimyrus isidori	4.34±0.20	2.22	2.87±0.16	2.43	2.22±0.05	2.56

Discussion

A successful fisheries management requires knowledge on growth factors of the fish populations in order to evaluate the well-being of the fish resources as well as the productivity and the ecological status of habitats (Dan-Kishiya, 2013). The output gathered from this fisheries investigation documented size structures, length-weight relationships and condition factors of the eleven (11) Mormyrids inventoried in Niger River in Benin. In this study, the size structures of the species examined showed a high variability of length (SL) within population that globally comprised small to moderate sizes for most species, except *Mormyrops anguilloides*, *Mormyrus rume*, *Hyperopisus bebe*, *Campylomormyrus tamandua* and *Marcusenius senegalensis* exhibiting relatively large SL varying between 7.7-44.7cm, 10.0-42.1cm, 5.8-35.9cm, 16.5-24.3 and 6-23.6cm, respectively (Table 1).

In this fisheries survey in Niger River, the mean standard lengths (SLm) recorded for *Mormyrus rume*, *Petrocephalus bovei* and *Pollimyrus isidori* agreed with those reported by Konan *et al.* (2007) in the Coastal Rivers in South-Eastern of Ivory Coast. However, the SLm recorded in this study were higher than those reported by Laleye (2006) for *Petrocephalus bovei* in the Oueme River in Beni. Also, in the current investigation, *Hyperopisus bebe* and *Mormyrus rume* showed higher SLm compared to those reported by Olopade (2013) in Oyan dam lake in Nigeria. In contrast, the current findings for *Mormyrus rume* were lower than those reported by Fawole (2002) in Lekki lagoon in Nigeria and lower than those reported by Nwani *et al.* (2006) in Anambra River in Nigeria. Likewise, the SLm of *Mormyrops anguilloïdes* was lower than those reported by Laleye (2006) in the Oueme River and by Konan *et al.* (2007) in the Coastal Rivers in South-Eastern of Ivory Coast. The dominant Mormyrid, *Marcusenius senegalensis* recorded in Niger River exhibited lower SLm compared to populations from Erinle Reservoir (Badejo and Oriyomi, 2015) and

Badagry Creek (Akintade *et al.*, 2016) in Nigeria and from the Coastal Rivers in South-Eastern of Ivory Coast (Konan *et al.*, 2007). According to Sidi Imorou *et al.* (2019), these variabilities in Mormyrid lengths were the results of differential habitat conditions, mainly water quality, availability of food resources, climate changes, ecosystem disturbances and overfishing. Particularly, the relatively lower sizes recorded for most Mormyrids in this survey may be due to multiple anthropogenic disturbances occuring in Niger River. Most of these degradation factors were the use of chemical fertilizers and pesticides for adjacent agriculture, the retrievals of water for domestic uses and crop productions, the proliferation of invasive floating vegetations, the introduction of invasive species, mainly *Oreochromis niloticus*, over fishing etc.

With respects to the 18 months study period, the eleven (11) Mormyrids examined in Niger River in Benin exhibited a relatively high variability in length-weight patterns with slopes (*b*) ranging between 2.2469 (*Brienomyrus niger*) and 3.632 (*Mormyrus hasselquisti*). Among them, Student Test (Sokal and Rohlf, 1995) depicted five (5) Mormyrids, *Hyperopisus bebe, Mormyrus rume, Hippopotamyrus pssittacus*, *Marcusenius senegalensis* and *Mormyrus hasselquisti* that showed significant ($p<0.05$) positive allometric growth with *b* between 3 and 3.7 suggesting that these species became more rotund as standard length increased (Gbaguidi and Adite, 2016). Probably, these fishes exhibited a relatively high tolerance to critical habitat conditions due to multiple disturbances. The negative allometric growth (*b* between 2.25-3.0) recorded for the six remaining Mormyrids, *Brienomyrus niger*, *Campylomormyrus tamandua*, *Mormyrops anguilloides*, *Mormyrus macrophthalmus*, *Petrocephalus bovei* and *Pollimyrus isidori* suggested that these fishes became less rotund as standard length increased (Barnham and Baxter, 1998). The low growth performances of these species were probably the results of the low tolerance to habitat conditions (Table 1). When comparing with other regional water bodies, the allometric coefficient (*b* = 3.10) recorded for *Mormyrus rume* agreed with those reported by Nwani *et al.* (2006) in Anambra River in Nigeria. Also, our findings for this species was higher than those reported by Laleye (2006) in Oueme River and by Konan *et al.* (2007) in the Coastal Rivers of Ivory Coast and by Nzeh & Lawal (2012) in a small Lake in Ilorin in Nigeria. Similarly, the slope (*b*) recorded for *Hyperopisus bebe* in this survey was higher than those reported by Olele (2013) in Warri River in Nigeria and by Laleye (2006) in Oueme River. Likewise, the dominant Mormyrid, *Marcusenius senegalensis* displayed better well-being (*b* =3.21) than populations reported by Laleye (2006) in the Oueme River, by Konan *et al.* (2007) in the Coastal Rivers of Ivory Coast and by Akintade *et al.* (2016) in Badagry Creek in Nigeria. Nevertheless, in Niger River in Benin, species such *Brienomyrus niger, Petrocephelus bovei* and *Pollimyrus isidori* exhibited lower growth performances *b* =2.24, *b* =2.69 and *b* =2.38, respectively, compared to populations from the Sô River in Benin (Hazoume *et al.*, 2017), from the Coastal Rivers of Ivory Coast (Konan *et al.*, 2007) and from Oueme River (Laleye, 2006), respectively.

