academicresearchJournals

Vol. 6(1), pp. 11-19, January 2018
DOI: 10.14662/ARJASR2017.098

ISSN: 2360-7874
http://www.academicresearchjournals.org/ARJASR/Index.htm

Academic Research Journal of Agricultural Science and Research

Full Length Research

FISH DIVERSITY ASSESSMENT IN A MANGROVE ECOSYSTEM OF SOUTH BENIN (WEST AFRICA)

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Accepted 23 December 2017

Fish is an important food for many rural populations particularly in Africa. In order to assess the current state of those resources of the Ouidah lagoon in south Benin, a study has been carried out. It aims at investigating on the water quality and to assess the fish diversity of Ouidah lagoon. In this study, water quality parameters such as temperature, pH, dissolved oxygen and depth were measured monthly. Common fishing gears were identified and fish landing from local fishermen were recorded monthly. The results of the water quality analysis show that there is a significant difference between the values of dissolved oxygen, pH and depth of the different stations unlike other physicochemical parameters. Twenty-one (21) fish species belonging to sixteen (16) families were identified. Cichlids were the most represented family (19.09%) with four species, followed by Clupeids (9.52%) with two species. Other fish families such as, Elopidae, Gerreidae, Haemilidae, Aralichthydae, are represented only by one specie. In Ouidah lagoon, local fishermen use different gears for fishing: gillnets, throwing nets and traps. Biological indexes calculated showed differences between fish diversity. It is noted also a bad distribution of individuals from one specie to another. Fish distribution in Ouidah lagoon has been influenced by sea through fish migrations and the rehabilitation of the mangrove swamp in the zone which provides better ecological conditions.

Key words: Fish diversity, Water quality, exploitation, Ouidah lagoon, south Benin.

Cite this article as: LAWANI LB, FOUSSENI A, MAMA VJ, CHIKOU A, LEDEROUN D, LALEYE P (2018). FISH DIVERSITY ASSESSMENT IN A MANGROVE ECOSYSTEM OF SOUTH BENIN (WEST AFRICA). Acad. Res. J. Agri. Sci. Res. 6(1): 11-19

INTRODUCTION

Fish is an important food for over 400 million Africans, contributing essential proteins, minerals and micronutrients to their diets. Paradoxically, despite the high dependence on fish as a source of animal protein, fish consumption in sub-Saharan Africa and particularly in Benin, is the world's lowest. According to FAO/SFW (2015), fish consumption in Benin per capita reached 13.4 Kg in 2013. When compared to Benin's main neighbours, fish consumption per capita in Burkina Faso amounted to 5.80 kg, 2.00 kg in Niger, 15.9 kg in Nigeria and 6.60 kg in Togo in 2013 (Honfoga *et al.*, 2017). This fish consumption in Benin has been complemented by

importation. With 54 000 tons of live or frozen fish imported, fish importation is among the top four imported foods (rice, chicken, fish and milk products), representing altogether 60-100 billion CFA annually (INSAE, 2016). However, to meet the increasingly demand for fish and to reduce the importation, most wild capture fisheries, from inlands, swamp and mangroves have reached their production limit or are over-fished. The challenge is to better understand these ecosystems to maximize their production.

Most of fishing activities in Benin, are essentially located in the south region of the country which has an important hydrological complex composed of many lakes, lagoons and rivers distributed into two Ramsar complexes. The eastern complex includes Ouémé river, Nokoue lake and Porto-Novo lagoon whereas the western complex is constituted by coastal lagoon, Aheme lake, Mono and Couffo Rivers (Hachimou, 1995, Sohou *et al*., 2009). These ecosystems harbour many fish species and other aquatic animals such as birds (herons and whistling ducks), tortoises, sandpipers, and mongoose.

