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First Data of the Ichthyological Fauna in the Bandama River at the Lamto Scientific Nature Reserve (Côte d'Ivoire, West Africa)

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Abstract

Fish species composition and organization of the Bandama River at the scientific nature reserve of Lamto have been investigated for the first time. The study was conducted from March 2021 to February 2022. Gillnets and traps were used to collect fish. A total of 41 species belonging to 35 genera, 13 families, and 5 orders were captured. The best-represented orders were the Siluriformes with 5 families and 11 species and the Perciformes with 3

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families and 14 species of fish. The Cichlidae, Mormyridae, and Alestidae represented the best diversified family with 13, 5, and 5 species respectively. This study also showed a decrease in the average size of individuals of the main species retained, which could reflect overexploitation of the stocks. The Shannon index (2.21 bits/ind.) and equitability (0.58) values obtained reflect a more or less distribution of individuals by species. These results will make it possible to establish a database for the conservation of this fish population and its habitat.

Keywords: Ichthyofauna, Diversity, Bandama River, Scientific reserve of Lamto, Côte d'Ivoire

Introduction

Aquatic ecosystems provide many services that are not often valued (Brummett *et al*., 2008). Despite this importance, aquatic resources are seriously threatened by various anthropogenic activities such as using of ichthyotoxins in fishing, pollution of various origins (agricultural, domestic, and industrial), the introduction of alien species, construction of agro-pastoral, irrigation, and hydroelectric dams and deforestation (Kamdem and Toham, 1998; Kouamélan *et al*., 2003). These activities result in the loss of biodiversity in the hydro systems. Ivorian rivers are not immune to all anthropic actions mentioned above. This situation has a negative impact on the dependent on fishing. Faced with these disturbances and threats to the structure of aquatic ecosystems and particularly to the diversity of the fish fauna, the an urgent need to take adequate measures for rational and sustainable management of the hydro systems (Lévêque, 1994). Most environmentalists agree that the establishment and conduct of any policy for the development and preservation of aquatic ecosystems must be preceded by a knowledge of fish populations and their living environment. This approach includes evaluation of the specific composition of fish communities, studying biology (reproduction, growth, diet, parasitism), ethology and distribution of the different species, identifying and characterizing habitats offered by the environment, and analyzing correlations between species and environmental variables. Recent data on the fish fauna of the Bandama River are those of Kien *et al*. (2021) and concern only three sites in the lower course of the Bandama River. There is no report on the ichthyofauna of the Bandama River near the Lamto. However, this protected area would constitute one of the most productive habitats.

According to Aigoui and Dufour (2008), fish need to move to ecologically different environments to properly conduct the major life history phases of their life cycle. As a result, fish from the peripheral ecosystems could move to the part of the River near the Lamto reserve to feed or reproduce.

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Thus, this area would be the last viable refuge for many species fleeing high pressure areas. It would thus play an undeniable role in the renewal of stocks in the rest of the unprotected river. However, the fishermen of the camps surrounding the River carry out their activity in the Bandama area near the reserve. Thus, the current study aimed to make a qualitative and quantitative inventory of the ichthyofauna of the Bandama River adjacent to the Lamto Scientific nature reserve.

Materials and Methods

Location of the study area

The Bandama River adjacent to the Lamto Scientific Reserve is situated in the central part of Côte d'Ivoire (West Africa), at the tip of the "V baoulé" between the Guinean savanna and the semi-deciduous forest. It is located in the region of Agneby-Tiassa, in the department of Tiassalé, at approximately 165 km north-west of Abidjan, between 6°13 and 6°15' North latitude and 4°06' and 5°03' West longitude. With a catchment area of 25 km^2, the vegetation of the study area is a mosaic of forest-savanna, constituted by forest galleries along the Bandaman River, fragments of dense semi-deciduous forest and savanna with roast tree (Vuattoux *et al*., 1998).

The Bandama River at the Lamto Scientific Reserve is located in the center part of Côte d'Ivoire, between latitudes 6°9''N and 6°15''N and longitudes 5°0' W and 5°02' W (Figure 1). The river is characterized by four seasons determined by the rainfall regime (Pagney, 1988). There is a long rainy season (April to July), a small dry season (August), a small rainy season (September to October), and a long dry season (November to February). In the last decades, the average annual rainfall observed was 100.75 mm, with an average annual temperature of 28.27°C. Plantations of coffee, rubber, and food crops have developed around this station. There are also a few dwellings.

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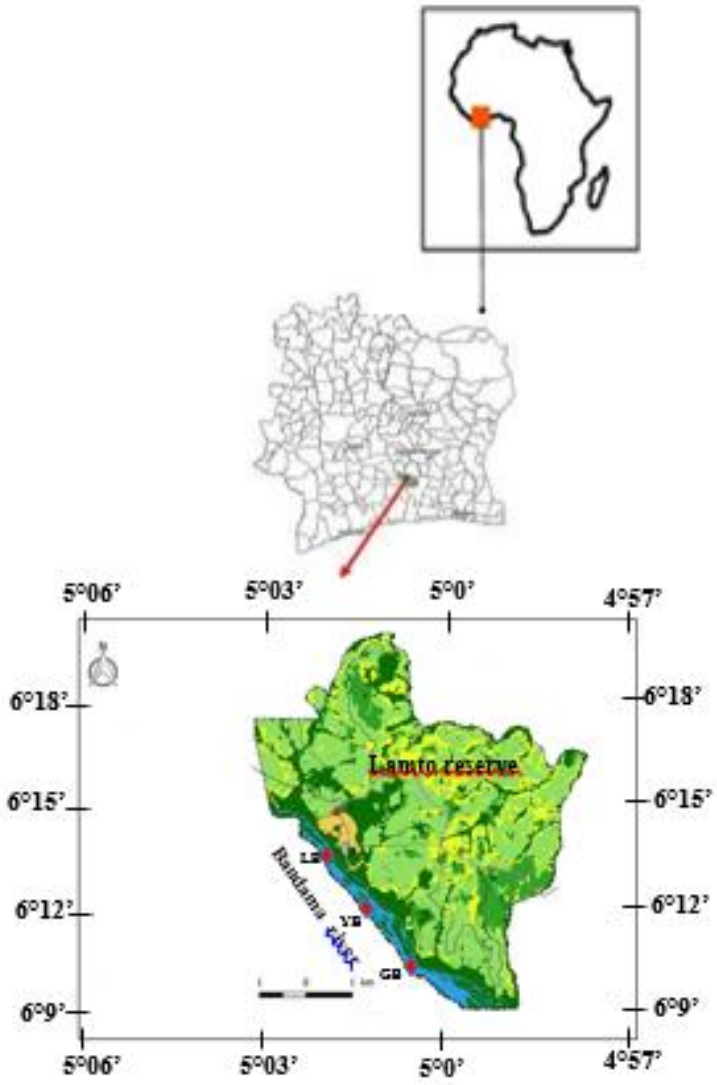