As indicated by the results, Mormyrids fishes from Niger River displayed mean condition indices (Km) varying between 0.11 and 4.94, suggesting that in this riverine water, Mormyrids showed low to moderate well-being. These findings were lower than those reported by Sidi Imorou *et al.* (2019) in Okpara stream of Oueme River for *Marcusenius senegalensis* showing Km=8.61, *Mormyrus rume* (Km=17.13), *Hyperopisus bebe* (Km=20.14) and *Petrocephalus bovei* (Km =2.01). Likewise, the mean K of *Marcusenius senegalensis* in Niger River was lower than those reported by Akintade *et al.* (2016) in Badagry Creek in Nigeria and by Badejo and Oriyomi (2015) in Erinle Reservoir in Nigeria. Also, *Mormyrus rume* exhibited lower condition factors compared to those reported by Fawole (2002) in Lekki lagoon in Nigeria, by Nwani *et al.* (2006) in the Anambra River and by Badejo and Oriyomi (2015) in Erinle Reservoir. Similarly, Olele (2013) reported higher Km for *Hyperopisus bebe* in Warri River in Nigeria. As results, the condition factors of most Mormyrids from Niger River were reduced indicating relatively low plumpnesses. In particular, species such *Mormyrus rume, Mormyrus hasselquisti*, *Hippopotamyrus*

pssittacus, *Marcusenius senegalensis*, *Mormyrops anguilloides*, *Mormyrus macrophthalmus* and *Hyperopisus bebe* displayed reduced Km less than 1 that indicated a relatively low well-being. Nevertheless, in Niger River, *Brienomyrus niger*, *Campylomormyrus tamandua*, *Pollimyrus isidori* and *Petrocephalus bovei* showed moderate condition factors ranging between K=1.91 and K=4.94. In general, combined degradation factors such as climate changes, overfishing, invasion of floating plants, introduction of exotic fishes, water retrievals, uses of chemical fertilizers and pesticides in adjacent agriculture could cause reduced productivity levels leading to low well-being of the fish ressources.

Conclusion

This fisheries investigation provides baseline information on the growth factors of Mormyrid fishes from Niger River, currently under various degradation factors in Benin. Although species such *Mormyrus rume*, *Mormyrus hasselquisti*, *Hippopotamyrus pssittacus*, *Marcusenius senegalensis* and *Hyperopisus bebe* showed positive allometric growth trends, more than half of the Mormyrids inventoried, *Mormyrops anguilloides*, *Mormyrus macrophthalmus*, *Brienomyrus niger*, *Campylomormyrus tamandua*, *Pollimyrus isidori* and *Petrocephalus bovei* displayed negative allometric growth patterns. Further ecological studies are required to implement an early management strategy for habitat protection and species conservation in order to assure a sustainable exploitation of the Mormyrid stocks in Niger River.

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References

Aboubacar A, Humphrey S. 2007. Atlas Bassin du Niger. Autorité du bassin du Niger, ABN, Niamey.

Abowei J. 2010. The condition factor, length-weight relationship and abundance of Ilisha africana (Block, 1795) from Nkoro River Niger Delta, Nigeria. Advance Journal of Food Science and Technology **2,** 6-11.

Adjibade KN, Adite A, Arame H, Sidi Imorou R, Sonon SP. 2019a. Biodiversity and community structure of Mormyridae (Pisces: Teleostei: Osteiglossiformes) from Niger River at Malanville (North-Benin): Threats, conservation and valorization perspectives. International Journal of Sciences; 8(5): 106-116.

