**Update of ichthyofauna diversity and ecological status of a coastal River Nero (Côte d’Ivoire – West Africa)**

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**Abstract** The general aim of this study is to update the inventory of the fish species and to specify distribution patterns in the Nero River ichthyofauna in order to establish some basis for the conservation of these fish communities and their habitat. From February 2009 to January 2010, thirty-three sites were sampled monthly with gill nets and a backpack electrofisher, and environmental variables were recorded. Overall, 46 species included in 33 genera, 24 families and 9 orders were collected. Eleven families and 30 species were the first records for the Nero River. Including all species previously listed in the literature, the number of species presently known in the Nero River and its tributaries is revised to 59. Four families, Alestidae (21%), Schilbeidae (19%), Cyprinidae (17%) and Cichlidae (16%) that made up 73% of the total number of the catches, were the most dominant. The most dominant numerical species were *Schilbe mandibularis* and *Brycinus longipinnis*. Fish species and sampling sites along with eight environmental variables were ordinated with canonical correspondence analysis (CCA) coupled to the Monte Carlo test. Ecological status based on fish assemblage according to environmental variables and anthropogenic pressures showed that miss dead wood leaves and roots, electrical conductivity, total dissolved solids, mud, nitrite, basin width, dissolved oxygen and pH, were the primary factors influencing fish distribution. The environmental tolerance index (ETI), ecological tolerance ($t_k$) and optima ($u_k$) values of 10 species to 8 different environmental variables were analyzed. Six species (*Hemichromis fasciatus*, *Epiplatys chaperi*, *Barbus ablabes*, *B. longipinnis*, *Hemichromis binaculatus* and *Chromidotilapia guntheri*) have high ETI and a cosmopolitan distribution in the Nero River. In the tributaries of the middle
1. Introduction

Despite vast arid areas, Africa possesses extremely diverse freshwater systems (Lemoalle, 2006). Since the 18th century, ongoing ichthyofaunistic surveys were conducted in most of the basins (Lévêque and Paugy, 2006a, b).

Freshwater fish represent an important component of the aquatic ecosystem and are highly valued for their economic, social and aesthetic importance (Dirican et al., 2012). Fish are already involved in environmental policies as biodiversity and ecological quality indicators (Kestemont et al., 2000; Schmutz et al., 2007) and they have been used successfully in biogeographical studies, ecoregion delineations (Abell et al., 2008), conservation evaluations (Moyle and Randall, 1998) and assessments of ecologically acceptable water regime management (Jowett, 1997).

In Côte d’Ivoire, the investigations have yielded the publishing of several papers (e.g. Daget and Iltis, 1965 on Côte d’Ivoire freshwater rivers and Costal estuarine basin fish; Paugy et al., 1994 on fish biology and diversity in West Africa rivers; Gourène et al., 1999 on the impact of hydroelectric dams on fish communities in Ayamé lake; Koné et al. 2003a,b on Gô and San pedro Rivers; Kouamélan et al., 2003 on Boubo River; Yao et al., 2005 on Combœ River; Konan et al., 2006; Aboua et al., 2010, 2012 on fish communities and biotic index integrity of Bandama River) and an increase in the knowledge on the ivorian ichthyofauna. Those studies have also explored the relationships between fish communities and environment factors. These studies have also helped to enumerate more than 153 freshwater species and subspecies of fish grouped into 71 genera, 28 families and 11 orders in various habitats (Gourène and Ouattara, 2010; Paugy, 2009).

However, ichthyological data are subject to numerous changes inherent to the description of new species, taxonomic revisions, improvement of sampling methods and anthropogenic disturbances. As a result, periodic updates of these data are required. It is in this context that the present study which focuses on the Nero River (Côte d’Ivoire, West Africa) was conducted. Also, for all policy development decisions, preservation of aquatic ecosystems should be based on the knowledge of fish populations and their habitat.