Many studies showed that aquatic resources of the south of Benin and particularly those of the east complex are over exploited (Laleye *et al*., 1997; Roche International, 2000; Villanueva, 2004; Laleye and Akele, 2005; Lederoun, 2006; Adandedjan, 2012; Adite *et al*., 2013). On the other hand, information related to the west complex water bodies and their resources are scarce. This is due to the fact that very few works have been carried out to assess accurately biological aspects of some fish species in the coastal lagoon (Adandedjan, 2012; Fousseni *et al*., 2013; Houndonougbo *et al.,* 2013).

Among the few literatures on this second part of the lagoon, Honfoga *et al* (2017) studied the profitability and sustainability of modern fish farming in the south of Benin while Adandedjan (2012) and Adite *et al* (2013), studied partially the fish diversity of these hydrological complexes. Other investigations have been carried out on the ecology of other aquatic resources. It appears also that fish diversity has not been extensively studied in the Coastal lagoon and the relations between fish and their environment has not been sufficiently assessed (Villanueva, 2004).

Mangroves are peculiar ecosystems serving as nurseries for many fish species and bridge between fresh and marine waters. There is a crucial and pressing need to provide with accurate and appropriate information for the management of these aquatic ecosystems. Therefore, to fill this information gap, this study is aimed at assessing the current state of fish diversity, their ecology and to characterize the exploitation of the lagoon's resources of the west complex in the South of Benin.

MATERIAL AND METHODS

Description of the study area and sampling sites

The coastal lagoon is a narrow water body stretching between the north and the south sand strings between 1°48 and 2°16 East and 6°16 and 6°20 North. It is constituted by two components: Ouidah lagoon and Grand-Popo lagoon. The coastal lagoon is lying following a parallel direction to the Atlantic Ocean for 60 km between Grand-Popo and Togbin (figure 1). The Ouidah lagoon extends from Togbin to Djondji. It is characterized by three hydrologic periods: "floods" from August to November which causes inondations for the bordering villages, "dry season" from December to March and the "rainy season" from April to July. It connected to the ocean by the "bouche du Roy" (Adandedjan, 2005). The vegetation of the lagoon is constituted essentially by mangroves and prairies.

SAMPLE COLLECTION AND PROCESSING

Sample collection

Fish and water samples were collected at five stations according to three criteria: (i) the accessibility of the stations, (ii) the water salinity gradient and (iii) the availability and collaboration of the local fishermen. The five stations were Togbin, Hio, Avlékété, Djègbadji and Azizakoué. At each station, three sampling sites were marked out or selected. All the stations and sites were geo-referenced using a Carmin model E-GPS.

Some physico-chemical parameters of the water were measured. At each sampling site, surface (5-10cm) and sub-surface (1m) water were collected. The temperature, the pH and the dissolved oxygen were recorded insitu using a multimeter and an oxymeter (DO values and percentages). In addition, the transparency and the depth of the lagoon determined using a Secchi disc.

Fish sample data were collected monthly in each station from local fishermen for four months (January to April 2012). Fish samples collected were taken to the Laboratory of Hydrobiology and Aquaculture of the Faculty of Agronomic Sciences (University of Abomey-Calavi) for further analysis. Fish species were identified using the identification key of Paugy *et al* (2004).

Data processing

Total catches were recorded as soon as fishermen come back from fishing. Fishes were identified and sorted by species and each stock is weighted; fishing gears and fishing duration were recorded.

