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Assessment the conservation status and vulnerability of the ichthyological population of the Bandama River in the Marahoué Region (Central West of Côte d'Ivoire)

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The conservation status and the vulnerability to fishing pressure of the ichthyological population of the Bandama River located in the Marahoué Region (Côte d'Ivoire) were assessed. Sampling of fish fauna was conducted from September 2019 to November 2020 using experimental and artisanal fisheries. The results of International Union for Conservation of Nature show that, the majority of the fish species (88.7%) inventoried were classified as "least concern". The "high to very high" and "very high" categories are represented respectively by two species and one species. These include *Heterobranchus longifilis* and *Malapterurus electricus*, which belong to the "high to very high" vulnerability category, and *Clarias gariepinus*, which belongs to the "very high" category. In addition, 79.87% of the species in this stand have vulnerability between "low" and "moderate".

Key words: Vulnerability to fishing pressure, Ichthyofauna, *Heterobranchus longifilis, Malapterurus electricus, Clarias gariepinus.*

INTRODUCTION

Aquatic environments are a reservoir of great biodiversity and also play a very important bio-ecological role (Ndour et al., 2011). Unfortunately, these aquatic ecosystems are under increasing pressure from human activities (construction of dams, pollution from various sources, etc.) (Paul, 2017). Thus, man, through his activities, considerably threatens the survival of aquatic species and biological diversity. In Côte d'Ivoire, threats to aquatic biodiversity from anthropogenic activities are increasing (Kouamélan, 1999; Ouattara et al., 2007; Simmou et al., 2015; Monney et al., 2016). The portion of the Bandama River located in the Marahoué region in Central West of

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Côte d'Ivoire does not escape these anthropogenic pressures. Indeed, this watercourse is subject to numerous disturbances, among others, fishing, the discharge of industrial effluents from the company of lemonade and breweries of Africa (SOLIBRA) in Bouaflé, the use of fertilizers and of pesticides in the large sugar cane plantations of the integrated agricultural production unit of SUCRIVOIRE in Zuénoula. In addition, the politico-military crisis in Côte d'Ivoire has had a severe impact on the agricultural sector, the main source of income for farmers. In order to diversify sources of income, gold mining appeared as an alternative (Kouadio, 2008). Thus, in recent years the Bandama River watershed in the Marahoué region has been subject to heavy illegal mining operations and in violation of environmental protection regulations.

Faced with such a threat, the implementation of a system of management measures is necessary for the preservation of these fishery resources. These measures are based mainly on the knowledge of the state of the fishery resources. Indeed, knowledge of the conservation status and vulnerability to pressure are necessary in decision-making for the conservation of aquatic biodiversity (IUCN, 2020; Froese and Pauly, 2019). The present study aims to analyze and make available to the country's decision makers, information relating to the conservation status and vulnerability to fishing pressure of the ichthyofauna of the Bandama River in the Marahoué region (Central West of Côte d'Ivoire) for a better conservation.

MATERIALS AND METHODS

Study area

The Bandama watershed is located between longitudes 3°50' and 7°W, and between latitudes 5°10' and 10°20' N (Figure 1). This basin covers an area of 97500 km^2 and extends from the north to the south of the country (Ire et al., 2015). It is made up of two sub-watersheds:

(i) The sub-watershed of the Bandama rouge or Marahoué located between longitude 5°5' and 7°1' W and latitude 6°7' and 9°5' N. It has an area of 24300 km^2. The Marahoué River, with a length of 550 km, is the most important tributary of the right bank of the Bandama River. It is fed by two tributaries: the Béré in the East and the Yani or Bahoroni in the West (Irié et al., 2015).
(ii) The sub-watershed of the White Bandama is located between latitudes 5°14' and 10°21'North and longitudes 4° and 7° West. It is on the branch of White Bandama Blanc that the Kossou hydroelectric dam is built.

According to Diarra (2020), this immense expanse of water has favored numerous anthropic activities, including agriculture with the irrigation of nearly 50,000 ha of arable land and fishing with an average of around 100 tons of fish landed per year. In addition, the Bandama River watershed in the Marahoué region is subject to heavy formal and informal mining.