This river flows throughout agro industrial rubber and palm oil plantations where human activity is very intense (e.g. use of ichthyotoxin, discharges of household agriculture, and industry taking with it the reduction of spawning areas and food sources).

The available publications dealing with the species sampled in the Nero River are from Teugels et al. (1988) and Paugy et al. (1994). As Consequences, 22 and 28 species of fish were collected in this river, respectively. But, all these research were mainly based on the collections of fishes housed in Muséum National d’Histoire Naturelle (Paris, France) and in the Royal Museum for Central Africa (RMCA) (Tervuren, Belgium). Also, those publications did not address the question of patterns of neither distribution nor abundance of fishes.

As part of the project entitled “Characterization, utilization and conservation of freshwater fish biodiversity in Côte d’Ivoire”, the current study aimed to describe the fish community of the Nero River under anthropic influences in terms of its composition, distribution and influences of environmental factors.

2. Materials and methods

2.1. Study area and sampling sites

The Nero is a small coastal river (985 km² catchment area; 80 km length) (Iltis and Lévêque, 1982) located in the southwestern Côte d’Ivoire (Fig. 1). It rises at the edge of the Taï National Park and the Haute Dodo Classified Forest and flows southward to enter Atlantic Ocean close to Grand-Berebi town. The climate of the studied areas is typical of humid equatorial climate with four seasons, two dry (August–September and December–March) and two wet (October–November and April–July) season (Fadika et al., 2008). According to the ecological features of the river, three zones were distinguished along the upstream–downstream gradient: (1) the upper reaches (F7–F9 and P17–P24), the Nero river flows into the protected forest reserve where canopy closure was very high (80–90%), (2) the middle course (F4–F6 and P9–P16) is located throughout agro-industrial complexes including rubber industries and banana, palm tree, coffee, cocoa, rice and rubber tree plantations, (3) the lower zone (sites F1–F3 and P1–P8) in which the river flows through an urban agglomeration populated with the presence of towns and villages (Grand-Berebi, Kako village, Mami Berebi) before emptying into the Atlantic Ocean. Human activities occurred mostly in the middle and lower courses of the Nero River.

2.2. Data collection

Two types of complementary data (ichthyological and environmental data) were simultaneously collected during monthly campaigns performed from February 2009 to January 2010. A total of 33 sampling sites were collected along the Nero River (Fig. 1). A battery of 17 weighted monofilament gill-nets (bar mesh sizes 8, 10, 12, 15, 20, 25, 30, 35, 40, 45, 50, 55, 60, 65, 70, 80 and 90 mm), each measuring 30 m long by 2.5 m deep, were used in the deep areas in the main channel (sampling sites F1–F9). In each sampling site, nets were set between 5.00 pm and 7.00 am for night fishing, and between 7.00 am and 12.00 am for day fishing. A backpack electrofisher (Smith-Root Inc. Model 12 Pow) was used in shallow waters in the tributaries (sampling sites P1–P24). Electrofishing was...
accomplished by wading and applying the same catch effort (30 min fishing) in each sampling site.

Fish specimens were identified according to Paugy et al. (2003a,b) and Eschmeyer and Fricke (2012), measured to the nearest mm and weighed to the nearest 0.1 g with a top loading Sartorius balance (model BP 310S) and counted.

Prior to fish sampling, physicochemical variables such as water turbidity (cm) was measured using a Secchi disc; depth (m) with a ballasted rope; current velocity (m s$^{-1}$) with a propeller-driven current meter; electrical conductivity ($\mu$S cm$^{-1}$), a total dissolved solids or TDS (mg l$^{-1}$) and salinity ($^\circ$) were measured with a multiparameter WTW-LF 340; the value of dissolved oxygen (mg l$^{-1}$) with an oxymeter WTW DIGI 330; pH and temperature ($^\circ$C) with a pH-meter WTW-Ph 330 coupled with a thermometer. All these parameters were measured between 7.00 am and 9:00 am, and between 12:00 am and 1:00 pm. The mean canopy closure was expressed in %. Aquatic plants and substrate type (sand, gravel, mud, rock, clay and leaves-wood-roots) were measured as % of stream bottom surface overlain by the plants and each substrate type. Water samples were collected from each site and brought to the laboratory where chemical analysis [nitrates (NO$_3^-$), nitrites (NO$_2^-$) and phosphates (PO$_4^{3-}$)] was realized as described in APHA (2005).

