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First Assessment of Mormyridae diversity and abundance in the Niger River at Niamey, Niger

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To analyse the assessment of Mormyridae diversity and abundance in the Niamey fisheries on the Niger River, a study was conducted from August to November 2022. Fish data were collected bimonthly from artisanal fishing landings using gillnets, sparrowhawk nets, baited traps, and baited longlines. A total of 1279 individuals from fifteen species across nine genera were inventoried. Numerically, *Mormyrus rume* dominated the fish assemblages, comprising 29.9% of the mormyrid sub-community, followed by *Marcusenius cyprinoides* (15.0%), *Campylomormyrus tamandua* (12.9%), *Marcusenius senegalensis* (0.08%), *Petrocephalus bovei* (0.08%), and *Hippopotamyrus pictus* (0.16%). The Shannon-Weaver index of species diversity was moderate, reaching H' = 2.96. Major threats to the growth and survival of Mormyrids in the Niger River included overexploitation and anthropogenic disturbances such as domestic uses (e.g., ditch cleaning, clothes washing, bathing), invasion of floating plants (*Echhornia crassipes*), sand dragging, human waste dumping, and the use of chemical fertilizers and pesticides in adjacent agriculture. The results of this study will contribute to the design of a holistic species management scheme that includes habitat protection, species conservation, and valorisation.

Keywords: River Niger, Diversity, Characterization, Niger, Mormyridae

INTRODUCTION

Ocean, lakes, and watercourses provide essential food, employment, and economic benefits, supplying over 70% of the proteins for the African population (FAO, 218; Micha et Franck, 2004; Ticheler, 2000; Idowu, 2010). Tropical rivers have a vast diversity of ichthyology, which is not well known taxonomically or in terms of species biology and ecology (Byanikiro et al., 2017). Studying these aspects is crucial for conserving and monitoring ichthyological population (Mbimbi, 2006).

The Mormyridae family, endemic to sub-saharan African, includes 22 genera and 228 species (Hopkins et al.,2007; Kisekelwa et al.,2016; Byanikiro et al.,2017). They are found in many watercourses such as the Nile, Niger, Volta, Senegal, Zambezi, Gambia, Oueme, Mono, Chad, Congo, Ebrié, Kainji, Malawi, Tangamyika, Bagoé, Sassandra, Bandama, Comoé and Benoué (Blache, 1964; Daget and Illtis, 1965; Daget, 1960; Lowe-McConnell, 1969; Hopkins et al., 2007).Most Mormyridae measure between 9 and 50 cm, though some reach 1.5 m. They form shoals in murky rivers, aided by unique sensory organs (Kramer, 2009). Species in the Mormyridae family are among the commonly encountered on the River Niger at Niamey. The lack of knowledge about this family in the study area is very crucial. This family is the first to react when the

ecosystem is altered, and knowledge concerning this family is more than important for the development, management and sustainable use of this family. The studies conducted by Hamadou (2019) and Ibrahim (2018) revealed that the Mormyridae family is the most represented in the ichthyological inventories of the Say and Boubon regions in Niger. These studies highlight the dominance of this family of electric fish, common in Africa, within local aquatic communities. This prevalence could be explained by their strong adaptability to the specific ecological conditions of the Niger River, as well as their crucial role in local fisheries. The significant presence of Mormyridae in these ecosystems serves as an important indicator of biodiversity and reflects the overall state of fisheries in these areas.

In Niamey, the Niger River faces increasing pressure due to the establishment of numerous industries along its banks, encroaching on the natural habitat of these fish. As key species, Mormyridae play a fundamental role in the structure and productivity of aquatic ecosystems, contributing to the balance of these environments. It is therefore essential to better understand the ecology, diversity, and community structure of this family, both to ensure the sustainable management of populations and to use these species as bio-indicators of hydrosystem health. They are useful for monitoring biodiversity (Kerckhove, 2012). However, limited knowledge of their distribution and abundance complicate conservation efforts (Lundberg et al.,2000; Pigneur, 2005).

