Diversity and trophic guilds structure of fish assemblages from Aghien Lagoon (Côte d'Ivoire)

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Abstract. Diversity and trophic guilds structure of fish assemblages were investigated during the study of the Aghien lagoon. This lagoon is subject to strong fishing pressure. Samples were collected, with gillnets of different mesh sizes from June 2014 to May 2015. A total of 80 fish species belonging to 55 genera, 27 families and 10 orders were sampled. The Shannon index varied significantly from one sector to another (Kruskal-Wallis, $p < 0.05$). In fact, upstream is less diversified with 34 species compared to middlestream (62 species) and downstream (66 species). Unlike the Shannon specificity index (H'), equitability (E) varies slightly (Kruskal-Wallis, $p > 0.05$) from one sector to another. Equitability appears relatively high in the three upstream (E = 0.66), middlestream (E = 0.67) and downstream (E = 0.64) sectors. The evaluation of the environmental stress at the Aghien lagoon using the ABC method shows that the abundance curve is above that of the biomass. At the spatial level, environmental stress is very important in upstream and downstream compared to the middle zone. Fish species were classified in eight trophic guilds using available information: omnivore-generalist, omnivore-zooplanctonivore, predator1-insectivore, predator1-microphage, predator1-benthophage, predator2-generalist, predator2-piscivore and phytomicrophage. Predator2-generalist was most important with 66.42% for the upstream, 58.4% for the middlestream and 64.26% for the downstream.
Key Words: ichthyofauna, trophic characterization, environmental stress, lagoonary environment.

Introduction. Costal lagoons are considered worldwide as sites of high biodiversity and productivity (Mitsch & Gosselink 2000). They play an important ecological role in coastal ecosystems by providing several habitat types for many species, functioning as nursery areas and feeding grounds for opportunistic fishes (Franco et al 2008; Maci & Basset 2009; Pérez-Ruzafa & Marcos 2012). Many coastal lagoons support important fishing activities and some of them are intensively exploited for aquaculture activities (Pérez-Ruzafa & Marcos 2012).

Moreover, the characterization of fish fauna can reveal the influence of anthropogenic disturbances, both on hydrosystems and on the level of biological communities (Karr et al 1986; Oberdorff et al 2002; Ahouanssou 2011; Aboua et al 2012). Various authors emphasize that an aquatic ecosystem is deeply influenced by the activities developed on its watershed. However, anthropogenic activities likely to endanger or at least modify the biological diversity of the fish fauna are increasing during the last two decades in tropical Africa.

In Côte d'Ivoire, the lagoons system, which covers an area of approximately 1,200 km², extends for approximately 300 km along the coast (Durand & Skubich 1982). The lagoon fish population has been described by several authors who, moreover, have indicated that these ecosystems are currently subjected to several anthropic pressures (Albaret 1994; Villanueva 2004). In addition, the Ebrié lagoon complex, which includes the Aghien lagoon, is located in an area characterized by a dense human population. This high human density can appear as a major handicap when we discuss ways to better manage or even restore these hydrosystems. Therefore, more information is needed on the role and functioning of the lagoon system in our sustainable natural environment management plan. In contrast, little is known about the Aghien lagoon with regard to:

- ichthyofaunic diversity of the entire Aghien lagoon;
- structure of trophic guilds of fish assemblages;
- lagoon environmental stress assessment.

The main objective of this study was to characterize fish assemblage structures with a view to better conservation of resources in the Aghien lagoon.

Material and Method

Study area. The Aghien Lagoon is located north of the Ebrié lagoon between latitudes 5° 22' N and 5°26' N and longitudes 3°49' W and 3°55' W and it can reach 11 m deep (Tastet & Guiral 1994; Bédia et al 2009; Traoré et al 2012) (Figure 1). With an area of 19 km^2, the Aghien lagoon is separated from the Ebrié lagoon by the Potou lagoon. Aghien lagoon is subject to a very important hydrographic network composed of the rivers Mé (4 020 km^2), Bété (220 km^2) and Djibi (80 km^2) (Koffi et al 2014). The Bété and Djibi rivers flow directly into the Aghien lagoon, while the Mé flows into the natural channel separating the Aghien and Potou lagoons (Koffi et al 2014).