Figure 1. Location of the study area showing the sampling stations

Data collection

-Measurement of water physico-chemical parameters

Water physico-chemical parameters such as temperature, conductivity, dissolved oxygen, dissolved solids, and pH were measured using a multi-parameter type HANNA. Water transparency was estimated with a Secchi disk. These measurements were *in-situ* in the study area to a depth of at least 50 cm.

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-Sampling and identification of fish

Fishes were collected by experimental methods from March 2021 to February 2022 on the Bandama River at the Lamto Scientific Reserve station. Sampling covered the entire area of the water body. A battery of seven gillnets with different mesh sizes (10, 20, 30, 40, 60, 80, and 90 mm) was used. Each net measures 100 m long with a drop height of 3 m. Nets were set at 5:00 p.m. and visited at 7 : 00 a.m. the next day for the nighttime fishery, then visited and at 12 : 00 p.m. for daytime fishing. Other catching devices such as bamboo, liana traps, and lianas have been used to catch fish. The fish were identified according to the keys of Paugy *et al*. (2003a, b). The identified specimens were individually measured to the nearest millimeter (standard length (SL) and total length (TL)) and weighed to the nearest gram. The measurements were made using an ichthyometer and an electronic scale with a precision of 1 g, respectively.

Data analysis

-Specific numerical and weight abundances

Numerical and weight abundances (biomass) were calculated respectively by the following formulas:

N = $\frac{ni}{Nt}$ **x100**

With: ni = Number of individuals of a taxonomic group (species, family or order), Nt = Total number of individuals.

P = $\frac{p}{Pt}$ **x100**

With: p = Weight of individuals in a taxonomic group (species, family or order), Pt = Total weight of individuals in a sample.

-Diversity Index

Shannon and Weaver's (1963) diversity H' index and Piélou (1984) Equitability E were also calculated from the following formulas:

$$H' = -\sum_{s=1}^{s} Pi\ log2\ Pi$$

With :

Pi = $\frac{ni}{N}$

S = Number of species

N = Sum of the number of species

ni = Population size of each species

Pi = Relative abundance of species in the sample

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$$\mathbf{E} = \frac{H'}{loglog\ 2\ S}$$

Where:
H' = Shannon and Weaver specific diversity index
S = Specific richness

The Shannon and Weaver specific diversity index (H') expresses the degree of organization of the settlement, its value H' is between 0.5 (very low diversity) and 5 (most diverse and fairly distributed communities). Equitability is a measure of the quality of an organization. Its value fluctuates between 0 and 1 (when it is close to 0, one species largely dominates the settlement, when it is equal to 1, all the species tend to have the same abundance in a natural and undisturbed environment) (Barbault, 2000 and Dajoz, 2000). These indices were calculated monthly to assess their variation over time.

Analysis of size class structures

The analysis of the size class structure of fishes provides useful information, notably on the state of a given population (recruitment and reproductive success, level of exploitation of resources, one-time events affecting recruitment in a given year). The standard lengths (SL) obtained from the different individuals of the species selected for this study were grouped into size classes. In addition, the determination of the number and lengths of the size classes was done according to Sturge's rule (Scherrer, 1984).

-Determination of size classes

Number of classes = 1 + (3.3 log N)
With : N = total number of specimens examined
-Determination of the class i amplitude
Amplitude = (LS max - LS min) / Number of classes
With : LS = standard length

Microsoft Excel software and the PAST program was used to analyze various data.

Statistical analysis

Kruskall-Wallis and Mann-Whitney tests were applied to the data set to assess spatial variation of physicochemical parameters and fish populations at sampling stations. All steps of this method were computed using STATISTICA 7.1 software. Differences of $p < 0.05$ were considered significant.

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Results

Water physico-chemical parameters

The variations of the physico-chemical parameters of the different stations of the Bandama River at the Lamto Scientific Reserve are recorded in table 1. The temperature values ranged from 27.6 to 30 °C. Both small and large values were recorded at station GB. Dissolved oxygen values range from 1.77 to 3.7 mg/l. The low weight was found at station YB and the high value at GB. The pH ranges between 6.7 and 7.9 with the lowest value recorded at station YB and the highest at GB. The variation in dissolved solids is 51 to 62 mg/l. The lowest value was found at YB and the highest at LB. Conductivity varied from 111 µS/cm at station YB to 203 µS/cm at LB. The spatial variation in water transparency is 98-140 cm. The lowest value was noted at station LB and the highest at YB. The values of temperature, dissolved oxygen, pH, dissolved solids, and conductivity submitted to the Kruskal Wallis test did not reveal any significant difference between the three stations. Overall, the waters of the surveyed stations are warm, less oxygenated, alkaline, and moderately mineralised. The temperature, dissolved oxygen, pH, dissolved solids, conductivity, and transparency of the water subjected to the Kruskal Wallis test did not reveal any significant difference between the three resorts ($p < 0.05$).

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Table 1 : Physical and chemical parameters of the Bandama River at the Lamto Scientific Nature Reserve.