Sampling and identification of ichthyofauna

Sampling of fish fauna was conducted from September 2019 to November 2020 using experimental and artisanal fisheries. For experimental fisheries, nets were set in the evening between 17 and 18 h and retrieved the next day between 6 and 7 h for night fishing and rested between 7 and 8 h and then retrieved between 15 and 16 h for day fishing. The experimental fishing was carried out with 30 mesh nets of between 10 and 40 mm side length. Each of these gillnets was 50 m long and 2.5 to 3.5 m high. Concerning artisanal fisheries, the data collection team analyzed the catches of artisanal fishermen in order to complete the list of species actually present. The artisanal fishing was carried out using: seines (with mesh sizes varying from 12 to 17 mm), gillnets (with mesh sizes varying from 20 to 40 mm)

Sampling of fish fauna was conducted and caught species was identified and released. Identification of fish specimens encountered was performed down to the specific level using keys proposed by Paugy et al. (2003a, b); Sonnenberg and Busch (2009), Fricke et al. (2021); Froese and Pauly (2019).

Conservation status

The assessment of the conservation status of the fish fauna was done using the IUCN Red List (IUCN, 2020; Froese and Pauly, 2019). The IUCN Red List Categories and Criteria are intended to be an easily and widely understood system for classifying species at high risk of global extinction. It divides species into nine categories: Not Evaluated, Data Deficient, Least Concern, Near Threatened, Vulnerable, Endangered, Critically Endangered, Extinct in the Wild and Extinct.

Vulnerability to fishing pressure

The assessment of the degree of vulnerability of fish species was done according to Cheung et al. (2005) and Brodie (2010) from the Fishbase site (Froese and Pauly, 2019). Brodie (2010) defines vulnerability as the sensitivity displayed by organisms to impacts caused by fishing activities or other factors threatening their existence such as habitat loss. Thus, the probability of an impact occurring and the responsiveness of the target community should be considered when determining its vulnerability to fishing activities. According to Cheung et al. (2005), the vulnerability of a species refers to the exposure of fish to fishing pressure. For these authors, the model developed to estimate the risk of depletion of fish populations by fishing relies on historical and ecological parameters to predict the intrinsic vulnerability of fish populations. Overall, Cheung et al. (2005) established different levels of graded vulnerability (1-100): ″low″ (≤ 25), ″low to moderate″ (] 25; 35]), ″moderate″ (] 35; 45], ″moderate to high″ (] 45; 55]), ″high″ (] 55; 65]), ″high to very high″ (] 65; 75]), and ″very high″ (75 ≤).

RESULTS AND DISCUSSION

Conservation status

Using the IUCN Red List system, the 71 fish species collected in the Bandama River located in the Marahoué region and identified to the specific level were divided into 5 categories (Table 1 and Figure 2). The categories
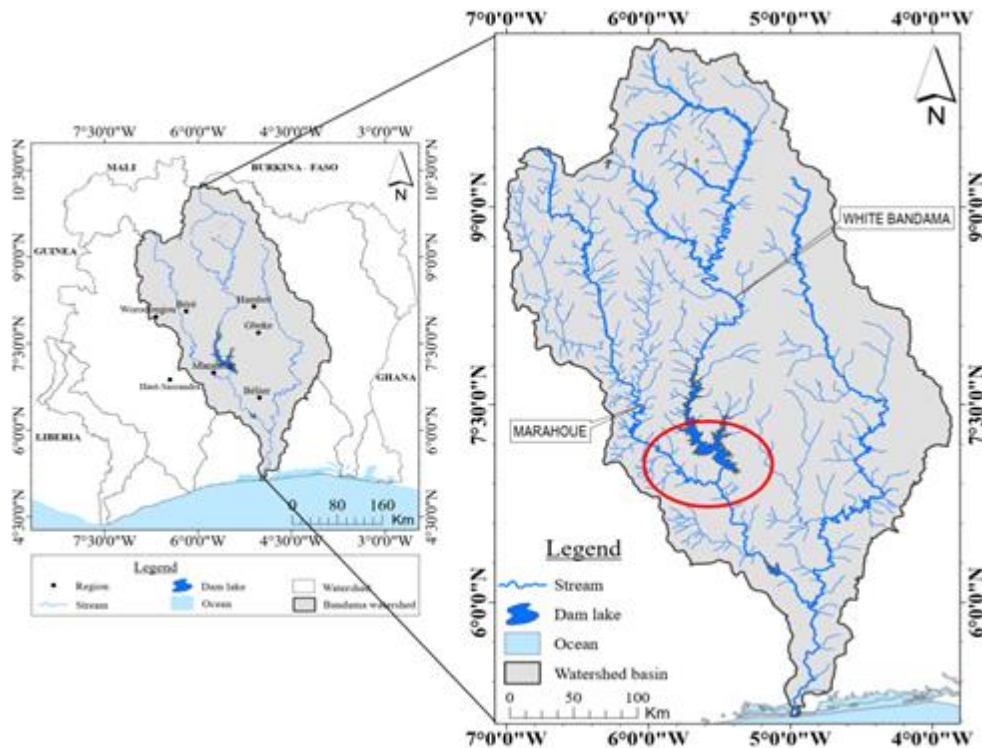
Figure 1. Location of the study area.