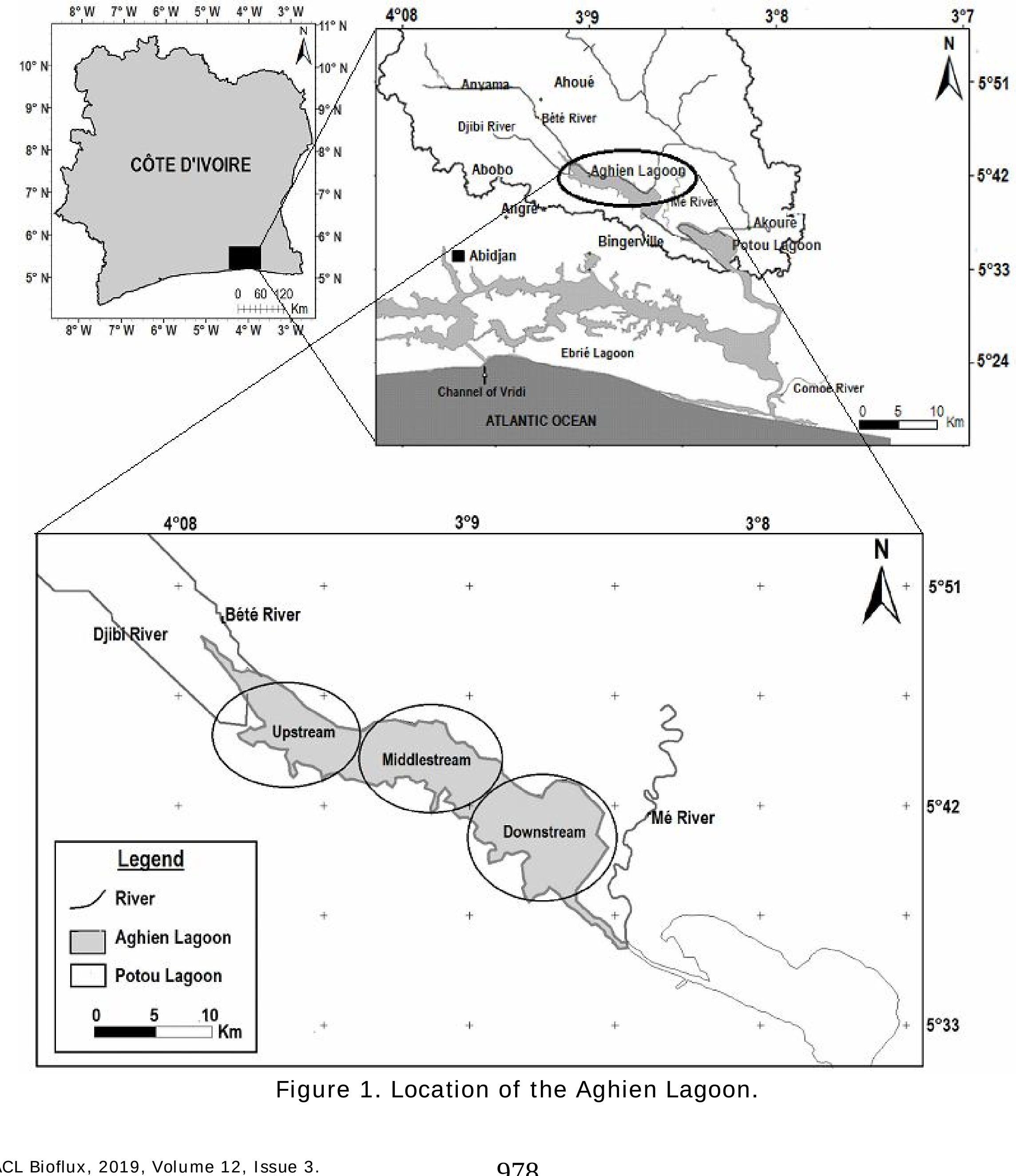

Figure 1. Location of the Aghien Lagoon.

Data collection. Regarding the ichthyological fauna, two sampling approaches were used for sampling: experimental fishing and artisanal fishing. For experimental fishing, the sampling carried out during the period of June 2014 to May 2015 due to one sampling campaign per month taking into account hydrological zonation, accessibility, sources of supply of the lagoon (rivers) and anthropogenic activities. For this fact, three fishing sectors have been defined: upstream (located near the mouth of the Djibi and Bété rivers); downstream (located near the mouth of the Mé River and the natural channel leading to the lagoon); middle zone (transition zone between upstream and downstream). Fishes were collected using gill nets (10 to 40 mm stretch mesh).

Concerning the artisanal fishing, the data collection team ensured to check the catches of the fishermen in the study area to complete the list of species.

The identification of collected specimens were performed at species level, based on the key proposed by Paugy et al (2003a, b), Sonnenberg & Busch (2009), Fricke et al (2018), as well as Froese & Pauly (2018).

Data analysis

Diversity and assessment of environmental stress. The species richness (S) corresponds to the total number of fish species observed during this study (Aliaume et al 1990). The expected species richness of the Aghien lagoon was estimated with the ACE and Chao 2 estimators using EstimateS software (Colwell 2013).

Using Shannon's diversity index (Shannon & Weaver 1963) and equitability index (Piélou 1969), we made a comparative study of the spatial variations of the diversity of fish population along the lagoon:

- ✓ $H' = -\Sigma qi\ Log_2(qi)$; where qi is the relative abundance of each species;
- ✓ $E = H' / Log_2\ (S)$; where H' is the Shannon's diversity index and S is the total number of species.

Between-sampling sites, differences in species diversity (number of species, Shannon diversity and equitability) were evaluated using the Kruskal-Wallis test, a non-parametric analysis of variance, followed by Mann-Whitney test to identify specific differences. Shannon's diversity index, equitability index and all statistical analyses were carried out by the software Paleotological Statistic (PAST) version 3.15 (Hammer et al 2001).

The Abundance-Biomass Comparison Index (ABC) was used to highlight the characteristics of fish assemblages that may result from environmental stress (Warwick 1986; Penczak & Kruk 1999). The ABC index is defined as the average of the difference between the cumulative proportions in terms of biomass and abundance. This model describes three scenarios:

- biomass curve is above abundance curve when there is no stress;
- biomass and abundance curves are superimposed when the environment is in equilibrium or with a moderate stress;
- biomass curve is below abundance curve when environmental stress conditions are high.

Trophic organization of fish assemblages. The trophic guild database of the species observed in the Aghien lagoon was compiled from bibliographical references (Albaret 1994; Da Costa et al 2007; Konan et al 2013) and information from Fishbase (Froese & Pauly 2018).

A factor analysis using a Principal Component Analysis (PCA) and Ascending Hierarchical Classification (AHC) program was performed on the correlation matrix from fish trophic guilds data to investigate the pattern of species assemblage. All these analysis were carried out using the software Paleotological Statistic (PAST) version 3.15 (Hammer et al 2001) and ADE-4 software (Thioulouse et al 1995).

Results and Discussion

Specific composition of the ichthyofauna of the Aghien lagoon. The ichthyological composition of the Aghien lagoon is recorded in Table 1. A total of 80 fish species belonging to 55 genera, 27 families and 10 orders were sampled. Perciformes was the most dominant order (11 families, 23 genera, 30 species). Cichlidae were the most diversified family (8 genera, 14 species). The genus *Brycinus* was the most abundant with 5 species.