2.3. Analytical procedure

Principal Component Analysis (PCA), based on physical and chemical parameters, and samples sites, was used to evaluate if the samples sites are grouping according to the ecological zones.

Beta diversity index ($\beta_H$) was used to examine the differentiation between sampling areas. Beta diversity ($\beta_H$) measures the change in diversity of species from one environment to another. $\beta_H$ generally ranges from 0 (complete similarity) to 1 (complete dissimilarity). A high beta diversity index indicates a low level of similarity, while a low beta diversity index shows a high level of similarity (Legendre and De Cáceres, 2013).

$$\beta_H = 2c/S_1 + S_2$$ (Srensen, 1948)

$S_1$ = total number of species in the first community, $S_2$ = total number of species in the second community, and $c$ = number of species common to both communities.

Between sampling areas, differences in species richness (number of species) were evaluated using the analysis of variance (ANOVA), followed by the Mann–Whitney test to identify specific differences.

The relationship between the environmental parameters and the fish communities was investigated by means of canonical correspondence analysis (CCA) (Ter Braak, 1986; Chessel et al., 1987). Given that gill nets are fixed and catch fish that move in search of food, only were used in this current study, data from electric fishing for the relationship between environmental variable and species distribution. In addition, data have been log$_{10}$($x + 1$) transformed prior to analysis to increase normality (Underwood, 1997; Ter Braak and Šmilauer, 2002). Forward CCA, unrestricted Monte Carlo permutation test (499 iterations) was used to select environment variables explaining variation in fish species data. Environmental and fish data were examined using CANOCO (Canonical Community Ordination, version 4.5).

The environmental tolerance index (ETI), ecological tolerance ($t_k$) and optima ($u_k$) values of the 10 most dominant species encountered in five or more sites and caught with electrofisher with 8 different variables were calculated. High ETI values were assigned for the highest environmental tolerance range of the individual species (Curry, 1999), while optima ($u_k$) and tolerance ($t_k$) estimates were used to understand the tolerance and optimum ranges of species (Ter Braak and Barendregt, 1986).

$$\text{ETI} = \frac{x}{A}$$ with $x$ variation range of a variable at stations where $x$ species was found; $A$: variation range of a variable at all stations.