		Measured Parameters					
Stations	**Values**	**T° (C)**	**O_2 (mg/l)**	**pH**	**TDS (mg/l)**	**Cond (µS/cm)**	**Trans (cm)**
Loumbossou	Min	29	1.9	6.8	59	172	98
	Mean	28	2.2	6.97	62	185	112
	Max	29.6	2.8	7.1	73	203	124
	SD	0.9	0.5	0.4	1.6	0.9	2
Yobouè	Min	28.79	1.77	6.17	51	111	120
	Mean	28.99	2.41	7.21	53.33	115.25	135.6
	Max	29.21	3.21	7.85	54	117	140
	SD	1.2	0.01	1	1.4	1.6	2.6
Gbahan	Min	27.6	3	7.23	53	156	113
	Mean	28	3.2	7.85	57	163	131
	Max	30	3.7	7.9	61	187	137
	SD	0.3	0.4	0.1	0.2	0.71	2.1

T° : Temperature ; O_2 : dissolved oxygen ; pH : hydrogen potential ; TDS : Dissolved solids of water ; Cond : conductivity ; Trans : water transparency ; SD : Standard deviation.

Fish Fauna Characterisation

Taxonomic composition / Shannon-Weaver diversity and Equitability Index

Forty-one fish species belonging to 35 genera, 13 families and five orders were recorded in the Bandama River at the scientific nature reserve of Lamto (Table 2). The most diversified order was Siluriformes with 5 families and 11 fish species. It is followed by the Perciformes order with 3 families and 14 species. The Osteoglossiformes and Cypriniformes order were each represented by one family with 5 and 3 species respectively. At the level of the families, the Cichlidae constitute the best diversified family with 13 species. It was followed by the families Mormyridae and Alestidae with 5 species each. The following 5 families emerged as monospecific: Hepsetidae, Distichodontidae, Malapteruridae Channidae, and Anabantidae.

The values of the Shannon-Weaver diversity and Equitability index calculated are 2.21 bits/ind. and 0.58 respectively.

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Table 2 : List of sampled fish species in the Bandama River at the Lamto Nature Reserve

Orders	Family	Species
OSTEOGLOSSIFORMES	Mormyridae	*Marcusenius furcidens*
		Marcusenius ussheri
		Marcusenius senegalensis
		Mormyrops anguilloides
		Mormyrus rume
CHARACIFORMES	Hepsetidae	*Hepsetus akawo*
	Alestidae	*Alestes baremoze*
		Brycinus imberi
		Brycinus longipinnis
		Brycinus macrolepidotus
		Brycinus nurse
	Distichodontidae	*Distichodus rostratus*
CYPRINIFORMES	Cyprinidae	*Barbus ablabes*
		Labeo coubie
		Labeo parvus
SILURIFORMES	Claroteidae	*Chrysichthys maurus*
		Chrysichthys nigrodigitatus
	Schilbeidae	*Schilbe intermedius*
		Schilbe mandibularis
	Clariidae	*Clarias anguillaris*
		Heterobranchus isopterus
		Heterobranchus longifilis
	Malapteruridae	*Malapterurus electricus*
	Mochokidae	*Synodontis bastiani*
		Synodontis schall
		Synodontis punctifer
PERCIFORMES	Channidae	*Parachanna obscura*
	Cichlidae	*Chromidotilapia guntheri*
		Hemichromis bimaculatus
		Hemichromis fasciatus
		Oreochromis niloticus
		Sarotherodon galilaeus
		Sarotherodon melanotheron
		Coptodon guineensis
		Coptodon zillii
		Hybride (Coptodon zillii x Coptodon guineensis)
		Coptodon sp
		Tilapia mariae
		Tylochromis jentinki
		Tylochromis intermedius
	Anabantidae	*Ctenopoma petherici*
TOTAL 5	13	41

Numerical and weight abundance

Figure 2 presented the numerical and weight abundance of fish families. The family of Claroteidae was dominant (59.13% and 48.82 %)

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followed by the Cichlidae (22.05 % and 25 %) and Mochokidae (6.84 % and 4.75 %). Figure 3 indicated the numerical and weight abundances of the cumulative catches of fish species. The main species which dominates the population in terms of numerical abundance is *Chrysichthys nigrodigitatus* with 53.95 %, it is followed by Hybrid (*Coptodon zillii* x *Coptodon guineensis*) (8.08 %), *Synodontis punctifer* (5.08 %), *Chrysichthys maurus* (4.51 %) and *Oreochromis niloticus* (2.82 %) of total catch. In terms of biomass, the preponderance is ensured by *Chrysichthys nigrodigitatus* (43.04 %) followed by the species Hybrid (*Coptodon zillii* x *Coptodon guineensis*) (9.60 %), *Labeo coubie* (5.85 %), *Oreochromis niloticus* (4.45 %) and *Clarias anguillaris* (4.31 %). None of the others exceeded 4 % of total biomass.