Some indices were used for biodiversity analysis. They

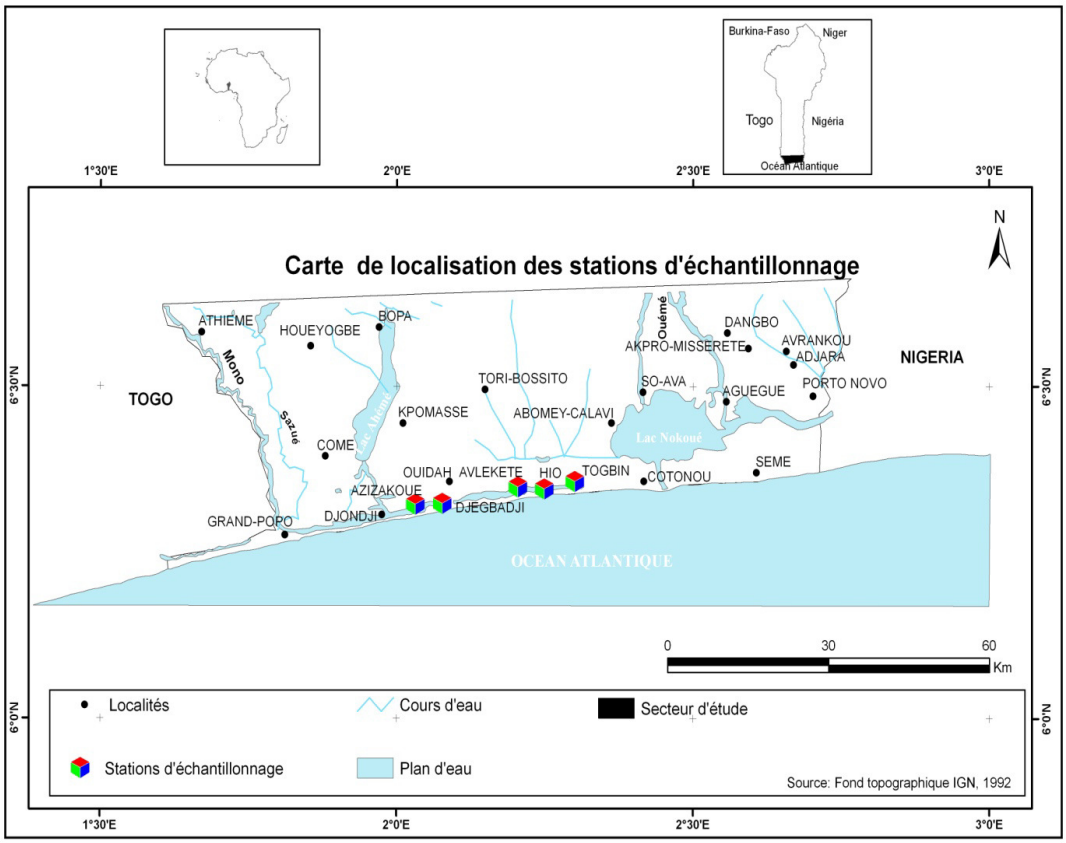

Figure 1: Map of Ouidah lagoon, South Benin showing the sampling Stations

include Marglef species richness index, Shannon-Wiener diversity index, Pielou equitability index and Jaccard's similarity index while Catch per Unit Effort (CPUE) caluculate by the formula CPUE= Total catch/Fishing effort was used to assess fish exploitation in Ouidah lagoon.

Statistical analysis

Means and variation coefficients were calculated per station and per month for physico-chemical parameters to appreciate spacio-temporal variations. ANOVA one way and Student-Newman-Keuls tests were performed to compare means of physico-chemical parameters' values. Principal Components Analysis and Cluster Analysis were done to form similar groups of the stations according to water quality. The results were presented in graphs and tables. Data processing and analyses were performed using Statview and SAS.

RESULTS

Variation of physico-chemical parameters

The mean values of the physico-chemical parameters of the water in the Ouidah lagoon are presented in Table 1. There were significant differences in dissolved oxygen (Anova, P = 0.009), pH (Anova, P = 0.02) and depth (P = 0.005) values among the stations. Dissolved oxygen, temperature and the pH values were higher at the surface than the sub-surface. The mean surface water dissolved oxygen values ranged from 6.25 ± 0.17 ppm (Avlékété) to 4.82 ± 0.30 ppm (Togbin). The water was slightly alkaline with mean pH values ranging between 7.57 ± 0.19 (Togbin) and 8.30 ± 0.10 (Azizakoué). The mean maximum depth of the lagoon was 1.66 ± 0.02 metres recorded at Azizakoué station while the mean minimum depth of 0.92 ± 0.06 was recorded at Togbin station.