selected are as follows: Least Concern (LC); Not Evaluated (NE); Near Threatened (NT); Data Deficient (DD) and Vulnerable (VU). Among the fish species, the conservation status of 3 species (4.2%) observed has not yet been assessed. They are therefore classified as Not Evaluated (NE). 1 species (or 1.4%) is described as Data Deficient (DD). The majority of species (63 species, or 88.7%) were described as Least Concern (LC). 4 species or 5.63% of the total species have a Special Conservation Interest. Among these species, 1 species (1.4%) (*Tilapia busumana*) is described as Vulnerable (VU) and 3 species (4.2%) are described as Near Threatened (NT). These are: *Marcusenius furcidens*, *Sarotherodon galilaeus*, *Sarotherodon occidentalis*.

Vulnerability

Regarding vulnerability to stress due to fishing pressure, the species are divided into seven classes ranging from "low" to "very high" (Table 1 and Figure 3). The "low" vulnerability is the most widespread with 28 species, or 39.4% of all species. Eighteen species (25.4%) belong to the "low to moderate" vulnerability range and ten species (14.1%) are in the "moderate" vulnerability category. The "moderate to high" and "high" vulnerability categories are

represented by eleven species or 15.5% and one species or 1.4% respectively. The "high to very high" and "very high" categories are represented respectively by two species, or. 2.8% and one species, or. 1.4% of the entire stand. These include *Heterobranchus longifilis* and *Malapterurus electricus*, which belong to the "high to very high" vulnerability category, and *Clarias gariepinus*, which belongs to the "very high" category.

DISCUSSION

Investigations on the ichthyofauna of the Bandama River located in the Marahoué region showed that based on the classification of the International Union for Conservation of Nature (IUCN), the majority of the fish species (88.7%) inventoried were classified as "Least Concern". In addition, 79.87% of the species in this stand have vulnerability between "Low" and "Moderate". This result shows that the majority of the fish species in this environment do not face significant threats. The conservation status is an indicator to evaluate the magnitude of the risk of a species. However, this indicator is not fixed, as it may change over time as threats to the species increase or decrease. Its reassessment is therefore regularly necessary (IUCN,

Table 1. Conservation status and vulnerability of the fish species encountered from Bandama River in the Region of Marahoué.