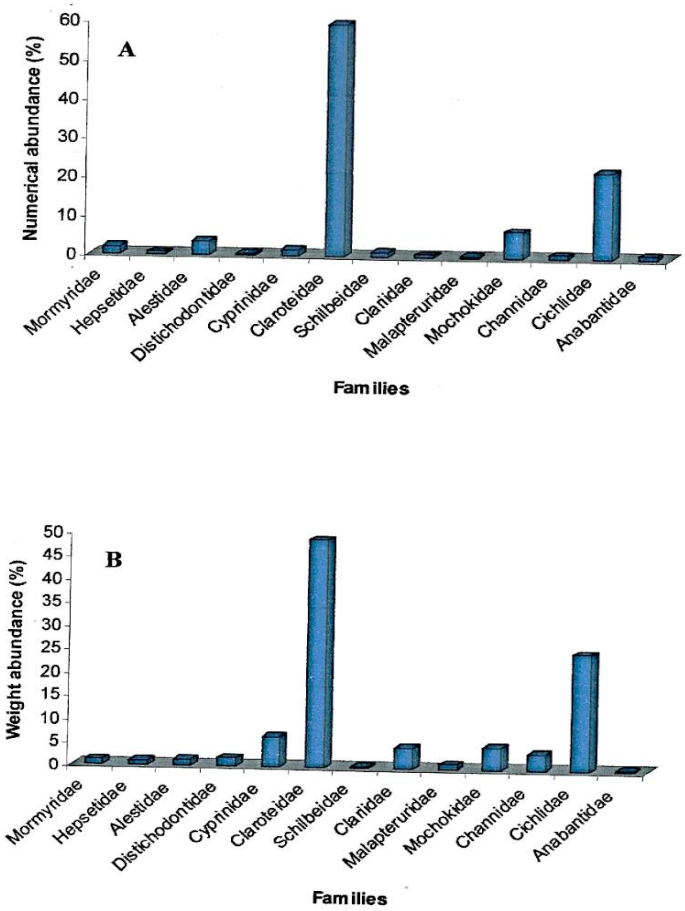

Figure 2 : Numerical (A) and weight (B) abundance of fish families

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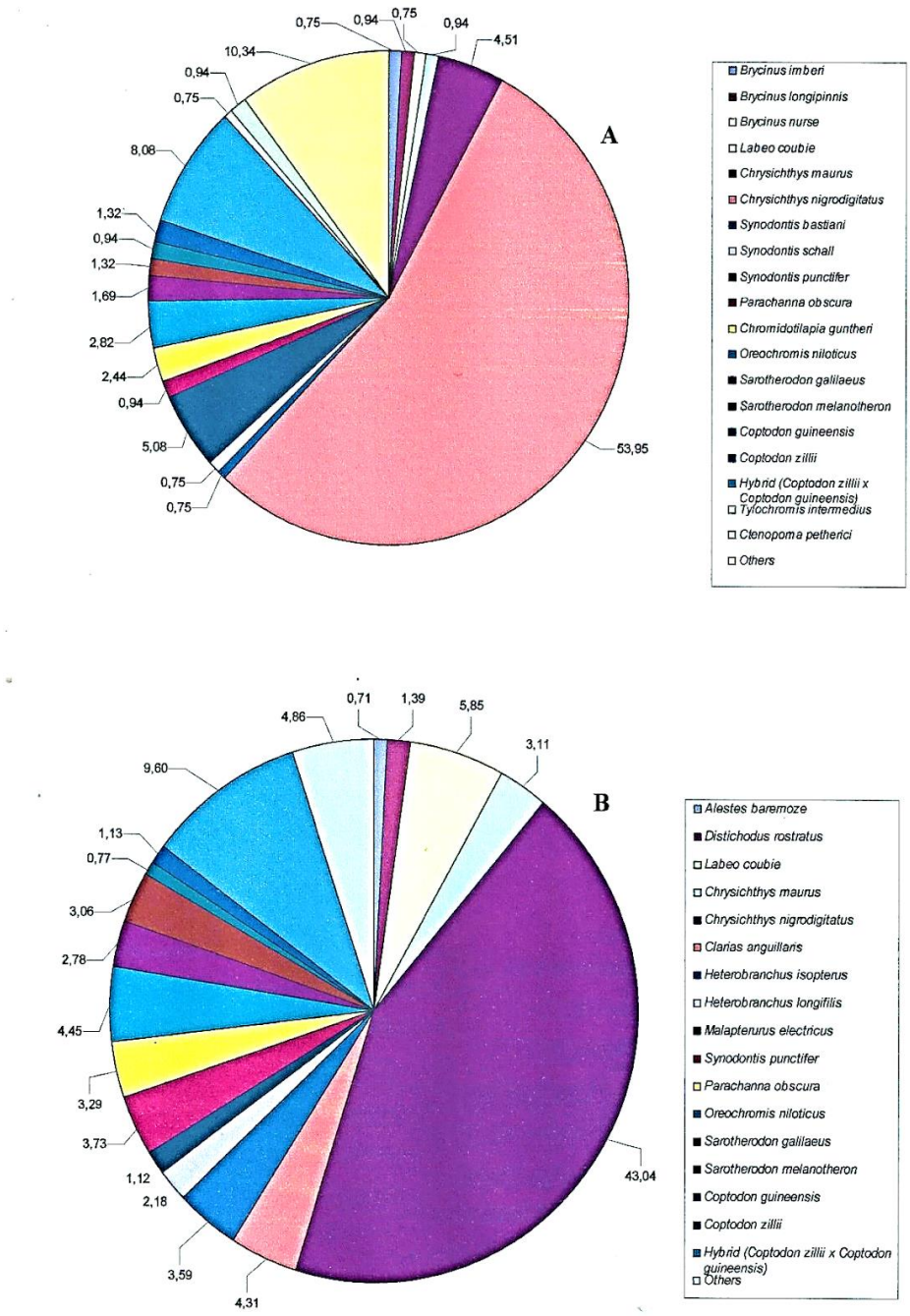

Figure 3 : Numerical (A) and weight (B) abundance of fish species

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Size structure of fish

The size structure of ichthyological fauna of the Bandama River at the scientific nature reserve of Lamto is represented by the Figures 4 and 5. The main species are *Chrysichthys nigrodigitatus*, *Chrysichthys maurus*, *Oreochromis niloticus*, Hybrid (*Coptodon zillii* x *Coptodon guineensis*) and *Synodontis punctifer*. The populations of the five species studied all present unimodal structures except the Hybrid (*C. zillii* x *C. guineensis*). The standard length of individuals of *Chrysichthys nigrodigitatus* species varied between 125 and 260 mm while that of individuals of *C. maurus* species ranged from 120 to 185 mm. *Chrysichthys nigrodigitatus* (53.95 %) representing the dominant species was mostly caught in the juvenile stage. For this species, the size class with the largest number of fish was between 125 and 140 mm SL (standard lenght) with 265 individuals (Figure 4A). For the fish species *Chrysichthys maurus* which represents 4.51 % of the fish caught, the size class with the largest number of fish varied between 120 and 133 mm SL with 20 specimens (Figure 4B). The standard length is ranged from 100 to 285 mm in *Oreochromis niloticus* and 114 to 205 mm in the Hybrid (Figure 4C). During their capture, *Oreochromis nioticus* (2.82% of the species considered) presented mostly a sub-adult size. The corresponding size class is 174 to 211 mm SL with 15 fishes. Two modes were identified in the Hybrid (8.08 % of catches) specimens (Figure 5A). The first mode includes 12 individuals whose size class varied from 140 to 153 mm SL and the second one includes 14 fish specimens ranging between 166 and 169 mm SL. The second peak reveals adult individuals of fairly large size. In *Synodontis punctifer* whose numerical percentage is 5.08 %, the standard length of the fish caught is between 108 and 126 mm (Figure 5B). The peak is observed in the individuals of size varying between 117 and 120 mm LS with a number of 13 individuals.