The cluster analysis of the stations based on the five principal physico-chemical parameters (Temperature, pH, Dissolved Oxygen saturation, transparency and depth) showed three hydrological zones (Figure 2) with an R^2 value of 0,78. The first group was characterized by a

Table 1 : Physico-chemical parameters of Ouidah lagoon

Physico-chimical parameters		Sampling stations					Probability	Variation Coefficient (%)	Number of measurment
		Avlékété	Azizakouè	Djègbadji	Hio	Togbin			
Temperature (°C)	Air	28.93±0,80	29,6±0,00	30,43±1,15	27.50±1.83	27.93±0.18	0.39	6.55	3
	Surface water	29.50±0.36	30.6±0.10	29.90±1.53	29.00±0.94	29.13±0.94	0.83	5.69	3
	Sub-suface water	29.40±0.49	30.25±0.15	29.73±1.55	28.97±0.84	29.33±1.05	0.94	5.86	3
pH	Surface water	8.18±0.12 **a**	8.30±0.10 **a**	7.63±0.09 **b**	7.97±0.03 **ab**	7.57±0.19 **b**	0.009*	2.55	3
	Depth water	7.93±0.22	8.15±0.05	7.60±0.30	7.83±0.17	7.30±0.21	0.18	4.87	3
Disolved Oxygen (ppm)	Surface water	6.25±0.17 **a**	4.98±0.07 **b**	5.67±0.37 **ab**	5.94±0.17 **ab**	4.82±0.30 **b**	0.02*	7.87	3
	Depth water	5.73±0.27	4.86±0.08	5.28±0.14	5.37±0.39	4.02±0.84	0.18	15.76	3
Saturation (%)	Surface water	90.30±2.26	72.70±0.42	75.73±13.75	83.52±4.45	66.02±8.07	0.33	17.46	3
	Depth water	84.00±5.64	70.62±0.67	80.27±4.57	78.95±8.58	57.80±14.55	0.28	20.08	3
Depth [m]		1,39±0,09 **a**	1.66±0.02 **a**	1.38±0.11 **a**	1.32±0.09 **a**	0.92±0.06 **b**	0.005*	11.32	3
Transparency [cm]		25.83±5.83	17.50±0.00	18.33±4.41	23.07±4.81	18.33±3.33	0.65	36.71	3

Values with a. b and ab letters are statistically different

depth of 1.30 m, a mean pH of 7.83 and dissolved oxygen saturation over than 73% and contains Avlékété, Hiyo and Djègbadji stations. The second group was constituted by Azizakoue station. It was characterized by lower oxygen saturation and a pH higher than the first group. The last group has low values and included only Togbin station; the dissolved oxygen saturation values were under 5% and the depth was 0.93 m.

COMPOSITION AND VARIATION OF THE ICHTYOFAUNA IN OUIDAH LAGOON

Fish Composition

The checklist of fish species recorded in Ouidah lagoon during the study was presented in Table 2. Overall, 21 species belonging to 16 families were recorded. Cichlids are the most represented (19.09%) with four species (*Sarotherodon melanotheron*, *Coptodon guineensis*, *Hemichromis bimaculatus and Hemichromis fasciatus)*. They were followed by Clupeids with 2 species (*Ethmalosa fimbriata* and *Pellonula leonensis)*. Other families were represented by only one specie. The number of the most represented fish species are as follow *Elops senegalensis* (250), *Eucinostomus melanopterus* (572)*; Sarotherodon melanotheron* (1308); *Liza falcipinnis* (462). The analysis of the table 2 showed that there were eight (8) freshwater species, eight (8) marine species and five (5)