Species	Conservation status	Vulnerability
Alestes baremoze	Least concern (LC)	Low vulnerability (22 of 100)
Amphilius atesuensis	Least concern (LC)	Low to moderate vulnerability (35 of 100)
Auchenoglanis occidentalis	Least concern (LC)	Moderate vulnerability (38 of 100)
Auchenoglanis biscutatus	Least concern (LC)	Moderate to high vulnerability (48 of 100)
Enteromius macrops	Least concern (LC)	Low to moderate vulnerability (33 of 100)
Brienomyrus brachyistius	Least concern (LC)	Low vulnerability (19 of 100)
Brycinus imberi	Least concern (LC)	Low vulnerability (10 of 100)
Brycinus macrolepidotus	Least concern (LC)	Low to moderate vulnerability (31 of 100)
Chiloglanis occidentalis	Least concern (LC)	Low vulnerability (10 of 100)
Chrysichthys maurus	Least concern (LC)	Moderate to high vulnerability (46 of 100)
Chrysichthys auratus	Least concern (LC)	Low to moderate vulnerability (27 of 100)
Chromidotilapia guntheri	Least concern (LC)	Low vulnerability (25 of 100)
Chrysichthys johnelsi	Least concern (LC)	Low to moderate vulnerability (35 of 100)
Clarias anguillaris	Least concern (LC)	Moderate to high vulnerability (54 of 100)
Clarias buettikoferi	Least concern (LC)	Low vulnerability (16 of 100)
Clarias gariepinus	Least concern (LC)	Very high vulnerability (79 of 100)
Clarias laeviceps	Not Evaluated (NE)	Low to moderate vulnerability (26 of 100)
Coptodon guineensis	Least concern (LC)	Low vulnerability (19 of 100)
Coptodon zillii	Not Evaluated (NE)	Low to moderate vulnerability (27 of 100)
Ctenopoma kingsleyae	Least concern (LC)	Moderate vulnerability (38 of 100)
Ctenopoma petherici	Least concern (LC)	Low to moderate vulnerability (31 of 100)
Distichodus rostratus	Least concern (LC)	Moderate to high vulnerability (52 of 100)
Enteromius leonensis	Least concern (LC)	Low vulnerability (10 of 100)
Enteromius macrops	Least concern (LC)	Low to moderate vulnerability (33 of 100)
Enteromius pobeguini	Least concern (LC)	Low vulnerability (13 of 100)
Enteromius sublineatus	Least concern (LC)	Low vulnerability (16 of 100)
Enteromius trispilos	Least concern (LC)	Low vulnerability (20 of 100)
Hemichromis fasciatus	Least concern (LC)	Low vulnerability (14 of 100)
Hemichromis bimaculatus	Least concern (LC)	Low vulnerability (19 of 100)
Hepsetus odoe	Least concern (LC)	Low vulnerability (21 of 100)
Heterobranchus isopterus	Least concern (LC)	Moderate to high vulnerability (50 of 100)
Heterobranchus longifilis	Least concern (LC)	High to very high vulnerability (69 of 100)
Heterotis niloticus	Least concern (LC)	Moderate to high vulnerability (55 of 100)
Hydrocynus forskahlii	Least concern (LC)	Moderate vulnerability (39 of 100)
Labeo coubie	Data deficient (DD)	Moderate vulnerability (39 of 100)
Labeo parvus	Least concern (LC)	Moderate to high vulnerability (51 of 100)
Labeo senegalensis	Least concern (LC)	Moderate vulnerability (40 of 100)
Labeobarbus bynni	Least concern (LC)	Moderate vulnerability (39 of 100)
Lates niloticus	Least concern (LC)	Moderate to high vulnerability (47 of 100)
Malapterurus electricus	Least concern (LC)	High to very high vulnerability (74 of 100)
Marcusenius furcidens	Near threatened (NT)	Moderate vulnerability (35 of 100)
Marcusenius senegalensis	Least concern (LC)	Moderate vulnerability (35 of 100)
Marcusenius ussheri	Least concern (LC)	Low to moderate vulnerability (34 of 100)
Mastacembelus nigromarginatus	Least concern (LC)	Moderate vulnerability (43 of 100)
Micralestes occidentalis	Least concern (LC)	Low vulnerability (10 of 100)
Mormyrops anguilloides	Least concern (LC)	Moderate to high vulnerability (47 of 100)
Mormyrus hasselquistii	Least concern (LC)	Moderate to high vulnerability (47 of 100)

Table 1. Contd.