$$u_k = \frac{\sum_{i=1}^{n} y_{ik} \cdot x_i}{\sum_{i=1}^{n} y_{ik}}$$

$$t_k = \sqrt{\frac{\sum_{i=1}^{n} y_{ik} (x_i - \bar{x})^2}{\sum_{i=1}^{n} y_{ik}}}$$
| Orders and families | Species | Species code | Lower course | Middle course | Upper course |
|-------------------|---------|--------------|--------------|--------------|--------------|
| Elopiformes       | Elops lacerta** | E.lac | + | + | |
| Clupeiformes      | Pellyonula leonensis* | P.leo | + | + | + |
| Osteoglossiformes | Papyrocranus afer | P.afe | + | + | + |
| Mormyridae*       | Brienomyrus brachyistius* | B.bra | + | + | + |
| Characiformes     | H. occidentalis | H.oc | + | + | + |
| Alestidae         | B. longipinnis | B.lon | + | + | + |
| Cypriniformes     | B. macrolepidotus | B.mael | + | + | + |
| Cyprinodontiformes| Epiplatys chaperi* | E.ch | + | + | + |
| Perciformes       | Epiplatys dageti | E.dag | + | + | |
| Cichlidae         | Monodactylus sebae* | M.seb | + | | |
| Citharichthys stampflii | C.gun | + | + | + | + |
| Hemichromis bimaculatus* | H.bim | + | + | + | + |
| Hemichromis fuscatus | H.fas | + | + | + | + |
| Sarotherodon melanotheron* | S.mel | + | + | + | + |
| Thysochromis ansorgii* | T.ans | + | + | + | + |
| Tilapia guineensis | T.ran | + | + | + | + |
| Tilapia mariae | T.mar | + | + | + | + |
| Tilapia zillii* | T.zi | + | + | + | + |
| Tilapia guineensis × T. zillii* | T.hyb | + | + | + | + |
| Liza falcippinis* | L.fal | + | + | + | + |
| Awaous laterisriga* | A.lat | + | + | + | + |
| Eleotris vittata* | E.vit | + | + | + | + |
| Paralichthysiidae | Citharichthys stampflii* | C.sta | + | + | + |
| Freshwater species | 30 | 28 | 26 | 14 | + |
| Marine and/or brackish water species | 15 | 14 | 4 | 0 | + |
| Hybrid species | 1 | 1 | 1 | 1 | + |
| Total | 46 | 43 | 31 | 15 | + |

*, presence; 1, fishes with marine and/or brackish water affinities; 2, hybrid species; *, families and species reported for the first time in the Nero River.
where $y_{ik}$ and $i$ are the abundance of each taxon ($k$), and the value of each environmental variable ($x$) in the sample $i$, respectively. A C2 computer program was used to find the tolerance and optimum estimates of individual species (Juggins, 2003). Statistical analyses were done with species encountered in five or more sites.

3. Results

3.1. Fish community composition and abundance

A total number of 13,616 fish were caught, comprising 46 species, 33 genera, 24 families and 9 orders. Thirty freshwater species, 15 marine and/or brackish water species ($Elops$ lacerta, $Pellomula$ leonensis, $Caranx$ hippos, $Lutjanus$ goreensis, $Eucinostomus$ melanopterus, $Plectorhinchus$ macrolepis, $Pomadasys$ jubelini, $Monodactylus$ sebae, $Sarotherodon$ melanotheron, $Tilapia$ guineensis, $Liza$ falcipinnis, $Awaous$ lateristriga, $Periophthalmus$ barbarus, $Eleotris$ vittata and $Citharichthys$ stampflii) and one hybrid ($T$. guineensis $\times$ $Tilapia$ zillii) were reported (Table 1). The best represented order was Perciformes with 10 families and 20 species. It was followed by Siluriformes which included 4 families and 7 species. Cichlidae family was the most diverse with 9 species, followed by Cyprinidae and Clariidae with 6 and 4 species, respectively. Others families were each represented by 1 or 2 species.

Based on the percentage of occurrence, 6 species were the most represented in the Nero River. $Hemichromis$ fasciatus (52.17%), $Chromidotilapia$ guntheri (32.61%), $Barbus$ ablabes (28.26%), $Brycinus$ longipinnis (26.09%), $Hemichromis$ bimaculatus (23.91%) and $Epiplatys$ chaperi (21.74%).

In terms of numerical abundance, four families included 73% of the total catches: Alestidae (21%), Schilbeidae (19%), Cyprinidae (17%) and Cichlidae (16%) were the most represented. The most abundant species were $Schilbe$ mandibularis and $B. longipinnis$ (19% each one). The other species represented each less than 9% of the total captures. In the upper course, the dominant families were Cyprinidae (44% of the total number of fishes sampled in this catchment area), Cichlidae (22%) and Alestidae (21%). The mainly represented species in this area were $Barbus$ tiekoroi (23%), $B. longipinnis$ (21%), $B. ablabes$ (17%) and $H. bimaculatus$ (13%). In the middle catchment, Schilbeidae were the most abundant family (34%), followed by Alestidae (26%) and Cichlidae (14%). Two species, $S. mandibularis$ (34%) and $B. longipinnis$ (23%) accounted for more than 50% of the total catch in this area. In downstream, ichthyofauna were dominated by Cyprinidae.