The aim of this study is to characterise the Mormyridae population of the River Niger through its diversity and exploitation. This is based on the evaluation of the ecological quality of this hydro-system through the physico-chemical parameters, the inventory of the species of Mormyridae, determination of the typology of the fishing gears used in the capture and determine the parameters of exploitation of the abundant species of Mormyridae.

MATERIALS AND METHODS

Study location and choice of study stations

The study area is Niamey town (South-West Niger) at the latitude 13°30’49’’N and longitude 2°6’35.3”E. Three stations were selected with the help of the National Fisheries and Aquaculture Directorate: Tondibia (13°33’52.0’’N, 2°00’33.8’’E), Barrage Yantalla (13°31’9’’N, 2°4’18’’E) and Gamkalley (Figure 1). The selection criteria included accessibility during the sampling period, presence of Mormyridae species in fishermen’s catches, easy collaboration with local fishermen and fishmongers, and distance between stations to ensure representative coverage of the sector.

Evaluating Habitat Characteristics

The water quality of the Niger river was assessed in situ at each sampling site. Depth and transparency were measured to the nearest 1 cm using a Secchi disc. Temperature and dissolved oxygen were measured to the nearest 0.1°C and 0.1 mg/l using a multi-parameter device (EcoSense ODO200). pH was measured to the nearest 0.1 using a pH (Hanna HI 9813-6). Conductivity was measured to the nearest 1.1 µS/cm using a conductivity meter (Hanna model). Fish samples size was measured using an ichthyometer.

Fish collection

Each station was visited twice a month between 7 a.m. and 10 a.m. to check catches. Mormyridae samples were collected from 34 fishermen and 9 fishmongers. The numerical abundance of Mormyridae were surveyed. Various fishing gears (shape, size, mesh size, and techniques) were examined to maximize the chances of harvesting specimens of all sizes (Lalèyè, 1995).

After identification, the following morphometric characteristics of the species were measured:

Total length (Lt): Length from the mouth to the end of the caudal fin.

Standard length (Ls): Length from the mouth to the base of the tail.

Total weight of each fish.

Data Analysis

Data processing of physico-chemical parameter measurements generated a summary table (mean, standard deviation, minimum, maximum, and coefficient of variation). The kurskal-Walli's test was used to assess station or month effects (Adandédjan, 2012). If variation existed, the Mann Withney test compared stations and months in pairs. Statview, Past (Paleontological Statistics) and Python were used for these tests.

Diversity, exploitation, and growth parameters

Diversity indices and conservation status

The Mormyridae specimens collected were identified using the identification key (1990), Paugy et al. (2003) and Fish Base (2013), with confirmation by the DPA (Fish and Aquaculture Directorate). The specific richness of Mormyridae (S), representing the number of species in each environment, was determined:

• Specific richness of Mormyridae (S): The number of species in each environment.

Predicted richness ($\hat{S}$): The probable number of species in the study area using the Jackknife method.

With S = the number of species observed at all stations and K = the number of unique species and n = the number of stations.

The Shannon-Wiener diversity index (H') is used to characterise species diversity, as it is independent of sample size and considers the relative abundance of each species (Daget, 1979). Expressed in bits per individual, a higher H' indicate greater diversity and (Washington, 1984) is calculated using the equation:

The equitability (Eq) index (Pielou, 1969) measures the regularity of species distribution in each ecosystem. It ranges from 0 to 1, with values near 1 indicating equal abundance of all species (Amanieu and Lasserre, 1982). An Eq value of 0 mean a single species dominates (Da Fronseca, 1968). The equitability index (Eq) is calculated using the formula:

Jaccard's Similarity Index (JSI): is an intercommunity specific diversity index that indicates whether there is similarity between the different stations sampled. Its expression is:

a + b total number of species in the two communities combined and c is the number of shared species.

Conservation status of Mormyridae species

The CITES and IUCN websites were used to collect data on the conservation status of the fish population (CITES, 2017; IUCN, 2018). This status assesses a species risk of extinction at a given time and can change based on threats to its existence. Conservation status is periodically reassessed using rigorous risk assessment systems (IUCN, 2018).