Mormyrus rume	Not evaluated (NE)	High vulnerability (63 of 100)
Oreochromis niloticus	Least concern (LC)	Low to moderate vulnerability (30 of 100)
Papyrocranus afer	Least concern (LC)	Moderate vulnerability (38 of 100)
Parailia pellucida	Least concern (LC)	Low vulnerability (22 of 100)
Pellonula leonensis	Least concern (LC)	Low vulnerability (12 of 100)
Pellonula vorax	Least concern (LC)	Low vulnerability (13 of 100)
Pelmatochromis nigrofasciatus	Least concern (LC)	Low vulnerability (15 of 100)
Petrocephalus bovei	Least concern (LC)	Low vulnerability (13 of 100)
Pollimyrus isidori	Least concern (LC)	Low vulnerability (11 of 100)
Polypterus endlicherii	Least concern (LC)	Moderate to high vulnerability (48 of 100)
Raiamas nigeriensis	Least concern (LC)	Low to moderate vulnerability (25 of 100)
Raiamas senegalensis	Least concern (LC)	Low to moderate vulnerability (32 of 100)
Sarotherodon galilaeus	Near threatened (NT)	Low to moderate vulnerability (35 of 100)
Sarotherodon melanotheron	Least concern (LC)	Low vulnerability (16 of 100)
Sarotherodon occidentalis	Near threatened (NT)	Low to moderate vulnerability (35 of 100)
Schilbe mandibularis	Least concern (LC)	Low to moderate vulnerability (29 of 100)
Synodontis bastiani	Least concern (LC)	Low to moderate vulnerability (25 of 100)
Synodontis koensis	Least concern (LC)	Low vulnerability (14 of 100)
Synodontis punctifer	Least concern (LC)	Low vulnerability (24 of 100)
Synodontis schall	Least concern (LC)	Low vulnerability (21 of 100)
Thysochromis ansorgii	Least concern (LC)	Low vulnerability (12 of 100)
Tilapia busumana	Vulnerable (VU)	Low vulnerability (15 of 100)
Pelmatolapia mariae	Least concern (LC)	Low to moderate vulnerability (28 of 100)
Tylochromis jentinki	Least Concern (LC)	Low vulnerability (22 of 100)

Source: Central West of Côte d'Ivoire, UICN (2020) and Froese and Pauly (2019).
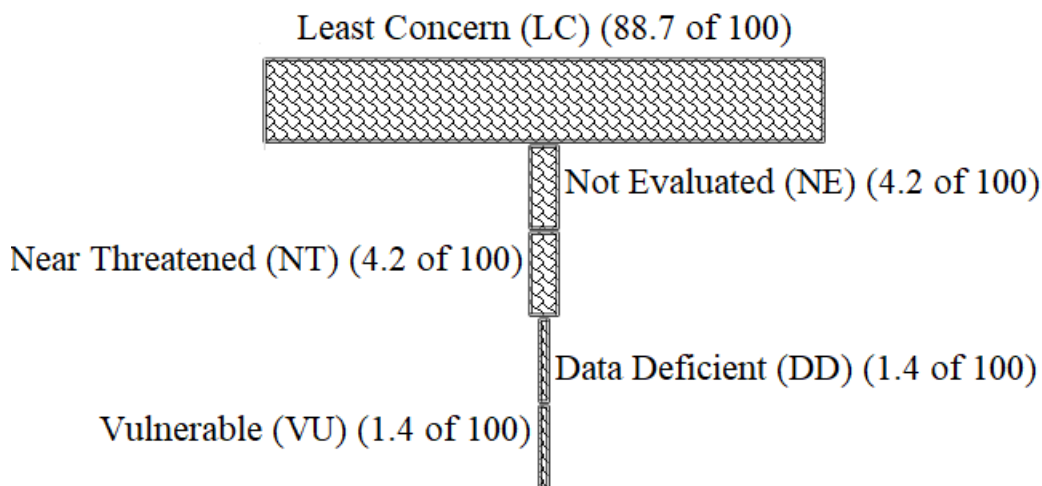

Figure 2. Proportion of the different categories of conservation status of the ichthyofauna of the Bandama River in the Region of Marahoué (Central West of Côte d'Ivoire).