![Figure 1](image1.png)

**Figure 1** Principal Component Analysis (PCA) plots showing site distribution in relation to significant environmental variables. A = main channel sites; B = sites located in the middle catchment tributaries; C1 = sites located in the lower catchment tributaries; C2 = sites located in the upper catchment tributaries.

![Figure 2](image2.png)

**Figure 2** CCA diagram correlation among environmental variables and species caught with electrofisher in Nero River. Abbreviations are given in Table 1.
(21%) and Clupeidae (15%) families. The most abundant species were *P. leonensis* (15%) and *B. ablabes* (14%).

### 3.2. Fish community distribution along up-downstream gradient

The principal component analysis (PCA), showed four different areas along the Nero River (Fig. 2): sampling sites with grill net in the main channel (A); sites in the middle courses tributaries (B); sites in downstream tributaries (C1) and sites in upstream tributaries (C2).

According to ecological features of the river and the PCA, twelve species are common to all the three areas of the Nero River. The upstream and downstream areas share 15 species. Twelve species are common to upstream and middle course. Twenty-nine species were common to middle and lower areas of the Nero River.

The lower and the middle courses harbour richest and the more important species (43 and 31 species, respectively; 93% and 67% of the total richness) (Fig. 3). The lower catchment harbour had the highest number of marine and/or brackish water species (14 species). In the middle course, the Cichlidae and Claridae were the most diverse with respectively 8 and 4 species. The upper course had the lowest number of species with 15 species and was dominated by the Cyprinids (5 species). Eleven (11) marine and/or brackish water species (*E. lacerta, C. hippos, L. goreensis, E. melanopterus, P. jubelini, M. sebae, T. guineensis, L. falcipinnis, P. barbarus and C. stampflii*) were collected only at downstream sites. Two species (*Tilapia mariae and A. lateristriga*) were caught only in the middle course. *B. tiekoroi* was only found in the upper course.

At the site scale, *H. fasciatus* and *C. guntheri* were the most ubiquitous species, occurring at 73% (24 sites) and 45% (15 sites) of sites.

The beta diversity index calculated, along longitudinal gradient, is very high (0.79) among the middle and lower area. The lowest index (0.51) was observed between upper and lower, and among upper and middle area respectively. The Mann–Whitney test revealed no significant difference (*p > 0.05*) between the species richness of the sampling area (upstream, middle and lower course).

### Table 2 CCA summary table shows correlation among environmental variables and species.

| Axes | 1 | 2 | 3 | 4 | Total inertia |
|------|---|---|---|---|----------------|
| Eigenvalues | 0.545 | 0.392 | 0.200 | 0.099 | 3.120 |
| Species-environment correlations | 93.3 | 94.8 | 93.2 | 75.0 | |
| Cumulative percentage variance | | | | | |
| of species data | 17.5 | 30.0 | 36.4 | 39.6 | |
| of species-environment relation | 44.1 | 75.8 | 92.0 | 100.0 | |
| Sum of all eigenvalues | 3.120 | | | | |
| Sum of all canonical eigenvalues | 1.236 | | | | |

### Table 3 Tolerance (*tk*), optimum (*uk*), mean, maximum, minimum and standard deviation (SD) values of 10 species caught with electrofisher and 8 environmental variables in Nero River.