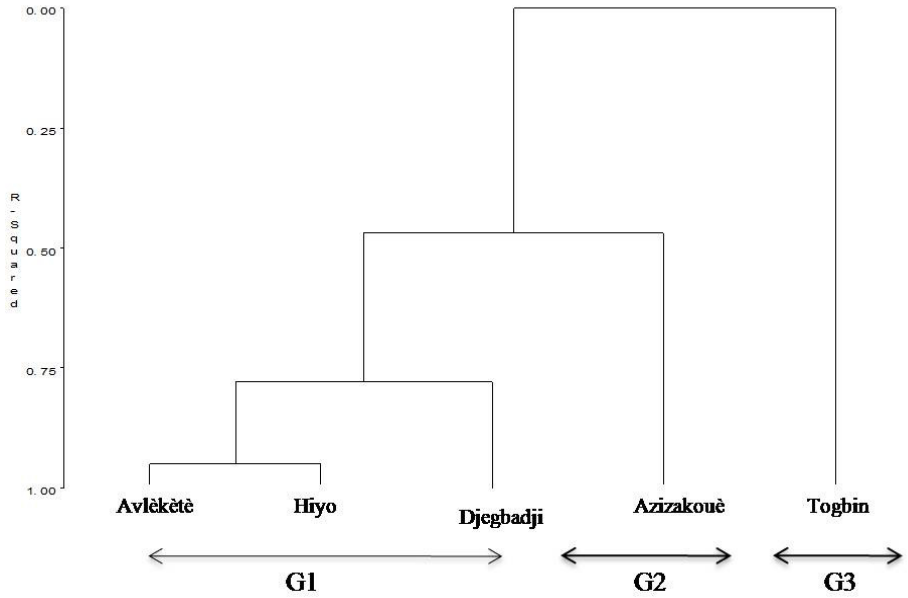

Figure 2: Dendrogram classifying the sampling sites based on water characteristics

Table 2: Checklist of fish species recorded in Ouidah lagoon

N°	Family	Species	Avlékété	Azizakoué	Djègbadji	Hio	Togbin	Origin
1	Carangidae	*Caranx hippos* [Linnaeus, 1766)		x	x			Ma
2	Claroteidae	*Chrysichthys nigrodigitatus* [Lacépède, 1803)	x	x	x	x		Co
3	Aralichthydae	*Citharichthys stampflii* [Bleeker,1862)		x				Ma
4	Claridae	*Clarias gariepinus* [Burchell, 1822)	x					Co
5	Cynoglossidae	*Cynoglossus senegalensis* [Kaup, 1858)	x	x				Ma
6	Elotridae	*Eliotris senegalensis* [Steindachner, 1870)	x	x				Es
7	Elopidae	*Elops senegalensis* [Regan, 1909)	x		x	x		Ma
8	Clupeidae	*Ethmalosa fimbriata* [Bowdich, 1825)		x	x			Ma
		Pellonula leonensis		x				Co
9	Gerreidae	*Eucionotomus melanopterus* [Bleeker, 1863)	x	x	x	x		Ma

Table 2: Continuation

10	Cichlidae	*Hemichromis bimaculatus* [Gill, 1862)	x					Co
		Hemichromis fasciatus [Peters, 1852)	x	x	x	x		Co
		Sarotherodon melanotheron	x	x	x	x	x	Es
		Coptodon guineensis (previously *Tilapia guineensis) Gunther, 1862*	x	x	x	x	x	Es
11	Gobidae	*Gobionellus occidentalis* [Boulenger, 1909)		x				Es
12	Mugilidae	*Liza falcipinnis* [Valenciennes, 1836)	x	x	x	x		Ma
13	Channidae	*Parachanna obscura* [Günther, 1861)	x			x	x	Co
14	Haemilidae	*Pomadasys jubelini* [Cuvier, 1830)	x	x	x			Ma
15	Schilbeidae	*Schilbe intermedius* [Rüppell, 1832)				x		Co
16	Mochokidae	*Synodontis nigrita [Valenciennes, 1840)*	x			x		Co
Total			**14**	**13**	**10**	**10**	**3**	