Adjibade KN, Adite A, Arame H, Sidi Imorou R, Sonon SP. 2019b. Feeding ecology of *Marcusenius senegalensis* (Pisces : Osteoglossiformes : Mormyridae; Steindachner, 1870) from Niger River at Malanville (North-Benin). International Journal of Fisheries and Aquatic Studies; 7(4): 86-92.

Akintade AO, Edwin CO, Simon EA. 2016. Length–Weight Relationship, Condition Factor and Sex-ratio of Fish Fauna in Badagry Creek, Lagos, Nigeria. International Journal of Marine Science **6,** 1-8.

Arnegard ME, Carlson BA. 2005. Electric organ discharge patterns during group hunting by a mormyrid fish. Proceedings of the Royal Society B **272,** 1305-1314.

Atobatele OE, Ugwumba AO. 2011. Condition factor and diet of *Chrysichthys nigrodigitatus* and *Chrysichthys auratus* (Siluriformes: Bagridae) from Aiba Reservoir, Iwo, Nigeria. Revista de Biologia Tropical **59,** 1233-1244.

Badejo OA, Oriyomi O. 2015. Seasonal Variation, Abundance and Condition Factor of Fish Species in Erinle Reservoir. American Scientific Research Journal for Engineering, Technology, and Sciences (ASRJETS) **12,** 136-142.

Bagenal TB, Tesch FW. 1978. Age and growth. In: Bagenal F, Ed. Methods for Assessment of Fish Production in Freshwaters. IBP Handbook 3, Blackwell Scientific Publications, Oxford 101-136.

Le Cren ED. 1951. The Length-Weight Relationship and Seasonal Cycle in Gonad Weight and Condition in the perch (*Perca fluviatis*). Journal of Animal Ecology **20,** 201-219.

Dan-Kishiya AS. 2013. Length-Weight relationship and condition factor of five species from a tropical water supply Reservoir in Abuja,Nigeria. American Journal of Research Communication **1,** 175-187.

Deekae SN, Abowei JFN. 2010. *Macrobrachium macrobrachion* (Herklots, 1851) length-weight relationship and Fulton's condition factor in Luubara creek, Ogoni land, Niger Delta, Nigeria. International Journal of Animal and Veterinary Advances **2,** 155-162.

Fawole OO. 2002. Morphometry and diet of *Mormyrus rume* in the Lekki lagoon, Nigeria. Revista de Biologia Tropical **50,** 689-694.

Gbaguidi HMAG, Adite A. 2016. Abundance, length-weight relationships and Fulton's condition factor of the freshwater cichlid *Sarotherodon galilaeus* (Pisces: Teleostei: Perciformes) from a sand-dragged man-made lake of Southern Benin, West Africa. Journal of Biodiversity and Environmental Sciences **8,** 75-87.

Harder W. 2000. Mormyridae and Other Osteoglossomorpha (CD Rom). Expert Center for Taxonomic Identification, ETI, University of Amsterdam, Amsterdam.

Hauber ME. 2011. Description and Improvement of the "Whedo"-Aquaculture- System in Malanville (North of Benin). PhD thesis, Universtität Würzburg, Germany, 203p.

Hazoume RUS, Chikou A, Koudenoukpo CZ, Adite A, Bonou CA, Mensah GA. 2017. Length-weight relationships of 30 species of fish of the river Sô in Benin (West Africa). International Journal of Fisheries and Aquatic Studies **5,** 514-519.

Hopkins CD, Lavoué S, Sullivan JP. 2007. Mormyridae. In: Stiassny MLJ, Teugels GG, Hopkins CD, Ed. Poissons d'eaux douces et saumâtres de basse Guinée, ouest de l'Afrique centrale (The Fresh and Brackish Water Fishes of Lower Guinea, West-Central Africa), Vol. 1. IRD Éditions, Paris 219-334.

Koba G. 2005. Les pratiques de pêches dans le Fleuve Niger au Benin et leurs impacts sur la faune ichtyologique. Mémoire de DEA, Université d'Abomey-Calavi, Benin 73p.

Konan FK, Ouattara A, Ouattara M, Gourène G. 2007. Weight-Length relationship of 57 fish species of the Coastal Rivers in south-Eastern of Ivory Coast. Ribarstvo **65,** 49-60.

Laë R, Williams S, Morand P, Mikolasek O. 2004. Review of the present state of the environment, fish stocks and fisheries of the river Niger (West Africa). In: Welcomme R, Petr T, Ed. Proceedings of the Second International Symposium on the Management of Large Rivers for Fisheries: Sustaining livelihoods and biodiversity in the new millennium, Vol. I. Rome: FAO, 199-277. Phnom Penh, Cambodge. ftp://ftp.fao.org/docrep/fao/007/AD525e/ad525e09.pdf

Laleye PA. 2006. Length–weight and length–length relationships of fishes from the Oueme River in Benin (West Africa). Journal of Applied Ichthyology **22,** 330-333.