| Species | Ecological status | Width | Mud | DwLR | pH | Oxy | Cond | TDS | Nitrite |
|---------|-------------------|-------|-----|------|----|-----|------|-----|--------|
| *H. fasciatus* | *uk* | 4.82 | 31.84 | 19.21 | 6.35 | 3.53 | 90.17 | 48.63 | 0.059 |
| | *tk* | 6.09 | 48.33 | 31.64 | 6.39 | 3.86 | 95.97 | 52.27 | 0.095 |
| *C. guntheri* | *uk* | 6.60 | 58.00 | 12.31 | 6.11 | 2.49 | 157.77 | 59.77 | 0.057 |
| | *tk* | 7.70 | 68.42 | 21.41 | 6.15 | 2.86 | 236.98 | 63.66 | 0.087 |
| *B. ablabes* | *uk* | 6.70 | 22.31 | 27.28 | 6.46 | 3.65 | 77.72 | 41.09 | 0.061 |
| | *tk* | 8.74 | 28.21 | 37.82 | 6.48 | 4.19 | 81.19 | 42.26 | 0.086 |
| *B. longipinnis* | *uk* | 4.83 | 7.31 | 6.54 | 6.49 | 5.08 | 61.97 | 40.51 | 0.008 |
| | *tk* | 4.99 | 14.48 | 7.97 | 6.50 | 5.11 | 62.50 | 37.58 | 0.009 |
| *H. bimaculatus* | *uk* | 3.67 | 17.92 | 5.77 | 6.87 | 4.91 | 86.75 | 40.51 | 0.044 |
| | *tk* | 4.68 | 21.99 | 9.47 | 6.89 | 4.96 | 91.54 | 42.29 | 0.083 |
| *E. chaperi* | *uk* | 8.79 | 33.90 | 26.46 | 6.12 | 3.07 | 78.76 | 47.44 | 0.054 |
| | *tk* | 10.62 | 44.20 | 35.59 | 6.15 | 3.82 | 82.99 | 50.15 | 0.070 |
| *A. atesuensis* | *uk* | 4.49 | 10.93 | 17.22 | 6.56 | 5.33 | 74.90 | 40.81 | 0.030 |
| | *tk* | 4.95 | 22.79 | 20.07 | 6.57 | 5.43 | 77.26 | 41.35 | 0.067 |
| *E. dageti* | *uk* | 5.03 | 30.63 | 19.88 | 6.40 | 2.88 | 439.37 | 47.73 | 0.030 |
| | *tk* | 6.05 | 48.53 | 30.61 | 6.44 | 3.12 | 545.66 | 53.46 | 0.062 |
| *B. trispilos* | *uk* | 4.20 | 1.00 | 9.50 | 6.27 | 4.82 | 60.09 | 36.60 | 0.006 |
| | *tk* | 4.43 | 2.24 | 11.29 | 6.28 | 4.93 | 60.84 | 37.07 | 0.007 |
| *P. bovei* | *uk* | 10.00 | 79.38 | 15.34 | 5.26 | 0.83 | 131.36 | 78.17 | 0.069 |
| | *tk* | 10.11 | 80.10 | 17.97 | 5.26 | 0.93 | 131.50 | 78.23 | 0.07 |

| Mean | 6.37 | 33.63 | 19.17 | 6.30 | 3.79 | 136.26 | 48.81 | 0.053 |
| Minimum | 3.67 | 1.00 | 5.77 | 5.26 | 0.83 | 60.09 | 36.60 | 0.006 |
| Maximum | 10.62 | 80.10 | 37.82 | 6.89 | 5.43 | 545.66 | 78.23 | 0.095 |
| SD | 2.19 | 23.95 | 9.76 | 0.41 | 1.36 | 129.91 | 12.54 | 0.029 |

DwLR, dead wood, leaves and roots; TDS, dissolved solids; Width, basin width; Oxy, oxygen; Cond, electrical conductivity.
3.3. Fish community and environmental factors

The first axis of the CCA diagram (Fig. 4) explained 94.8% of the relationship among 46 common species and 19 environmental variables (Table 2). According to Monte Carlo selection test, dead wood leaf roots (41.20%), electrical conductivity (37%), total dissolved solids (27.20%), mud (33.90%), nitrite (40%), basin width (27.8%), dissolved oxygen (32.8%) and pH (29.5%) were the eight most influential variables and had significant effects on fish occurrence \( (p < 0.05) \) in the Nero river.