RESULTS

Physico-chemical parameters

Table 1 summarizes the value of the physico-chemical parameters of the water during the four months of sampling. No significant differences (P>0.05) were observed between stations except for the depth, where the Man Whitney test showed a significant difference between the Tondibia and Yantalla Dam stations. The mean water temperature was 29 °C, with the lowest in August (27.9 °C) and the highest in November (31.0 °C). The average pH ranged from 6.73 in November to 7.2 in August. Dissolved oxygen averaged 6.60 mg/l, with the lowest in August (5.12 mg/l) and the highest in November (7.04 mg/l). Oxygen saturation followed similar trends. The average TDS was 0.26 ppm, with monthly variation from 0.165 ppm in November to 0.40 ppm in September. Water conductivity ranged from 36.4 mS in November to 38.3 mS in August and September. Depth varied, with a maximum of 9.67 m in September and a minimum of 6.53 m in August.

Community of Mormyridae

Fish Diversity

Table 2 illustrates the species recorded during the study. The Mormyridae community in the Niger River between August and November comprised 15 species across 10 genera. Hippopotamyrus, Marcusenius, Mormyrus, and Pollimyrus each had two species, had three, and the other genera had one species each. The Jackknife estimated (Ŝ) species richness at 17.

Diversity Indices and Conservation Status

Overall, the Shannon-Wiener diversity index is equal to 2.96 bits and the Pielou equitability is equal to 0.76. Mormyridae diversity is therefore average (H’ ε [2.6; 3.9]) and no one species is dominant (Eq ε [0.7; 0.8] within the Mormyridae community.

Spatial variations in diversity indices

Table 3 summarizes the diversity indices across Tondibia, Barraye Yantalla, and Gamkalley stations. Richness is low at all stations (H’=1.63, 1.82, 1.69) with Tondibia showing lower Pielou equitability (0.66) compared to the average equitability at Barrage Yantalla and Gamkalley (0.73, 0.74). Mormyridae communities at these stations are dominated by Mormyrus rume and Pollimyrus isidori, representing 33.7% and 40.7% of catches respectively.

Temporal variations in diversity indices

Table 4 summarizes diversity index change over time. In August, H’ was 1.77 and Eq was 0.77, indicating low diversity with no specific Mormyridae dominance. October and November showed similar low diversity (H’ around 1.33) and Eq values (around 0.53), with no clear species dominance. However, September had lower H’ (1.33) and Eq (0.53), indicating a dominance of Mormyrus rume, which accounted for 66 % of the catches that month.

Jaccard index

To understand the relationships between the Mormyridae communities at the different stations, Jaccard’s index was calculated (Table 5). This index shows that there is a similarity between the Mormyridae communities at the Barrage Yantalla and Tondibia stations and between the Gamkalley and Barrage Yantalla stations, but the Mormyridae community at the Gamkalley station is different from the Tondibia station.

Conservation Status of the Fish Population

Based on the classification of the International Union for Conservation of Nature (IUCN), the fish species collected during this study on the Niger River and identified down to the specific level can be divided into three (03) categories (Figure 2). These are the categories: Data Deficient (DD); Not Evaluated (NE); Least Concern (LC).

Of all the species identified up to the specific level, one (01) Mormyrops oudoti (i.e. 6.67%) is described as Data Deficient (DD). The conservation status of 3 of the species observed such as Campylomormyrus tamandua, Pollimyrus ihuysi and Mormyrus macrophthalmus (i.e. 20%) has not yet been assessed (NE). Most species in the River Niger have been described as species of Least Concern (LC), representing 73.3% of the population.