Table 1

Fish fauna list of the Aghien lagoon (1 = presence; 0 = absent)

Order	*Family*	*Species*	*Upstream*	*Middlestream*	*Downstream*
Characiformes	Alestidae	*Alestes baremoze*	1	0	0
		Brycinus brevis	0	0	1
		Brycinus imberi	1	1	1
		Brycinus nurse	1	1	1
		Brycinus longipinnis	1	1	1
		Brycinus macrolepidotus	1	1	1
		Micralestes occidentalis	0	0	1
	Hepsetidae	*Hepsetus odoe*	1	1	1
Clupeiformes	Clupeidae	*Ethmalosa fimbriata*	0	1	0
		Odaxothrissa ansorgii	0	0	1
		Pellonula leonensis	1	1	1
		Pellonula vorax	1	1	1
		Sardinella rouxi	0	1	0
Cypriniformes	Cyprinidae	*Clypeobarbus hypsolepis*	1	1	0
		Enteromius ablabes	0	1	1
		Enteromius raimbaulti	0	1	0
Cyprinodontiformes	Nothobranchiidae	*Epiplatys olbrechtsi*	0	1	1
	Poeciliidae	*Rhexipanchax schioetzi*	0	1	1
		Rhexipanchax nimbaensis	0	1	1
Mugiliformes	Mugilidae	*Mugil cephalus*	0	1	0
		Neochelon falcipinnis	1	1	1
Osteoglossiformes	Mormyridae	*Brienomyrus brachyistius*	0	1	0
		Marcusenius furcidens	0	0	1
		Marcusenius senegalensis	0	1	1
		Marcusenius ussheri	0	1	1
		Marcusenius sp.	1	1	0
		Mormyrops breviceps	0	0	1
		Mormyrus rume	0	1	1
		Petrocephalus bovei	0	1	1
		Petrocephalus pellegrini	0	1	1
		Pollimyrus isidori	1	1	1
	Notopteridae	*Papyrocranus afer*	1	1	1
Eleopiformes	Eleopidae	*Elops lacerta*	1	1	1
Perciformes	Carangidae	*Caranx hippos*	0	0	1
		Trachinotus teraia	0	1	1
	Channidae	*Parachanna obscura*	0	1	1
	Cichlidae	*Chromidotilapia guntheri*	1	1	1
		Coptodon guineensis	1	1	1
		Coptodon walteri	0	1	1
		Coptodon zillii	1	1	1
		Hemichromis bimaculatus	0	0	1
		Hemichromis fasciatus	1	1	1
		Oreochromis niloticus	0	0	1
		Pelmatolapia mariae	0	1	1
		Sarotherodon caudomarginatus	1	1	1
		Sarotherodon melanotheron	1	1	1
		Tilapia busumana	0	0	1
		Tilapia sp.	1	1	1
		Tylochromis intermedius	1	1	1
		Tylochromis jentinki	0	1	0
	Eleotridae	*Eleotris senegalensis*	0	0	1
		Eleotris vittata	0	1	1
		Kribia kribensis	0	1	0
	Gerreidae	*Gerres nigri*	0	0	1
	Gobiidae	*Awaous lateristriga*	0	1	1
		Bathygobius soporator	0	0	1
		Gobioides sagitta	0	1	0
	Haemulidae	*Pomadasys jubelini*	0	1	1
	Monodactylidae	*Monodactylus sebae*	0	1	1
	Polynemidae	*Galeoides decadactylus*	0	0	1

Order	Family	Species	Upstream	Middlestream	Downstream
		Polydactylus quadrifilis	1	1	1
	Sciaenidae	*Pseudotolithus senegalensis*	0	0	1
	Sphyraenidae	*Sphyraena afra*	0	1	0
Pleuronectiformes	Paralichthyidae	*Citharichthys stampflii*	0	1	1
	Cynoglossidae	*Cynoglossus senegalensis*	0	1	1
Siluriformes	Claroteidae	*Auchenoglanis occidentalis*	1	0	0
		Chrysichthys auratus	0	1	1
		Chrysichthys maurus	1	1	1
		Chrysichthys nigrodigitatus	1	1	1
	Clariidae	*Clarias anguillaris*	1	0	1
		Clarias ebriensis	1	1	1
		Clarias gariepinus	1	1	1
		Gymnallabes typus	0	0	1
		Heterobranchus isopterus	1	1	1
		Heterobranchus longifilis	1	1	0
	Malapteruridae	*Malapterurus electricus*	0	1	1
	Schilbeidae	*Parailia pellucida*	1	1	1
		Parailia spiniserrata	0	1	1
		Schilbe intermedius	1	1	1
		Schilbe mandibularis	1	1	1
10	**27**	**80**	**34**	**62**	**66**

Spatial variation of the ichthyological composition. The spatial variation of the fish population allowed to identify 34 species divided into 8 orders, 12 families and 23 genera in upstream. In the middle zone, 10 fish orders, 25 families, 43 genera and 62 species could be counted. In downstream, 66 species have been identified. These were divided into 10 orders, 26 families and 45 genera. Only the Siluriformes (3 families, 25%) were the best represented order in number of families in the middle zone. In upstream, Perciformes (9 families) and Siluriformes (4 families) were dominant. With 10 and 4 families, Perciformes and Siluriformes were the most diversified orders in downstream. The Cichlidae family was the best diversified in the three sampling sectors. This family was composed by 9, 11 and 8 species respectively in upstream, middlestream and downstream.

Estimate of the expected species richness of the Aghien lagoon. The sampling effort in terms of number of species is illustrated in Figure 2. For the species richness estimators considered in this study, the cumulative species curves show increasing trends at the end of the sampling period in the Aghien Lagoon. The species richness (80) observed during this study is between 79 (ACE formula) and 84 (Chao 2 formula). The recorded species richness is 95.23% of that predicted by the Chao 2 model.

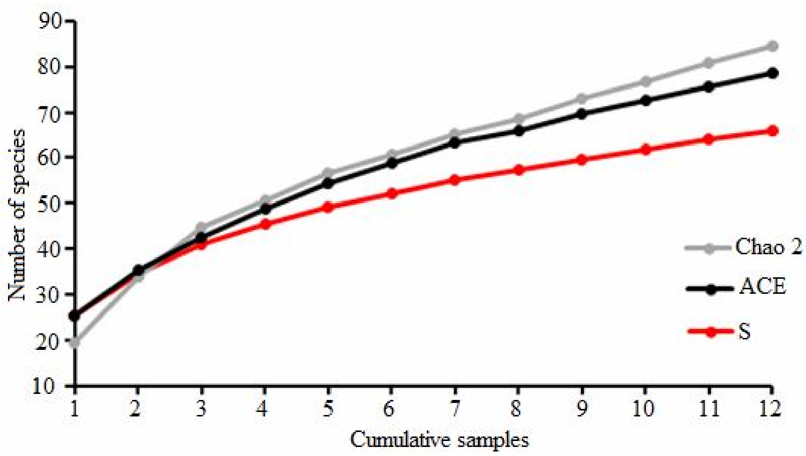

Figure 2. Curves of accumulation of the number of fish species in the Aghien lagoon.