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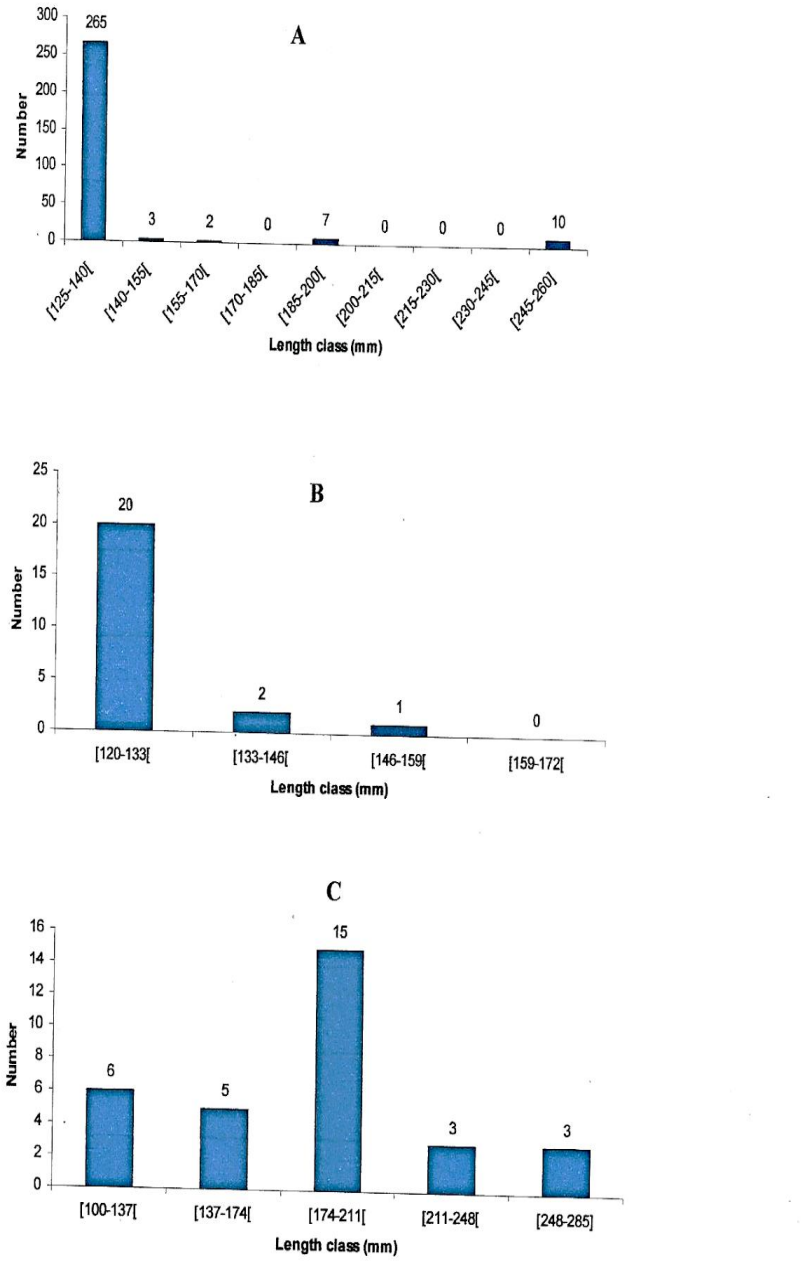

Figure 4 : Size frequency distribution of *Chrysichthys nigrodigitatus* (A), *Chrysichthys maurus* (B) and *Oreochromis niloticus* (C) specimens

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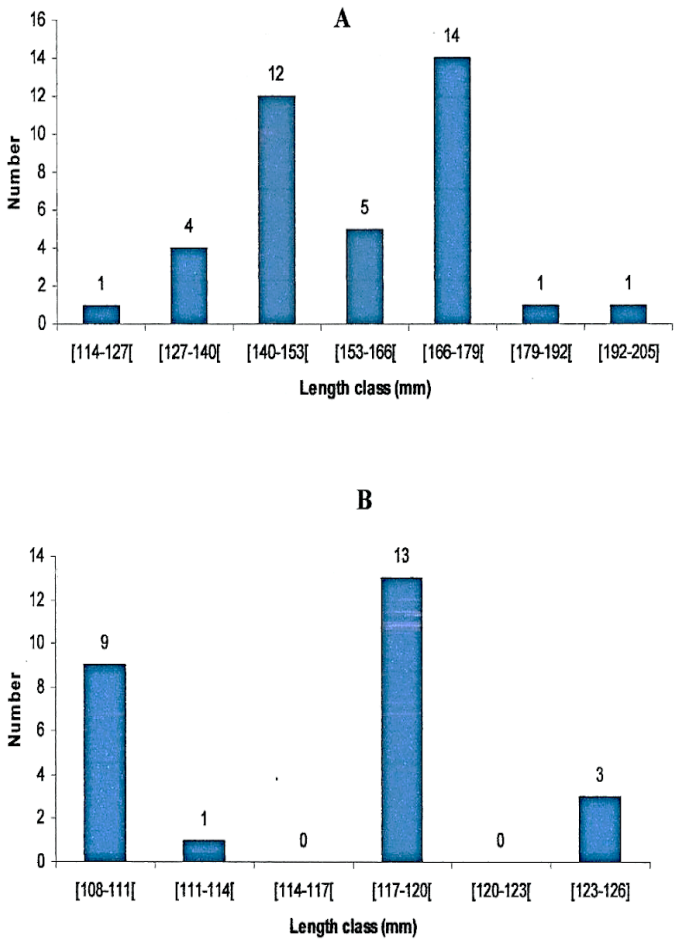

Figure 5 : Size frequency distribution of Hybrid (*Coptodon zillii* x *Coptodon guineensis*) (A) and *Synodontis punctifer* (B) specimens

Discussion

Knowledge of the water parameters is essential for fish life (Guissé and Niass, 2020). They state that temperature and dissolved oxygen are the two most important parameters for fish growth. In the present study, the average water temperature recorded is 28.99 ± 1.2 °C and is within the optimal temperature range (23- 31 °C) proposed by Lalèyé *et al*. (2004) for a favorable