According to CCA axis I and II, four groups of areas associated with environmental variables and species were distinguished: Group 1, composed of two species (Barbus punctilaudenius and Heterobranchus longifilis) were most influenced by a variable dead wood leaf and roots. Group 2 with Parachanna obscura, Epiplatys dageti, E. vittata, Poropanchax runculleri, Petrocephalus bovei and C. anguillaris species were correlated to electrical conductivity, mud, total dissolved solids and nitrates. Group 3 represented by B. tiekoroi, Briemomyrus brachyistius, A. lateristriga, Heterobranchus isopterus, Amphilius atesensis, H. bimaculatus, B. longipinnis, Barbus trispilos, Brycinus macrolepidotus and T. hybryde. These species were under influence of pH and water dissolved oxygen. Group 4 represented by H. fasciatus, C. guntheri and Procatopus schioezi were influenced by basin width.

Among dominant species, 6 have cosmopolitan distribution in the Nero River, and relatively high environmental tolerance. Thus, the level of ecological tolerance index was very high for H. fasciatus (ETI = 0.72). Followed by C. guntheri (ETI = 0.46), B. ablabes (ETI = 0.39), B. longipinnis (ETI = 0.36), H. bimaculatus (ETI = 0.33) and E. chaperi (ETI = 0.30), Optima \( (t_k) \) and tolerance \( (t_k) \) (Table 3) showed that six species H. fasciatus \( (t_k = 6.35) \), B. ablabes \( (t_k = 6.46) \), B. longipinnis \( (t_k = 6.49) \), H. bimaculatus \( (t_k = 6.87) \), A. atesensis \( (t_k = 6.56) \) and E. dageti \( (t_k = 6.40) \) have high environmental requirements concerning pH. Two species \[ B. ablabes \ (t_k = 0.061) \] and \[ P. bovei \ (t_k = 0.069) \] have a high sensibility for nitrite. Of all the species collected, B. trispilos, H. bimaculatus and B. longipinnis showed the higher tolerance level \( (t_k) \) for the most parameters during this study (Table 3).

4. Discussion

The first important point to be considered in the study of a fish community is to establish the list of species. Hugueny and Léveque (2006) reported 18 species from the Nero River while Teugels et al. (1988) and Paugy et al. (1994) listed 22 and 28 species respectively. In the present study, 46 species were recorded. Eleven fish families (Elopidae, Mormyridae, Amphiliidae, Chanidae, Carangidae, Lutjanidae, Gerreidae, Haemulidae, Monodactyidae, Mugilidae and Paralichthyidae) and 30 species not previously reported from this River were collected during this survey. Conversely, twelve species (Pellomula vorax, Brycinus derhami, Brycinus imberi, Lepidarchus adonis, Barbus bigornei, Barbus waldroni, Chrysichthys auratus, Chrysichthys mauros, Aplocheilichthyis spilaechin, Fundulopanchax walkeri, Poropanchax normani and Eleotris senegalensis) formerly registered by Teugels et al. (1988) and Paugy et al. (1994) have not been found. This difference could be related to the sampling procedure, the types of habitats, sampling periods, human activities (Gourène et al., 1999; Kouamélan et al., 2003; Clay, 2004) and systematic methods of data collection and analysis. In Nero River, Perciformes and Siluriformes are the most orders that contain the most families and species. These observations were common to the majority of streams in the same biogeographical province (Léveque et al., 1991). The presence of a large number of those two orders could also be explained by the fact they found favorable condition which allows them to develop and grow. About families, three of them (Cichlidae, Cyprinidae and Claridae) dominate by the species number and four of them (Alestidae, Schilbeidae, Cyprinidae and Cichlidae) were responsible for the largest proportion of the total number of individuals collected at the different sites. These observations could be compared to those of few authors who mentioned that the four families are very abundant in Côte d’Ivoire Rivers (Koné et al. 2003a,b; Kouamé et al., 2008; Aboua et al. 2010; Konan et al., 2013). These families have also developed a good adaptation into Nero River responses to the most environment variables. Abundance of S. mandibularis and B. longipinnis among others species of Nero River could be explained by the fact these species are of no commercial interest. Certain species (eg., M. sebae, C. stumptlli, L. falcipin, etc.) were in clear regression owing to human activities (overfishing, the modification of water quality by deforestation for rubber, palm oil, cocoa and coffee cultivation, etc.).