Co=Continental specie; Ma= Marine specie and Es= Estuarine specie

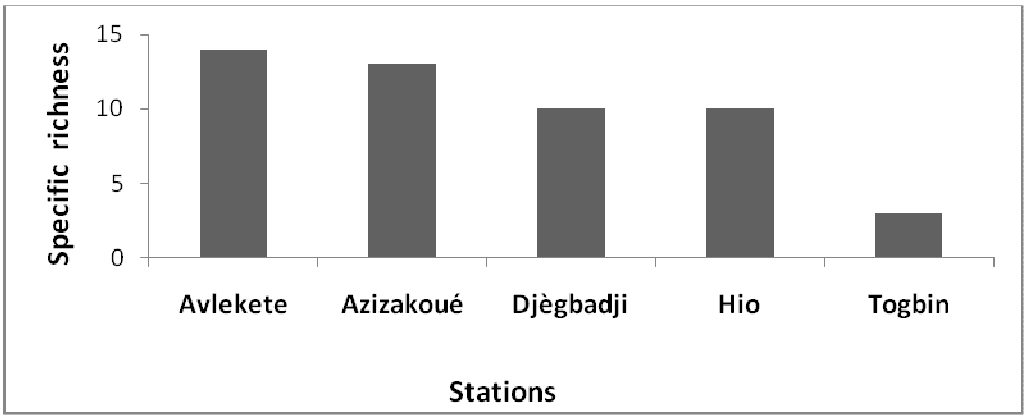

Figure 3: Variation of the specific richness according to stations

estuarine species.

Variation of the ichtyofauna in Ouidah lagoon

There was spatial variation in species richness (figure 3). The high specific richness (14 species), was obtained at Avlékété station followed by Azizakoué station (13 species). Togbin station had the lowest specific richness (3 species only) while Hiyo and Djegbadji stations had 10 species. Catches are dominated by freshwater species which represent 68.13% of total and 43% of the species richness.

Shannon's index and Pielou's index indicated low fish diversity (H'= 0.49) and bad distrbution of individuals beyond fish species at Togbin station (E = 0.45). Besides, a good distribution of species and a good repartition of individuals were recorded beyond fish populations at Azizakoue and Hio stations (H'=1.58 ; E= 0.62 and H=1.45 ; E=0.63 respectively).

Analysis of Table 3 showed that fish species were

Table 3: Variation of the Jaccard's index in the stations

Location	Avlékété	Azizakoué	Djègbadji	Hio
Azizakoué	50.00			
Djègbadji	42.11	**64.29**		
Hio	**60.00**	35.29	**53.85**	
Togbin	21.43	14.29	18.18	30.00

similar from one station to another. Thus fish populations of Azizakoue and Avlekete, Djegbadji and Azizakoue and Hio and Djegbadji were similar with Jaccard's index values of 50%, 64.29% and 53.85% respectively.

Fish exploitation in Ouidah lagoon

At the five sampling stations local fishermen employed a wide range of gears in their fishing operations. The fishermen used nylon or polyamide nets of various sizes and types depending on the fish to be targeted. The main gears used include gilinets, longline, hook and line and a variety of traps. Other types include castnets, setnets, beach seines, encircling net for crayfish etc. Traps are used both for fish and for crayfish. At Togbin, Hio and Avlékété, gillnets were used whereas in Djègbadji and Azizakoue the castnets were used. Traps were used only in Togbin station. Gillnets used in Ouidah lagoon are 30 to 40 meters long and 5 meters wide. They are tied at their upper side to plastic floats. The fishermen use three mesh type of throwing net in Ouidah lagoon: small meshes (10-15 mm), middle meshes [20mm) and largest meshes (>20mm).

Catch per Unit Effort (CPUE) varied with sampling stations and fishing gears. Spatially, the higher CPUE (1010.5 g/h) was obtained at Avlékété station, followed by Hio and Azizakoué (respectively 915.5 g/h and 729.6 g/h). Lower values were recorded at Togbin and Djègbadji stations (474.5 and 235.4 g/h) respectively. In relation to fishing gears, the CPUE values obtained varied from 178.9 g/h for active gillnets to 1127.8 g/h for passive ones. However, the active castnet at Djegbadji station has the lower CPUE (451.6 g/h).