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life of ichthyofauna in water bodies. In intertropical Africa, average temperature values are generally high and most often above 20°C. Thus, the average temperature recorded indicates that the water is relatively hot. This would be related to the fact that the Bandama River in the reserve is completely open and therefore receives direct sunlight that warms the water. According to Chouti *et al*. (2010), oxygen levels provide information on the health of streams and can be used to assess fish habitat quality. The dissolved oxygen measured indicates that the Bandama River waters at the scientific nature reserve of Lamto are less oxygenated (1.77± at 3.21± mg/l). This low oxygen content could be attributed mainly to the high proportion of macrophytes that cover most of this proportion of plant debris present in the environment. This debris would indirectly cause a depletion of the dissolved oxygen concentration by their accumulation and decomposition in the waterways (Wilcock *et al*., 1995). Indeed, the bacteria responsible for the decomposition of organic matter increase the biochemical oxygen demand and release carbon dioxide into the environment through respiration (Wilcock *et al*., 1995). In addition, this could be due to the anthropic activities in or near the Bandama River. In fact, the dead arm of this river where the present study was conducted, receives agricultural fertilizer from the surrounding villages by runoff water. In addition, the Bandama River waters are subject to pollutants due to chemicals used by mines and gold mining. All these activities contribute to modifying the environmental parameters, especially the oxygen. The pH is a measure of the hydrogen ion activity of a system. It determines the acidity or basicity of this system. The pH values measured vary between 6.17 and 7.85 with a mean value of 7.21±1. The Bandama waters River at Lamto is therefore basic. These data are comparable to Koné's (2009) and Berté's (2009) data on this river. Almost all of the stations on the Bandama River have slightly alkaline waters. Indeed, these results are due to the biological and geological processes occurring in the water body, and by the grounds nature crossed by this one as noted Rodier *et al*. (2009). According to Welcomme (1985), conductivity allows a better appreciation of the chemical richness of a zone. In this study, the mean conductivity and dissolved solids rate values are respectively 115.25 ± 3.1 µS/cm and 53.33 ± 3.4 mg/l. Using the Rodier *et al.* (2009) scale, analysis of the conductivity data revealed that the Bandama River waters at the Lamto are low mineralized. Such as conductivity and the dissolved solids rate are two positively correlated parameters, and the observations made on conductivity apply to the dissolved solids. Welcomme (1985) indicates that in a natural environment, water conductivity variations are influenced by several factors including precipitation, evaporation, and substrate type. The transparency values measured oscillate between 120 and 140 cm with a mean value of 135.6 ±4.6 cm. Berté (2009) noted that the Bandama River waters between Kossou and

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Taabo lakes were the most transparent in the basin (309.102 cm). Compared to the data in this study with that of this author, it appears that the Bandama River waters at the scientific nature reserve of Lamto are less transparent. This is due to the high turbidity of the water linked to the quantity of suspended matter and the discharges of anthropic activities, particularly gold mining in the Bandama River.

In this study, 41 fish species belonging to 35 genera, 13 families, and 5 orders were identified. Some authors such as Adou *et al*. (2017) and Kien *et al*. (2021) had collected 40 and 44 fish species from Ayamé 2 Dam Lake and the lower Bandama River, respectively. The Bandama River, which surrounds the Lamto scientific reserve and in which the present study was investigated, has a fairly diversified fish fauna despite its small size. Comparison with the previous situation is difficult because there are practically no data on the fish fauna in this area of the Bandama River. Nevertheless, the richness obtained in this study is important compared to that noted by Kien et al. (2021) in the lower Bandama River where a high fishing pressure is exerted on a fairly large area. This important specific richness is explained by the fact that this zone of the river is protected and constitutes a last viable refuge for many species fleeing the places of significant fishing pressures of other sites of the Bandama River. The study area has the lowest level of anthropic pressure, compared to other parts of the Bandama River. These results indicate that this environment offers ecological conditions (breeding site and food resources), allowing the establishment of these species. Indeed, the study area has different types of habitats that can provide food resources due to the presence of the gallery forest. These habitats are suitable spawning areas for these species and allow significant colonization by fish. Therefore, this area would undeniably renew stocks in the rest of the unprotected river. The dominant orders namely Perciformes and Siluriformes were similar to the observations made by Ekpo and Udoh (2013), Eyi *et al*. (2016), Ibemenuga *et al*. (2017), and Konan *et al*. (2019). This is a remarkable fact in Africa's rivers and water bodies particularly in Côte d'Ivoire. These results are explained by the fact that these fish orders are among Africa's dominant orders (Lowe Mc Connell, 1987). Another reason is that these orders of fish are more diverse and have been able to adapt to different ecological conditions. The ichthyofauna of the Bandama River waters at the scientific nature reserve of Lamto is dominated by the families Claroteidae and Cichlidae in terms of numerical and biomass proportion. This order does not seem to be maintained in all streams. Indeed, the results of Eyi *et al*. (2016) showed that the Cichlidae, Claroteidae, Mormyridae and Alestidae are the most important families in terms of number of species. Adou *et al*. (2017) also reported Cichlidae's dominance in Lake Ayame 2. The high proportion of the family Claroteidae would be due to the many rocks in the environment. Rocky and clay substrates seem to be the best

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habitats for this family of fish as mentioned by Kisekelwa *et al*. (2014) in their work. The Cichlidae follows this family. It could be explained by the fact that the family Cichlidae is particularly abundant in many African rivers and reservoirs as suggested by Montchowui *et al*. (2008), Ouédraogo *et al*. (2015), and Adou *et al*. (2017). In addition, it is well known that Cichlid fishes are the most species-rich family of all teleost fishes, and their diversity is centered in the great African rivers and lakes. According to Van Dyke (2003), their abundance is attributed to their natural trait such as high reproductive rates, high rate of juvenile and adult survival, or strong competitive abilities that allow them to dominate other species. Also, Cichlids fishes dominate due to their diet flexibility (Daddy *et al*., 1991). Indeed, this family's specimens can thrive on a wide range of food items. Despite of the depletion of the environment in oxygen, the families Mormyridae and Alestidae, which are intolerant species, have been found. It is well known that species of these fish families are rapidly affected by adverse environmental conditions and would therefore be good indicators to characterize the current state of a habitat and the changing state of an ecosystem. The existence of the surrounding vegetation could explain their presence in the Bandama at Lamto. Indeed, this vegetation leads to the provision of a large amount of nutrients for the fish. Thus, the species that are more successful in exploiting these resources and reproducing will be more abundant, as Koné *et al*. (2003) indicated. In addition, Mormyridae and Alestidae could therefore be considered pioneer and opportunistic species that take advantage of new food sources available in the environment. The present study revealed that *Chrysichtys nigrodigitatus* is the main species regarding the numbers and biomass of catches in the Bandama at Lamto. It is followed by Hybrid (*Coptodon zillii* x *Coptodon guineensis*), *Synodontis punctifer*, *Chrysichthys maurus* and *Oreochromis niloticus*. Their important presence would be due to the characteristics of the environment that are favorable to them.