DISCUSSION

Physico-chemical characteristics of stations

Water's importance isn't just about availability and quantity but also its quality, crucial for supporting aquatic and terrestrial life (Ajibade et al., 2008). Physico-chemical parameters, influenced by factors like precipitation, evaporation, and human activities, affect fish community indices (Adite et al., 2013). Water temperature ranged from 27.4°C to 31.4°C (average 26.7°C), like previous studies (Hassane, 2017). pH ranged from 6.5 to 7.6 (average 6.89), within optimal ranges for aquatic life (IBGE, 2005). Dissolved oxygen averaged 6.60 mg/L and 91.1% saturation, adequate for fish survival (Odokuma and Okpokwasili, 1993). Conductivity averaged 36.4 mS, with total dissolved solids (TDS) averaging 0.26 ppm. Despite generally favorable conditions for fish, human activities like domestic uses and agricultural practices impact water quality negatively.

Community of Mormyridae

Specific Richness

The Mormyridae species richness in the study area along the Niger River includes 15 species across 9 genera. Mormyrus rume and Marcusenius cyprinoides are the most represented species. Overall, Mormyridae species richness at the three stations was moderate (H' = 2.96), with no dominant species (Eq = 0.76). This family is highly represented in the Niger River with 9 species (PGIPAP, 2012), while Oumarou (2018) recorded 14 species in restored fisheries by the PLCE/BN on the Niger River in Niger. Ibrahim (2018) and Hamadou (2019) reported Mormyridae as the most abundant family in their study areas, with 7 species in Boubon fisheries and 11 species in Say fisheries in Niger, respectively. Other various studies also highlight Mormyridae's prevalence: Lalèyé et al. (2004), Chikou (2006), Sirima et al. (2009), Montcho (2011), Sanogo et al. (2012), Bamogo (2016), and Alphonse et al. (2019) reported 12 species in the Ouémé river, 10 species in the Coemé basin in Burkina Faso, 21 species in the Pendjari river, 13 species in the Baoulé river basin in Mali, 7 species in the Ziga dam in Burkina Faso, and 11 species in the Niger river at Malenville and Gaya. Mormyrops oudoti, reported by PGIPAP (2012), was also encountered during this study. The estimated species richness was 17, compared to the 15 species sampled during the four-month study period. Sampling duration and study scope likely influenced this discrepancy. Ahouansou Montcho (2011) notes that biases in assessing species diversity are common, as sampling must be exhaustive to accurately determine total species richness (Walther and Moore, 2005; Walther and Morand, 1998; Novotny and Basset, 2000; Mao and Colwell, 2005).

Spatio-temporal variations in the Mormyridae Community and Conservation Status

From August to November, the inventory revealed 12 species at Tondibia, 12 species at Yantalla Dam, and 10 species at Gamkalley, with diversity indices H' of 1.63, 1.82, and 1.69 respectively.

Jaccard's index indicated differences between Mormyridae communities at Gamkalley and Tondibia. October showed lower diversity (H' = 2.29, Eq = 0.80), coinciding with species migration to spawning grounds. Most Mormyridae (73.3%) in the River Niger are classified as "Least Concern" by IUCN, like findings in Aghien Lagoon (Assi, 2019). Conservation status is dynamic and requires regular reassessment due to changing threats (IUCN, 2018).

CONCLUSION

The recent ichthyological study of the Niger River offers significant insights into the Mormyridae family's richness, abundance, diversity, distribution, and habitat conditions. Conducted over four months at Tondibia, Barraga Yanatalla, and Gamkalley stations, the research identified fifteen Mormyridae species, including Mormyrus rume, Marcusenius cyprinoides, Campylomormyrus tamandua, Pollimyrus isidori, Brienomyrus niger, and Hyperopisus bebe. Notably, five new species were documented beyond those listed by PGIPAP in 2012, bringing the total to fifteen.

The study also revealed issues with fishing regulation compliance, posing threats to sustainable management. These threats include river silting, agricultural runoff, invasive vegetation, waste dumping, and climate change. This research advances our understanding of the Niger River's ichthyofauna, addressing a gap since Coenen's (1987) study. However, it is limited by its focus on a single fish family over a brief period. To ensure sustainable fisheries management, ongoing and comprehensive studies are crucial. The Mormyridae family, as indicators of ecological water quality, plays a key role in monitoring the biotic integrity of this aquatic ecosystem.

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