Degree of organization of the fish population and assessment of environmental stress. Figure 3 shows the spatial variations of Shannon's specific diversity (H') and equitability (E) index. For the three sample sectors considered, the values of the specific diversity index (H') oscillated between 2.06 and 2.26 bits/ind., between 2.51 and 2.67 bits/ind. and between 2.41 and 2.55 bits/ind. in upstream, middlestream and downstream respectively. In fact, the lowest values (2.06 to 2.26 bits/ind.) are recorded in upstream while the highest values (2.51 to 2.67 bits/ind.) are observed in the middle zone. The Shannon diversity index varied significantly across sectors (Kruskal-Wallis, $p < 0.05$). The upstream was different from the two other two sectors (Mann-Whitney, $p < 0.05$). However, no significant difference is noted between the values of this index in middlestream and downstream (Mann-Whitney test, $p > 0.05$). In fact, the lowest values (2.06 to 2.26 bits/ind.) are recorded in Upstream while the highest values (2.51 to 2.67 bits/ind.) are observed in the middle zone.

In contrast to the Shannon specificity index (H'), equitability (E) varies slightly (Kruskal-Wallis, $p > 0.05$) from one sector to another. Nevertheless, equitability appears relatively high in the three sectors upstream (E = 0.66), intermediate (E = 0.67) and downstream (E = 0.64).

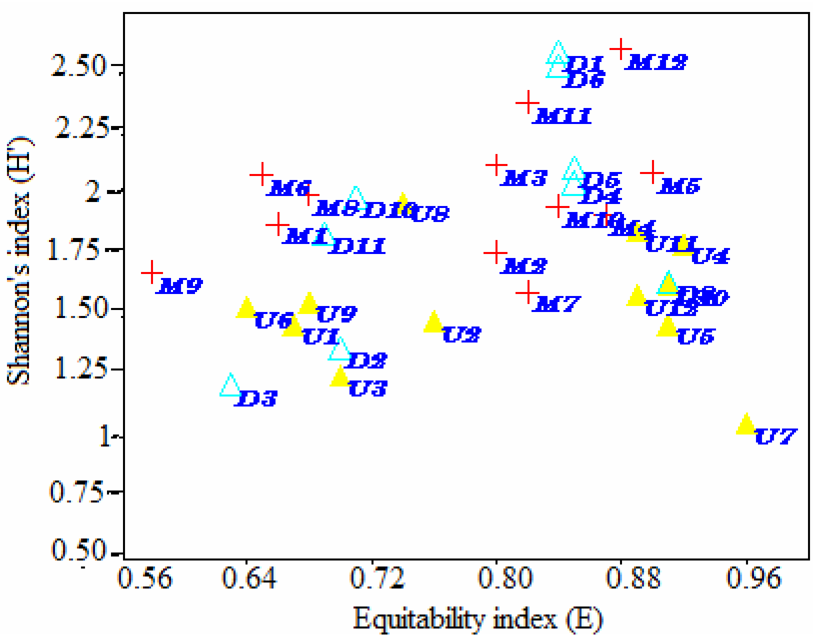

Figure 3. Spatial variation of the Shannon index (H') and equitability (E) of the fish fauna in upstream, middlestream and downstream in the Aghien lagoon. M1 à M12: middlestream; U1 à U12: upstream; D1 à D12: downstream.

For the environmental stress assessment, trends in ecological stress indices ABC are shown in Figure 4. The analysis of the abundance and biomass distributions of fish samples from the Aghien lagoon indicates that the abundance curve is above that of the biomass (Figure 4a). At the scale of the sampling sectors considered, abundance curves appeared higher than biomasses in the upstream and downstream zones (Figure 4b and 4d). However, in the Middlestream the abundance and biomass curves are more or less close (Figure 4c).