The diversity index (H') measures the degree of the settlement organization and the equitability enables to assessing the organization's quality (Dajoz, 2000; Barbault, 2000). According to these authors, good settlement organisation is reflected in an equitability close to 1. Low equitability results from the predominance of a few species over all other taxa. On the contrary, when there is not an abundance of a few organisms, the specific diversity is greater because spaces are spaces are freed up, thus favouring the proliferation of several other species. The Shannon index (2.21 bits/ind.) and equitability (0.58) values obtained in the Bandama River at Lamto scientific reserve are respectively close to and above the mean. This reflects a more or less distribution of individuals by species, suggesting that there are no dominant species in the Bandama River at Lamto, and the species distribution is regular.

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The study of the size structure of the main species made it possible to note that the individuals of *C. nigrodigitatus* and *C. maurus* captured are mostly small and, therefore juveniles. The decrease in the average size of individuals of these two species could reflect the overexploitation of the stocks. Indeed, these two fish species are highly prized by the local population. Therefore, these fishes are subject to intense illegal fishing in this area of the Bandama River, which is part of the Lamto nature reserve and is therefore monitored by the state. These illegal fishermen would use unconventional catching gear for fishing, leading to the overexploitation of fish stocks. This idea is confirmed by the assertion of Bédia (2015). Indeed, this author had noted that the lack of regulation of fishing gear could explain the high number of small individuals in the fisheries. The high number of *Oreochromis niloticus* individuals, the Hybrid (*Coptodon zillii* x *Coptodon guineensis*), and *Synodontis punctifer* consist of sub-adults. For these two fish species and the Hybrid, Almost all size classes are represented for these two fish species and the Hybrid. This size variability is due to the availability of food resources and predation as suggested by Ouattara *et al.* (2009). In this study, except the Hybrid, the populations of *Chrysichthys nigrodigitatus*, *C. maurus*, *Oreochromis niloticus* and *Synodontis punctifer* present a unimodal distribution. Therefore, they would be spared extinction (Lye-Koh *et al*., 1997). According to these authors, an endangered population has a bimodal size distribution, corresponding to juvenile specimens and adult specimens.

Conclusion

This study identified forty-one (41) fish species from 5 orders and 15 families in the Bandama River at the Lamto scientific nature reserve. The population is dominated by Siluriformes and Perciformes represented by the families Claroteidae and Cichlidae in terms of numerical and biomass proportion. *Chrysichtys nigrodigitatus* is the main species. It is followed by the Hybrid (*Coptodon zillii* x *Coptodon guineensis*), *Synodontis punctifer*, *Chrysichthys maurus*, and *Oreochromis niloticus*. Biological diversity remains high relatively according to the calculated diversity indices. In addition, the different species show a certain homogeneity in their distribution. This study also shows a decrease in the average size of individuals of the main species retained, which could reflect overexploitation of the stocks. This work is a preliminary study that will serve as a reference for subsequent monitoring investigations of the fish fauna of the Bandama River at the Lamto scientific nature reserve.

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References:

1. Adou, Y. E., Blahoua, K. G., Bamba, M., Yao, S. S., Kouamélan, E. P., N'Douba V. (2017). Premières données sur l'inventaire du peuplement ichtyologique d'un lac ouest Africain situé entre deux barrages hydroélectriques : Lac d'Ayamé 2 (Côte d'Ivoire). *Journal of Applied Biosciences*, 110 : 10808-10818.
2. Aigoui, I., Dufour, M. (2008). Guides Passes à poissons. (ed. (CETMEF) VNdFVeCdETMeF), 75p.
3. Barbault, R. (2000). Ecologie générale : Structure et fonctionnement de la biosphère. 5ème édition, Dunod, Paris. 326 p.
4. Bédia, A. T. (2015). Evaluation de l'exploitation de l'ichtyofaune du complexe lagunaire AghienPotou (Côte d'ivoire). Thèse de Doctorat Université Félix Houphouët Boigny (Côte d'Ivoire), 178 p.
5. Berté, S. (2009). Biologie et écologie de Distichodus rostratus (Günther, 1864) dans un hydrosystème particulier en côte d'ivoire. Thèse de Doctorat, Université d'Abidjan-Cocody (Côte d'Ivoire). 180 p
6. Brummett, R. E., Lazard, J., Moehl. J. (2008). African aquaculture: Realizing the potential. Food Policy, 33: 371-385.
7. Chouti, W., Mama, D., Alapini, F. (2010). Etudes des variations spatio-temporelles de la pollution des eaux de la lagune de Porto-Novo (Sud-Bénin). *Journal of Applied Biosciences*, 4 (4) 1017-1029.
8. Daddy, F., Abubakar, A., Aina, E. (1991). Studies on Tatabu flood plain vegetation and its utilization. p 16 – 20. In: 1990 National Institute of Freshwater Fisheries Research (NIFFR) Annual Report