DISCUSSIONS

Overall temperature values obtained were within the range of 23 to 31°C indicated by Laleye and Akele (2005) and Adandedjan (2012). The studies showed that this temperature range was favourable for the development of most tropical fish species found in South Benin. The trends observed for the mean depths in this study were in accordance with related studies (Roche International, 2000; Kitson, 2004; Adandédjan, 2012). The dissolved oxygen values showed that Togbin station was less oxygenated while Avlekete station had higher values. These values were lower than those recorded by Laleye and Akele (2005) at the same station but slightly higher than values recorded by Hounkpe and Bonou (2001); who recorded dissolved oxygen values of almost zero at Djegbadji station. Relative higher values recorded in this study could be due to the improvement of the ecosystem's quality. Mangrove swamp ecosystem rehabilitation has been initiated recently and the activities probably have a positive ecological effect.

The species richness of the Ouidah lagoon was lower than values recorded in many lagoons of Benin and West Africa. Lederoun (2006) recorded 49 fish species belonging to 30 families at Porto-Novo lagoon. Works conducted by Albatet, (1994) and Charles-Dominique (1994) in Ebrié Lagoon recorded respectively 153 and 79 fish species. The differences obtained between the present study and other lagoons in Benin and West Africa could be attributed to sampling effort (duration, spatio-temporal coverage and lagoons surfaces).

The specific richness of the lagoon varied spatially. High values were recorded at Avlekete and Azizakoue stations (14 and 13 species respectively). High species richness at Avlekete station could be due to mangrove swamps and relic forests present in the station. It has been established that bordering vegetation is very important for fish reproduction, feeding and recruitment. High specific richness recorded at Azizakoue station was due to its border with the sea, justified by the dominance of marine fish species. Lower values recorded in the other stations could be attributed to thedestruction of spawning zones by human activities, overfishing due to demographic pressure.

Catches analysis showed that *Sarotherodon melanotheron* dominates numerically at three out of five sampling stations (Avlekete, Djegbadji and Togbin) respectively with 59.6 %, 69.77 % and 85.29 %). The same trend was observed for weight abundance in the

same stations. The existence of *Sarotherodon melanotheron* species in Ouidah lagoon confirms its estuarine origin. The abundance of *Sarotherodon melanotheron* in Ouidah explains lower values of Shannon's index. Values of Pielou's index are also low. That could explain the bad distribution of individuals beyond species.

Fishes caught using traditional gears were of small sizes. Fishes from Azizakoue and Djegbadji stations, which were nearer the sea, were the smallest. This could be attributed to the fact that in south Benin, particularly in estuarine zones, the fish bio-ecology is characterized by longitudinal (up/down or ocean/lagoon) and transversal (water body/basin) migration processes (Hounkpe and Bonou, 2001; Ozigbo *et al.,* 2014). Fishes are probably caught during different migrations. Overfishing and using throwing nets were also to be taken into account as they contribute to fish stocks diminution. Fish species that reach the lagoon or the basin grow well in zones where bordering vegetation and mangrove swamp serve as habitats.

CONCLUSION

This study is a great contribution to the management of aquatic resources as it permitted to characterize Ouidah lagoon ecosystem and its biodiversity. Physico-chemical parameters are unequally distributed in the lagoon. Twenty-one fish species belonging to sixteen families have been recorded. Three fishing gears have been identified comprising throwing nets, gillnets and traps. Indexes calculated show bad distribution beyond fish species with dominance of Cichlids. Overall, ecological conditions of the Ouidah lagoon are favourable for fish development. The mangrove rehabilitation initiated these years during many governement and non governemental organisations programs have positive effects on fish biodiversity. If the monitoring of that fishing ecosystem is continued, the fish producton of Ouidah lagoon wll be enhanced.

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