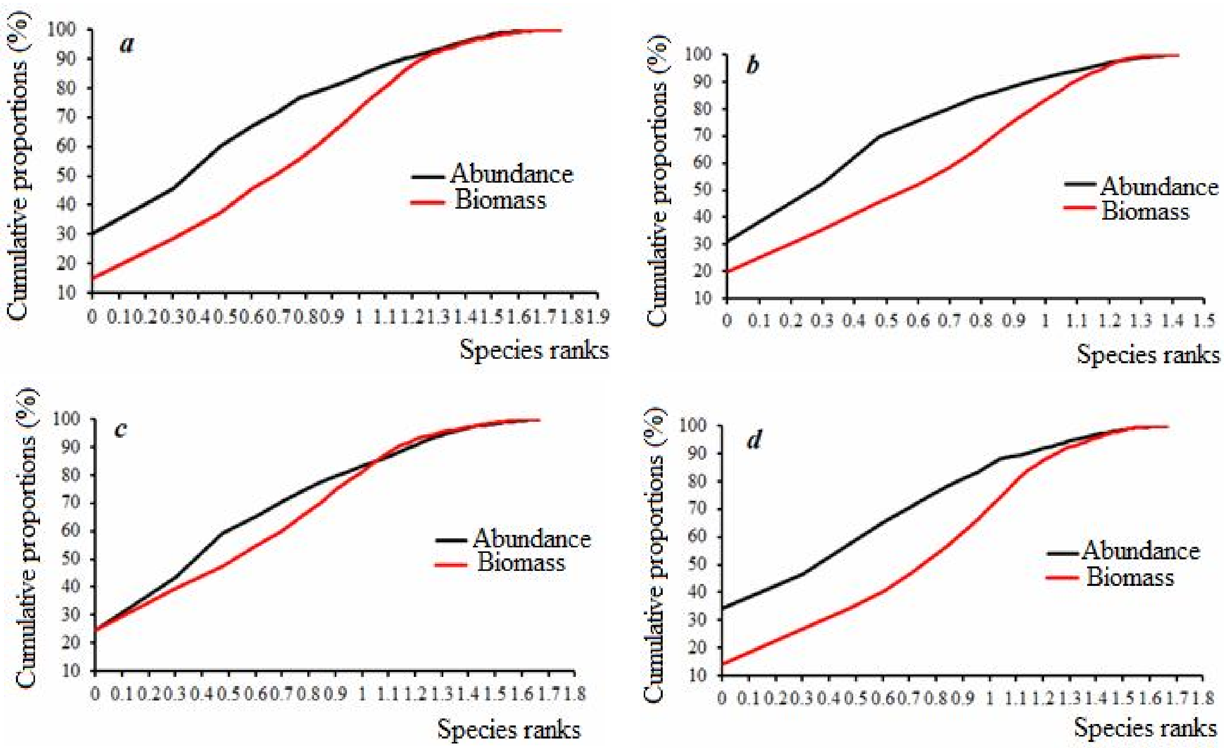

Figure 4. Spatial variation of the environmental stress described by the ABC curves of the Fish fauna. a):Aghien lagoon; b): upstream; c): middlestream; d): downstream.

Trophic organization of fish assemblages. The trophic structure of the ichthyofauna of Aghien lagoon was divided into 8 groups: omnivorous-generalists (O-gene), omnivorous-zooplanktonivorous (O-zoo), predator 1-insectivorous (P1-ins), predator 1-microphagous (P1-micr), predator 1-benthophagous (P1-bent), predator 2-generalist (P2-gene), predator 2-piscivorous (P2-pisc) and phytomicrophagous (Phyt-micr).

The trophic structure of the ichthyofauna is characterized by a predominance of predator 2-generalists (P2-gene) and phytomicrophagous (Phyt-micr) both in this lagoon and in the different sampling areas considered (Figure 5). Indeed predator 2-generalists represented 66.42%, 58.4% and 64.26% respectively in upstream, middle and downstream (Figure 5b). This group represented 62.78% of all abundance (Figure 5a). Thus, phytomicrophagous fish represent 25.5%, 20.89% and 16.59% respectively in middle zone, upstream and downstream (Figure 5b), or 20.29% of the total abundance (Figure 5a).

Principal component analysis (PCA) on the trophic class matrix was performed from the two first axes (43.94% variances for axis 1 and 36.27% for axis 2) (Figure 6a). The analysis of the ascending hierarchical classification carried out in the PCA plan has distinguished three types of trophic associations (Figure 6b). The first group includes predator 1-insectivorous (P1-inse), omnivorous-zooplanktonivorous (O-zoo) and predator 1-benthophagous (P1-bent). The second group consists of predator 2-piscivorous (P2-pisc) and omnivorous-generalists (O-gene). The third group is predator 2-generalist (P2-gene), predator 1-microphagous (P1-micr) and phytomicrophagous (Phyt-micr).

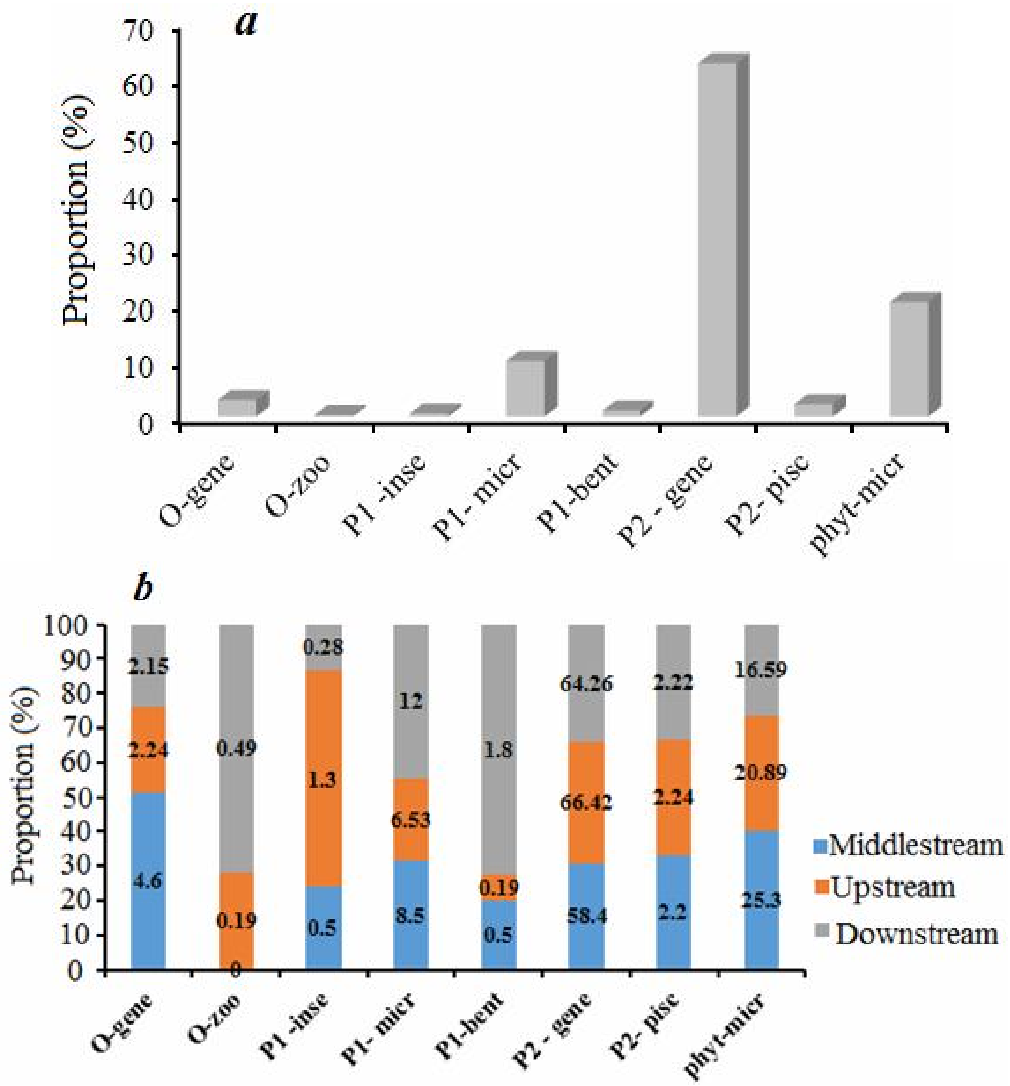

Figure 5. Trophic structure of the ichthyofauna of the Aghien lagoon expressed as a percentage. (P1-inse), predator 1-microphagous (P1-micr), predator 1-benthophagous (P1-bent), predator 2-generalist (P2-gene), predator 2- piscivorous (P2-pisc) and phytomicrophagous (Phyt-micr).