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

9. Dajoz, R. (2000). Précis d'écologie (7ème édition) Dunod. Paris 615 p.
10. Ekpo, I. E., Udoh. J. P. (2013). Species Richness and Diversity of Ichthyofaunal communities of the Lower Cross River floodplain, Nigeria. *International Research Journal of Environment Sciences*, 2(7) : 1-5.
11. Eyi, A. J., Konan, K. J., Tano, K., N'Da, K., Atsé, B. C. (2016). Étude préliminaire des communautés ichtyofauniques de la lagune Ono (Côte d'Ivoire). *Journal of Applied Biosciences*, 104 : 9894-9903.
12. Guisse, A., Niass F. (2020). Diversité et structure du peuplement ichtyologique de la réserve spéciale de la faune de Gueumbeul (Saint-Louis/ Sénégal). *International Journal Biological and Chemical Sciences*, 14(9): 3129-3143.
13. Ibemenuga, K. N., Opara, P. O., Okeke J. J. (2017). Fish community structure in a natural rainforest lake, Nigeria. *Animal Research International*, 14(3): 2809 – 2817.
14. Kamdem, T. A., Teugels, G. G. (1998). Diversity patterns of fish assemblages in the Lower Ntem River Basin (Cameroon), with notes on potential effect of deforestation. *Archiv für Hydrobiologie*, 141: 421-446.
15. Kien, K. B., Ndiaye, A., Aboua, B. R. D. (2021). Caractérisation De La Diversité, de la structure des tailles et du stress écologique au niveau du peuplement des poissons sur le fleuve Bandama (Côte d'Ivoire, Afrique De l'Ouest). *European Scientific Journal*, 17 (21). 260-281.
16. Kisekelwa, T., Hyangya, L., Masilya, M. P., Isumbisho, M., Kaningini, M. (2014). Contribution à l'inventaire systématique des poissons de la Rivière lowa en territoire de Walikale. Cahiers du CERUKI, (Numéro Spécial Alphonse Byamungu) : 20-28.
17. Konan, K. F., Assi, S. R., Boussou, K. C., Gourène, G. (2019). Update of ichthyofauna and its conservation status in the aghien lagoon, Côte D'Ivoire. *Croatian Journal of Fisheries*, 77 : 253-262.
18. Koné, N. (2009). Étude du peuplement ichtyologique du fleuve Bandama : secteur Yamoussoukro – Bouaflé (Côte d'Ivoire) et variation spatio-temporelle. Mémoire de DEA. Université de Cocody, Abidjan (Côte d'Ivoire) 62 p.
19. Koné, T., Teugels, G. G., N'Douba, V., Gooré Bi, G., Kouamélan, E. P. (2003). Premières données sur l'inventaire et la distribution de l'ichtyofaune d'un petit bassin côtier ouestafricain: Rivière Gô (Côte d'Ivoire). *Cybium*, 27 (2) : 101-106.

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

20. Kouamélan, E. P., Teugels, G. G., N'Douba, V., Gooré Bi, G., KONÉ, T. (2003). Fish diversity and its relationships with environmental variable in a West African bassin. *Hydrobiologia*, 505(1-3) : 139-146.
21. Lalèyè, P., Chikou, A., Philippart, J. C., Teugels, G. G., Vanderwalle, P. (2004). Etude de la diversité ichtyologique du bassin du fleuve Ouémé au Benin (Afrique de l'Ouest). *Cybium*, 28 (4) : 329- 339
22. Lévêque, C. (1994). Introduction générale : Biodiversité des poissons africains. In: Diversité biologique des poissons des eaux douces et saumâtres d'Afrique (Teugels G. G., Guégan J. -F. & Albaret J. -J., eds). Annales du Musée Royal de l'Afrique Centrale 275 : 7-16.
23. Lévêque, C., Paugy, D. (Eds.), (1999). Impacts des activités humaines. In Les poissons des eaux continentales africaines. Diversité, Ecologie, Utilisation par l'homme. Edition IRD, Paris : 365 - 383.
24. Lowe-McConnell, R. H, (1987). Ecological studies in tropical fish communities. Cambridge Tropical Biology Series, Cambridge University Press, Cambridge. 382 p.
25. Lye-Koh, H. T. G., Hallam, H. L., Lee, (1997). Combined effects of environmental and chemical stressors on a model of Daphnia population. *Ecological Modelling*, 103: 19-32.
26. Montchowui, Chikou, A., Kogbeto, M. J., Lalèyè, P. (2008). Biodiversité et structure des communautés de poissons du lac Hlan au Benin. *International Journal of Biological and Chemical Sciences*, 2 (2): 196-206.
27. Ouattara, N. I., Mester, L. E. (2009). Age et croissance de deux espèces de Cichlidae (Pisces) : *Oreochromis niloticus* (Linnaeus, 1758) et *Sarotherodon melanotheron* Rüppell, 1852 du lac de Barrage d'Ayamé (Côte d'Ivoire, Afrique de l'Ouest). Travaux du Muséum National d'Histoire Naturelle, 52 : 313- 324.
28. Ouedraogo, R., Soara, A. E., Oueda, A. (2015). Description du peuplement piscicole du lac Sahélien de Higa, un site Ramsar du Burkina Faso, Afrique de l'Ouest. *Journal of Applied Biosciences*, 95 : 8958-8965
29. Pagney, P. (1988). Le climat de Lamto (Côte d'Ivoire) in Lamotte M. et Tirefort J.L. (Eds), Le climat de la savane de Lamto (Côte d'Ivoire) et sa place dans les climats de l'ouest africain. Travaux Chercheurs de Lamto: 31-79p.
30. Piélou, E. C. (1984). The interpretation of ecological data. Wiley & Sons, New York, 7 p.
31. Rodier, J., Legube, B., Merlet, N. (2009). Analyse de l'eau. DUNOD, 9ème édition, Paris, 1526 p
32. Shannon, E. C., Weaver, W. (1963). The mathematical theory of communication. University of Illinois press. 117 p.

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

33. Scherrer, B. (1984). L'inférence statistique : les tests d'hypothèse in Biostatistique (Gaëtan M. M., éd) 1ere édition, Paris, 487p, 1984.
34. Van Dyke F. (2003). Conservation Biology; Foundations, Concepts, Applications. Springer, Netherlands.
35. Vuattoux, R., Konaté, S., Abbadie, L., Barot, S., Gignoux, J., Lahoreau, G. E. (1998). History of the Lamto Ecology Station and Ecological Studies at Lamto 1-2p.
36. Welcomme, R. L. (1985). River fisheries. FAO fisheries technical paper 262. Rome, 330 p.
37. Wilcock, R. J., McBride, G. B., Nagels, J. W., Northcott, G. L. (1995). Water quality in a polluted lowland stream with chronically depressed dissolved oxygen: causes and efects. N Z J Mar Freshw Res 29 : 277-288.