2020). Founded on a solid scientific basis, the IUCN Red List is recognized as the most reliable reference tool for knowing the level of threats to specific biological diversity. On the basis of precise information on endangered
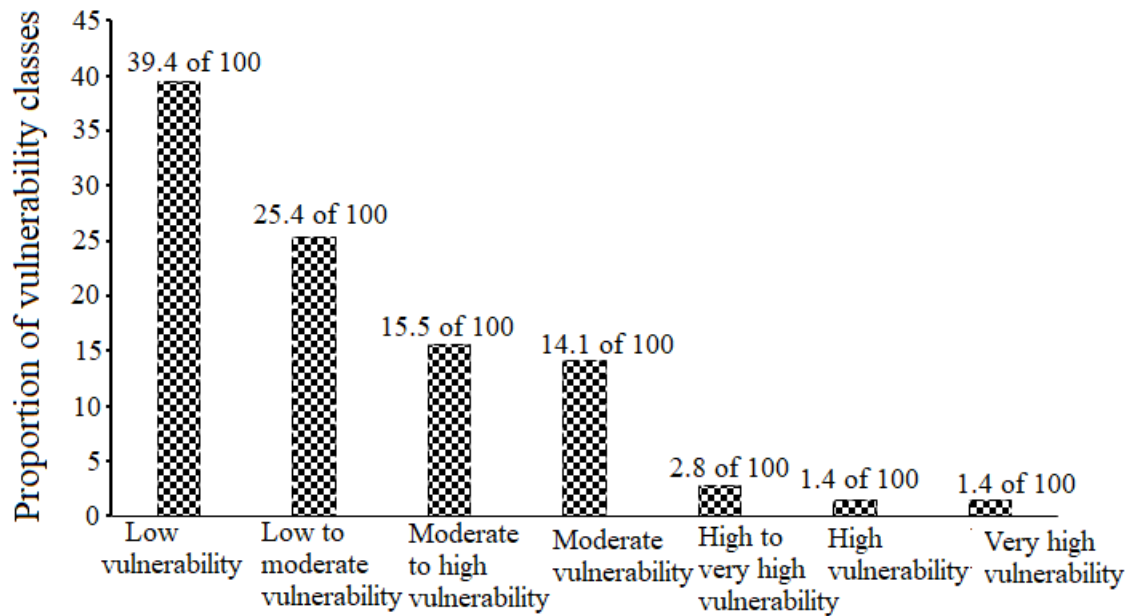
Figure 3. Proportion of the different vulnerability classes of the ichthyofauna of the Bandama River in the Region of Marahoué (Central West of Côte d'Ivoire).

species, its essential aim is to identify priorities for action, to mobilize the attention of the public and political leaders on the urgency and extent of conservation problems, and encourage all stakeholders to act to limit the rate of species extinction (IUCN, 2020; Froese and Pauly, 2019).

Moreover, among this population there is a significant percentage (5.63%) of species with a special status. Among these species, 1 species (*Tilapia busumana*) this species was listed by IUCN in 2020 as Vulnerable (VU) and 3 species (*Marcusenius furcidens*, *Sarotherodon galilaeus* and *Sarotherodon occidentalis*) these species were listed by IUCN in 2020 as Near Threatened (NT). According to Cheung et al. (2005), 21.13% of species have a vulnerability greater than the "Moderate" category. Consequently, these species with a restricted geographical distribution and the population size is due to deterioration of the ecological quality of their environment (IUCN, 2020; Froese and Pauly, 2019).

Conclusion

The present work revealed that the majority of fish species inventoried in the Bandama River in the Marahoué Region were classified as "Least Concern". However, three species have a special conservation status. These include *H. longifilis* and *M. electricus*, which belong to the "high to very high" vulnerability category, and *C. gariepinus*, which belongs to the "very high"

category. In addition, 79.87% of the species in this stand have a vulnerability between "Low" and "Moderate".

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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