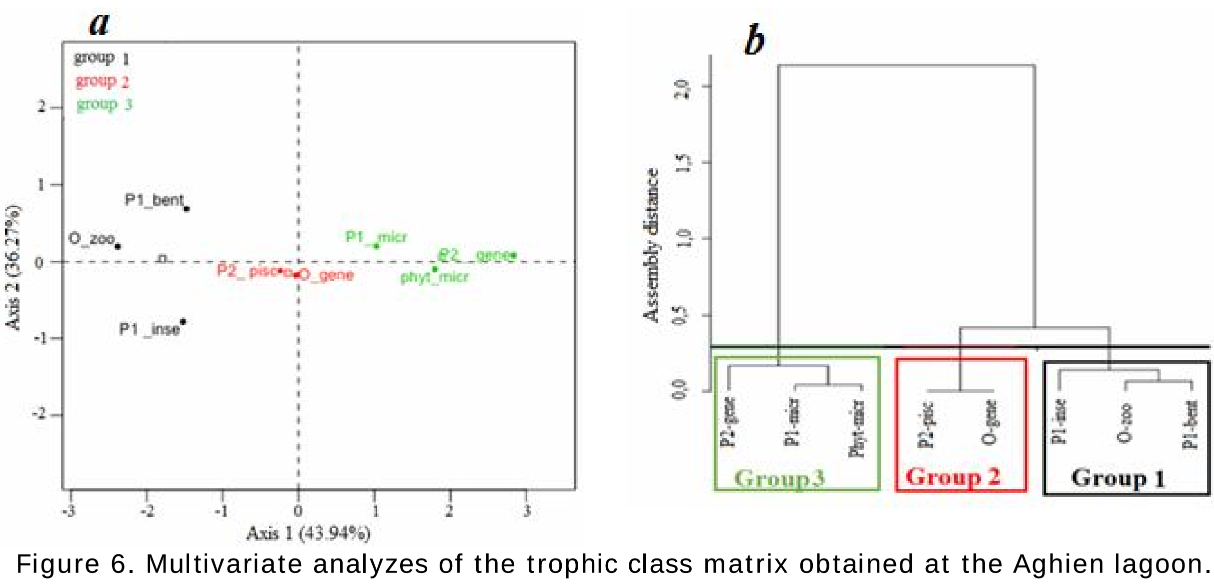

Figure 6. Multivariate analyzes of the trophic class matrix obtained at the Aghien lagoon. a) Principal Components Analysis (PCA); b) Ascending Hierarchical Classification (AHC).

Discussion. This study allowed us to observe 80 species of fish in the Aghien lagoon. The species richness recorded in the lagoon represents 52.29% of the total species richness of the Ebrié lagoon complex (153 species) to which the Aghien lagoon belongs (Albaret 1994). The previous study of Bédia (2015) carried out on the Aghien lagoon signed 45 species. This difference is mainly due to the low number of stations surveyed, the types of habitats prospected, the sampling procedure and the fishing effort used by Bédia (2015) during his work on the Aghien-Potou lagoon complex. As per Lévêque & Paugy (1999) and Pérez-Hernǎndez & Torrez-Orozco (2000), each type of sampling instrument has different species selectivity and it is thus difficult to compare the results obtained by different capture techniques. Besides, Malavoi & Souchon (1992) and FAO (2018) report that the sampling period (day or night; low or flooding water season) strongly affects the fishing results.

The results of the species richness estimators show that more than 95% of the fish species of the Aghien lagoon were recorded during the present study. Thus, methods and sampling effort used during the 12 sampling campaigns appeared satisfactory because they allowed to observe a maximum of fish species of the lagoon of Aghien.

Ichthyofauna of the Aghien lagoon is dominated by the Cichlidae family with 14 species. The high number of species of Cichlidae family in the Aghien lagoon has been highlighted by Villanueva (2004) and Bédia (2015). According to Blaber (2000), Chikou (2006) and Danadu (2014), the dominance of this family is due to their food flexibility.

Shannon index varied significantly between sampling zones. Indeed, the lowest index value (H'= 2.15 bits/ind) is obtained in upstream. The highest value of this index is obtained in the median zone (H'= 2.57 bits/ind). In comparison, this fishing area is the most diversified of the three fishing zones. This disparity is likely due to ecological conditions in sampling areas. Indeed, the upstream receives the waters of the Djibi and Bété rivers (fresh water) which drain very anthropized watersheds. On the other hand, the downstream is at the same time under the influence of the Mé River (fresh water) and the Potou lagoon (brackish water). The middlestream is a transition zone between the other two sectors. The heterogeneity of the median and the down zones, the regular communications between the freshwater environment (Mé River) and the brackish medium (Potou Lagoon), and also the important mineral and nutrient contributions explain the high specific richness of the middle zone and downstream. In addition, significant mineral and nutrient inputs from the land could promote high species richness.

Otherwise, the ecological characteristics of the median zone are both a food source (Paugy 2002) and a refuge for fish (Laleye et al 2004). Regarding equitability, it appeared relatively high in the three sectors of the sample. This result reflects a good degree of organization in each sampling area of the Aghien Lagoon (Da Fonseca 1968).