Lévêque C, Balian EV, Martens K. 2005. An assessment of animal species diversity in continental waters. Hydrobiologia **542,** 39-67.

Moller P. 1995. Electric Fishes: History and Behaviour. Fish & Fisheries Series, Chapman&Hall, London, 584p.

Moritz T, Linsenmair KE. 2007. The air-breathing behaviour of *Brevimyrus niger* (Osteoglossomorpha, Mormyridae). Journal of Fish Biology **71,** 279-283.

Moritz T, Laleye PA, Koba G, Linsenmair KE. 2006. An annotated list of the fishes from the River Niger at Malanville, Benin, with notes on the local fisheries. Verhandlung der Gesellschaft für Ichthyologie **5,** 95-109.

Nelson JS. 2006. Fishes of the World. Fourth edition, John Wiley and Sons, New York, USA, 601p.

Nwani CD, Ezenwaji HMG, Eyo JE, Ude EF. 2006. Length-Weight Relationship and Condition Factor of Four mormyrid species of Anambra river. Animal Research International **3,** 426-430.

Nzeh CG, Lawal A. 2012. Condition Factor, Gonadosomatic Index and Sex Ratio of the Family Mormyridae from a Small Lake in Ilorin, Nigeria. World Journal of Zoology **7,** 102-105.

Olele NF. 2013. Food items and general condition of *Hyperopisus bebe occidentalis* (Lacepede , 1803) caught in Warri River, Nigeria. African Journal of Environmental Science and Technology **7,** 402-409.

Olopade OA. 2013. Preliminary observations on the Family Mormyridae in Oyan Dam Lake. Transylvanian Review of Systematical and Ecological Research **1,** 33-48.

Paugy D, Lévêque C, Teugels GG. 2003. Faune des poissons d'eaux douces et saumâtres de l'Afrique de l'Ouest (The fresh and brackish water fishes of West Africa). Vol. II, Faune Tropicale, IRD Éditions, Paris, 815p.

PDC Malanville. 2006. Monographie de la commune de malanville. Mission de Decentralisation, Programme d'Appui au Demarrage des Communes, Afrique Conseil, Cotonou, 48p.

Rich M, Sullivan JP, Hopkins CD. 2017. Rediscovery and description of *Paramormyrops sphekodes* (Sauvage , 1879) and a new cryptic *Paramormyrops* (Mormyridae : Osteoglossiformes) from the Ogooué River of Gabon using morphometrics, DNA sequencing and electrophysiology. Zoological Journal of the Linnean Society **180,** 613-646.

Roberts TR. 1975. Geographical distribution of African freshwater fishes. Zoological Journal of the Linnean Society **57,** 249-319.

Scheffel A, Kramer B. 1997. Electrocommunication and Social Behaviour in *Marcusenius senegalensis* (Mormyridae, Teleostei). Ethology **106,** 404-420.

Schugardt C, Kirschbaum F. 2004. Control of gonadal maturation and regression by experimental variation of environmental factors in the mormyrid fish, *Mormyrus rume proboscirostris*. Environmental Biology of Fishes **70,** 227-233.

Sidi Imorou R, Adite A, Arame H, Chikou A, Adjibade KN, Sonon SP. 2019. Fish biodiversity and community structure of the Okpara stream from the Oueme River, Benin, West Africa. *in press*.

Sokal RR, Rohlf FJ. 1995. Biometry: The Principles and Practice of Statistics in Biological Research. 3rd Edition, WH Freeman and Co., New York, 887p.

Tesch B. 1978. Age and growth. In: WE Ricker, Ed. Methods for assessment of fish production in fresh waters. Blackwell Scientific Publications Ltd, Oxford 98-130.

Van Thielen R, Hounkpe C, Dagba L, Agon G. 1987. Guide de détermination des Poissons et Crustacés des Lagunes et Lacs du Bas-Bénin. Direction des Pêches, Cotonou, Bénin

Toerring MJ, Moller P. 1984. Locomotor and electric displays associated with electrolocation during exploratory behavior in mormyrid fish. Behavioural Brain Research **12,** 291-306.

Winemiller KO, Adite A. 1997. Convergent evolution of weakly electric fishes from floodplain habitats in Africa and South America. Environmental Biology of Fishes **49,** 175-186.