The contribution of marine and/or brackish species of the fish assemblage was high and accounted for 33% of the total number of species. Their presence was much more conspicuous downstream. This invasion of marine or brackish species in freshwater could be explained by the fact that such species have specialized gills and other adaptations that allow rapid regulation of ion exchange when moving between habitats (Carol and Michael, 1999). Also, marine and/or brackish species in freshwater could play an important role in the structuring of fish communities and equilibrate food chain (Leung and Camargo, 2005). Their presence in freshwater could also be related to feeding, spawning, nursery, growth and to avoid predators.

The beta indices calculated between upper, middle et lower course indicated no significant differences in the species composition but it was very high (0.79) into the middle and lower area. These analyses showed a relatively homogeneous and similitude ichthyofauna in different areas of the stream, characterized by the dominance of Alestidae, Schilbeidae, Cichlidae and Cyprinidae families. These observations were made on other Rivers such as Bandama (Léveque et al., 1983), Ehania (Konan et al., 2013) in Côte d’Ivoire.

Understanding the factors that influence fish community structure is important not only for accumulating basic information, but also to predict the effects of environmental change on the integrity of these communities (Suarez et al., 2004). Dead wood leaf roots; electrical conductivity, total dissolved solids, mud, nitrite, basin width, dissolved oxygen and pH were the most important factors in describing fish assemblage structure in the Nero River. Hydrological characteristics and morphology of the hydrosystems can be considered as factors in structuring biological communities they harbour (Pourriot and Meybeck, 1995). Thus, the nature of the substrate is an important ecological factor for fish communities. Indeed, the Catfish Family Claridae (eg., H. isopterus, H. longifilis and C. anguillaris) and others species such as H. fasciatus and
P. obscura, are known to be resistant and had light level of ecological tolerance index (ETI). Therefore, these species are more abundant in the waters composed by mud substrate in which dissolved oxygen is low and nitrite is high. By opposite, the less tolerant species have high dissolved solids (TDS) and conductivity. In addition, the influence of the width of the mainstream. Our results seem to indicate that total dissolved solids (TDS) have significant influence on the distribution of some species (eg., E. dageti, Poropanchax rancureli, C. anguillaris and P. boevi). These observations were in agreement with those of Da Costa at al. (2000). According to these authors, total dissolved solids (TDS) and conductivity were some of the most discriminating factors in the Agnèby and the Bia Rivers (Côte d’Ivoire).

5. Conclusion and management implications

This study allowed to update the inventory of the fish species and to specify distribution patterns in the Nero River ichthyofauna. In synthesis, our results revealed that, to date the total number of fish species known to occur in this basin is 59. The tributaries of the middle catchment, high concentrations of nitrite in the water, added to the presence of lot of tolerant species in the ichthyofauna are indications of disturbance of these areas. Correlations, optimum, tolerance and ETI values indicated that various species have a specific optimal level and a tolerable range for different variables. In the course of restoration and conservation efforts, further investigations on the Nero River must focus on identifying all the possible sources of water pollution in order to restrict pollution impacts and achieve a good ecological status of this aquatic ecosystem. In particular, the evaluation of the ecological impact of agro-industrial complexes effluents on fish communities. Therefore, preserving this forest and its canopy may be important for many fish species, especially for nitrite-intolerant ones. Furthermore, preserving this forest and its canopy may be important for the survival of these species. For this purpose, an adequate policing of this forest is required.

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