The evaluation of the environmental stress at the Aghien lagoon using the ABC method shows that the abundance curve is above that of the biomass. This result reflects a significant stress phase of the environment. This observation reveals an ichthyological stand dynamics that tends towards a larger component of small and low biomass species. Furthermore, large species and large biomass become scarce in the catches within this lagoon. At the spatial level, a significant stress situation is also recorded in upstream and downstream. However, the ecological stress evaluated in middlestream is relatively light. These differences in stress levels are likely to be related to differences in fishing pressures at these sites. In addition, the rivers also drain the pollution of the watershed to upstream and downstream.

The trophic structure of the ichthyological population of the Aghien lagoon is composed of eight trophic groups: is characterized by a large dominance of fish predator 2-generalists (62.78%). Like lagoons, only one trophic group dominates fish assemblages (Maci & Basset 2009). Albaret (1994) also observed this trend in the Ebrié lagoon. According to Hulot et al (2000), Duffy et al (2005), Da Costa et al (2007), Aliko et al (2010) and Trystram (2016) in "long" food webs, predation is a major regulator of abundances that increase with the reduction of environmental stress. Predation is therefore an important regulatory factor in stable environments compared to unstable environments. The predation control observed in Aghien lagoon suggests that this lagoon constitutes a relatively stable environment. The smaller trophic groups are predatorbenthophagous, predator- insectivorous and omnivorous-zooplanktonivorous. This shows that some trophic niches are still vacant in this lagoon. This result corroborates the assertion of Da Costa et al (2007) according to which all trophic levels available in a tropical environment are not exploited by native species.

Conclusions. This study helped to inventory 80 species of fish belonging to 55 genera, 27 family and 10 oders. The Cichlidae family is the most diverse. The Shannon index varied significantly from one sector to another. The low value of this index is obtained upstream while the largest in the median zone. In addition, no significant differences in the Shannon index were noted between the median zone and the downstream. Regarding equitability, no significant difference was noted between the three sectors. Moreover, this index appears relatively high in these sectors. Environmental stress is very important in upstream and downstream compared to the middle zone. Finally, the trophic structure of the ichthyological fauna is characterized by a dominance of predator 2-generalists.

Acknowledgements. Data of this study were collected during the project “Study of the water quality of the Aghien Lagoon” and authors are grateful to the promoters of this project: “Ministère des Eaux et Forêts de Côte d’Ivoire”.

References

Aboua B. R. D., Kouamélan E. P., N’Douba V., 2012 Development of a fish-based index of biotic integrity (FIBI) to assess the quality of Bandama River in Côte d’Ivoire. Knowledge and Management of Aquatic Ecosystems 404(08):1-19.

Ahouanssou M. S., 2011 Diversité et exploitation des poissons de la rivière Pendjari (Bénin, Afrique de l’Ouest). University of Abomey-Calavi, PhD Thesis, Abomey-Calavi, 234 pp.

Albaret J. J., 1994 Les poissons: biologie et peuplements. In: Environnement et ressources aquatiques de Côte d’Ivoire: les milieux lagunaires. Tome II, Edition ORSTOM, pp. 232-273.

Aliaume C., Lasserre G., Louis M., 1990 Organisation spatiale des peuplements ichtyologiques des herbiers à Thalassia du Grand Cul-de-Sac Marin en Guadeloupe. Revue Hydrobiologie tropicale 23(3):231-250.

Aliko N. G., Da Costa K. S., Konan K. F., Ouattara A., Gourène G., 2010 Fish diversity along the longitudinal gradient in a man-made lake of west Africa, Taabo hydroelectric reservoir, Ivory Coast. Ribarstvo 68(2):47-60.

Bedia A. T., 2015 Evaluation de l’exploitation de l’ichtyofaune du complexe lagunaire Aghien-Potou (Côte d’Ivoire). University of Félix Houphouët-Boigny, PhD Thesis, Abidjan, 181 pp.

Bédia A. T., N’zi K. G., Yao S. S., Kouamelan E. P., N’douba V., Kouassi N. J., 2009 Typologie de la pêche en lagune Aghien-Potou (Côte d’Ivoire, Afrique de l’ouest): Acteurs et engins de pêche. Agronomie Africaine 21(2):197-204.

Blaber S. J. M., 2000 Tropical estuarine fishes: ecology, exploitation and conservation. Blackwell Science Ltd, Oxford, 372 pp.

Chikou A., 2006 Etude de la démographie et de l’exploitation halieutique de six espèces de poissons-chats (Teleostei, Siluriformes) dans le delta de l’Ouémé au Bénin. University of Liège, PhD Thesis, Liège, 459 pp.

Colwell R. K., 2013 EstimateS, statistical estimation of species richness and shared species from samples. Version 9.1.0.

Da Costa K. S., Tito De Morais L., 2007 Structures trophiques des peuplements de poissons dans les petits barrages. In: L’eau en partage, les petits barrages de Côte d’Ivoire. IRD Edition, Paris, France, pp. 153-164.

Da Fronseca C., 1968 Théorie de l’information et diversité spécifique. Bulletin du Musée National d’Histoire Paris 2ème série 38:961-968.

Danadu M. C., 2014 Problématique de *Synodontis* Cuvier, 1816 (Siluriformes, Mochokidae) dans le bassin du fleuve Congo: systématique et écologie. University of Kisangani, PhD Thesis, Kisangani, 199 pp.

Duffy J. E., Richardson J. P., France K. E., 2005 Ecosystem consequences of diversity depend on food chain length in estuarine vegetation. Ecology Letters 8:301-309.
Durand J. R., Skubich M., 1982 Les lagunes ivoiriennes. Aquaculture 27:211-250.
FAO, 2018 La situation mondiale des pêches et de l'aquaculture. Atteindre les objectifs de développement durable. Rome, 254 pp.
Franco A., Franzoi P., Torricelli P., 2008 Structure and functioning of Mediterranean lagoon fish assemblages: a key for the identification of water body types. Estuarine, Coastal and Shelf Science 79(3):549-558.
Fricke R., Eschmeyer W. N., van der Laan R. (eds), 2018 Catalog of fishes: genera, species, references. Available at: http://researcharchive.calacademy.org/research/ichthyology/catalog/fishcatmain.asp. Accessed: December, 2018.
Froese R., Pauly D., 2018 Fishbase. World Wide Web electronic publication. Version (06/2018). Retrieved from http://www.fishbase.org.
Hammer O., Harper D. A. T., Ryan P. D., 2001 Paleontological statistics software package for education and data analysis. Palaeontologia Electronica 4(1):1-9.
Hulot H., Lacroix G., Loreau M., 2000 Functional diversity governs ecosystem response to nutrient enrichment. Nature 405:340-344.
Karr J. R., Fausch K. D., Angermeier P. L., Yant P. R., Schlosser I. J., 1986 Assessing biological integrity in running waters: a method and its rationale. Illinois Natural History Survey (Special Publication) 5:1-28.
Koffi K. J. P., N'go Y. A., Yéo K. M., Koné D., Savané I., 2014 Détermination des périmètres de protection de la lagune Aghien par le calcul du temps de transfert de l'eau jusqu'à la lagune. Larhyss Journal 19:19-35.
Konan K. F., Bony K. Y., Edia O. E., Kouamé K. M., Ouattara A., Gourène G., 2013 Effect of dam on the trophic guilds structure of fish assemblages in the Bia river-lake systems (south-eastern of Côte d'Ivoire). Bulletin of Environment, Pharmacology and Life Sciences 2(5):43-51.
Laleye P., Chikou A., Philippart J. C., Teugels G., Vandewalle P., 2004 Etude de la diversité ichtyologique du bassin du fleuve Ouémé au Benin (Afrique de l'ouest). Cybium 28(4):330-339.
Lévêque C., Paugy D., 1999 Les poissons des eaux continentales africaines: diversité, écologie, utilisation par l'homme. Edition IRD, pp. 153-166.
Maci S., Basset A., 2009 Composition, structural characteristics and temporal patterns of fish assemblages in non-tidal Mediterranean lagoons: a case study. Estuarine, Coastal and Shelf Science 83(4):602-612.
Malavoi J., Souchon Y., 1992 Hydrology and hydroecological dynamic in running waters. Revue des Sciences de l'eau 5(2):131-307.
Mitsch W. J., Gosselink J. G., 2000 Wetlands. John Wiley & Sons, New York, 920 pp.
Oberdorff T., Pont D., Hugueny B., Porcher J. P., 2002 Development and validation of a fish-based index (FBI) for the assessment of "river health" in France. Freshwater Biology 47:1720-1734.
Paugy D., 2002 Reproduction strategies of fishes in a tropical temporary stream of the upper Senegal basin: Baoulé River in Mali. Aquatic Living Resources 15:25-35.
Paugy D., Lévêque C., Teugels G. G., 2003a Poissons d'eaux douces et saumâtres de l'Afrique de l'Ouest, édition complète. Tome I. Edition IRD-MNHN-MRAC, Paris-Turvuren, 457 pp.
Paugy D., Lévêque C., Teugels G. G., 2003b Poissons d'eaux douces et saumâtres de l'Afrique de l'Ouest, édition complète. Tome II. Edition IRD-MNHN-MRAC, Paris-Turvuren, 815 pp.
Penczak T., Kruk A., 1999 Applicability of the abundance/biomass comparison method for detecting human impacts on fish populations in the Pilca River, Poland. Fisheries Resources 39:229-240.
Pérez-Hernǎndez M. A., Torres-Orozco R., 2000 Evaluation de la riqueza de especies de peces en lagunas costeras mexicanas: estudio de un caso en el Golfo de Mexico. Revista de Biologia Tropical 48:425-438. [in Spanish]

Pérez-Ruzafa A., Marcos C., 2012 Fisheries in coastal lagoons: an assumed but poorly researched aspect of the ecology and functioning of coastal lagoons. Estuarine, Coastal and Shelf Science 110:15-31.
Pielou E. C., 1969 An introduction to mathematical ecology. Wiley Intersci., New York, 285 pp.
Shannon C. E., Weaver W., 1963 The mathematical theory of communication. Urbana University Press, Illinois, 127 pp.
Sonnenberg R., Busch E., 2009 Description of a new genus and two new species of killifish (Cyprinodontiformes: Nothobranchiidae) from West Africa with a discussion of the taxonomic status of *Aphyosemion maeseni* Poll. 1941. Zootaxa 2294:1-22.
Tastet J. P., Guiral D., 1994 Géologie et sédimentologie. In: Environnement et ressources aquatiques de Côte d'Ivoire. Tome II, Edition ORSTOM, pp. 35-57.
Thioulouse J., Dolédec S., Chessel D., Olivier J. M., 1995 ADE software: multivariate analysis and graphical display of environmental data. In: Software per l'ambiente. Milano, Patrone Editore, pp. 57-62.
Traoré A., Soro G., Kouadio K. E., Bamba S. B., Oga M. S., Soro N., Biémie J., 2012 Evaluation des paramètres physiques, chimiques et bactériologiques des eaux d'une lagune tropicale en période d'étiage: la lagune Aghien (Côte d'Ivoire). International Journal of Biological and Chemical Sciences 6(6):7048-7058.
Trystram C., 2016 Ecologie trophique de poissons prédateurs et contribution à l'étude des réseaux trophiques marins aux abords de La Réunion. University of Réunion, PhD Thesis, Réunion, 344 pp.
Villanueva S. C. M., 2004 Biodiversité et relations trophiques dans quelques milieux estuariens et lagunaires de l'Afrique de l'Ouest: adaptation aux pressions environnementales. Institut National Polytechnique of Toulouse, PhD Thesis, France, 272 pp.
Warwick R. M., 1986 A new method for detecting pollution effects on marine macrobenthic communuties. Marine Biology 92:557-562.

Received: 24 February 2019. Accepted: 23 May 2019. Published online: 30 June 2019.
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How to cite this article:
Assi S. R., Konan K. F., Kouamé K. M., Boussou K. C., Aliko N. G., Gourène G., 2019 Diversity and trophic guilds structure of fish assemblages from Aghien Lagoon (Côte d'Ivoire). AACL Bioflux 12(3):977-988.