INNSPUB

Journal of Biodiversity and Environmental Sciences (JBES)
ISSN: 2220-6663 (Print) 2222-3045 (Online)
Vol. 19, No. 6, p. 63-79, 2021
http://www.innspub.net

RESEARCH PAPER OPEN ACCESS

Diversity and community characteristics of Eleotridae (Pisces: Actinopterygii: Perciformes) from the coastal waters of Benin (West Africa)

Pejanos Stanislas Sonon[1], Edmond Sossoukpe[2], Alphonse Adite*[1], Adam Gbankoto[3], Youssouf Abou[1]

[1]Laboratory of Ecology and Aquatic Ecosystem Management (LEMEA), Departement of Zoology, Faculty of Sciences and Technics, University of Abomey-Calavi, Cotonou, Benin

[2]Laboratory of Wetland Researches (LRZH), Departement of Zoology, Faculty of Sciences and Technics, University of Abomey-Calavi, Cotonou, Benin

[3]Laboratory of Physiology and Experimental Pharmacology, Faculty of Sciences and Technics, University of Abomey-Calavi, Cotonou, Benin

Article published on December 06, 2021

Key words: Breathing organs, Coastal waters, Eleotridae, euryhalinity, Management, Community structure

Abstract

Also called "squeakers", the fishes of Eleotridae family appear to be an important component of the Benin coastal water fisheries, but also have a potential for aquaculture. The current ichtyological survey documents eleotrid fish composition and community structure in the degrading coastal waters of Benin in order to contribute to habitat protection, species conservation and aquaculture valorization. Eleotrid samplings were made monthly from April 2017 to September 2018 in Lake Nokoué, Porto-Novo Lagoon, Coastal Lagoon and Lake Ahémé using castnets, seines, gillnets and traps. Five (5) species, *Dormitator lebretonis*, *Eleotris vittata, Eleotris daganensis*, *Eleotris senegalensis* and *Bostrychus africanus* have been inventoried. *Dormitator lebretonis* was the dominant eleotrid making 57.91% - 87.39% of the squeaker assemblages. The highest Shannon-Weaver index of eleotrid diversity (H'=3.82) was recorded in Porto-Novo Lagoon, a relatively less degraded ecosystem, whereas the lowest H'=1.54 was recorded in Lake Ahémé, a highly degraded coastal water. Eleotrids exhibited a relatively high tolerance to environmental quality due to their euryhaline behaviour and the presence of adaptive air breathing organs. A sustainable exploitation of squeakers requires a holistic approach of coastal waters management.

***Corresponding Author:** Alphonse Adite ✉ alphonseadite@gmail.com

Introduction

Commonly known as sleeper gobbies or squeaker, the fishes of Eleotridae family are one of the most widely distributed teleost taxon among the world (Nordlie, 1981). The Eleotridae family belongs to Gobioidei sub-order, Perciformes order, Actinopterygii subclass and Osteichthyes class. They are named « sleepers » because most eleotrids lie quietly on benthic habitats. Eleotrids are small to medium sizes fishes and are characterized by six branchiostegal rays, separate pelvic fins, depressed heads with interorbital width as large as the eye diameter or larger, second dorsal fins shorter than the caudal peduncle length, and rounded caudal fins (Pezold *et al.*, 2002). The species frequent low-altitudinal lentic-type habitats near banks with vegetation and prefer habitats like mangroves, slow brackish zones, channels and estuaries with salinity ranging from 0 to 25‰. Aquatic vegetation appears to be their natural habitats where squeakers forage on many food resources (Nordlie, 1978, Berra, 2001, Ekpo *et al.,* 2014). Most eleotrids possess air breathing accessory organs that allow them to cope with low-dissolved oxygen habitats that could expose them to hypoxia (Kramer, 1983). The species can survive more than 24 hours without water and display a relatively large ecological niche (Kramer, 1983; Chang, 1984).

The family of Eleotridae is highly speciose and comprises about 35 genera and 155 species dwelling tropical and subtropical areas worldwide (Nordlie1981; Nelson 1994; Keith *et al.,* 2006). Currently, 18 genera and 40 described species of eleotrid fishes are known from Australia (Hoese *et al.*, 2006). Squeakers are common in the Pacific Ocean in South America where 15 genera and 28 species occurs, with *Dormitator latifrons* (Pacific Fat Sleeper) considered as a relevant upcoming fish species for aquaculture, particularly in Ecuador and Mexico where some preliminary trials have been implemented (Hoese, 1978; Rodriguez *et al.*, 2012). In West Africa, 6 genera and 13 species of Eleotridae were inventoried and only one, *Kribia nana*, is strictly confined to freshwater while the remaining inhabits brackish waters (Leveque *et al.*, 1992). Teugels *et al.* (1992) reported four (4) species of Eleotrids, *Bostrychus africanus*, *Dormitator lebretonis*, *Eleotris vittata* and *Eleotris Danganensis* in the Nigerian coastal waters.

In Benin, squeaker fishes occur in coastal waters where they constitute an important component of artisanal fisheries (Adite, 2013; Laleye *et al.*, 2004; Kakpo *et al.* 2011; Adite *et al.*, 2013). In particular, species such as *Dormitator lebretonis* are massively exploited by fishermen because of their relative high cost and their high numeric abundance (Babatundé, 2015). Also, because of its small size and high organoleptic quality, *D. lebretonis* is consumed with many local foods such as corn meals, cassava meals and “Ablo”, a local bread made of corn. More importantly, *D. lebretonis* is used to substitute shrimp meal for sauce/soup seasoning because of its flavour. Despite its fisheries and food importance, little is known about the species composition, the biology and ecology of eleotrid fishes in Benin. In particular, nothing is known about species richness, diversity and the overall community structure in relation with habitat characteristics in the Benin coastal waters. In this study, we investigated on habitat quality and community structures (species composition, abundance, diversity) of Eleotridae from four coastal waters, Lake Nokoué, Coastal Lagoon, Lake Ahémé and Porto-Novo Lagoon, all located in Southern Benin. These ecological data will serve as reference for ecosystem and resource follow-up/ monitoring and management of eleotrid fishes in the Benin coastal waters.

Materials and methods

Study area and locations

The current study was conducted in the four (4) Benin coastal brackish waters of Southern Benin, Lake Nokoué, Coastal Lagoon, Lake Ahémé and Lagoon of Porto-Novo that constitute the natural habitat of Eleotridae in Benin (Fig. 1).

Lake Nokoué

Located between 6°20’ and 6°30’N, and between 2°20’ and 2°35’E, Lake Nokoué (Fig. 1) is the largest water body and the most productive brackish water in

Benin and covers about 150 km² (Lalèyè and Moreau, 2003). As brackish water, Lake Nokoué received salty water from marine environment (Atlantic Ocean) through Cotonou city channel (4.5 km length) in the South and the freshwater from Oueme River and Sô stream in the Southeast and North, respectively. During the wet period, these two running waters withdraw their water in Lake Nokoué (Texier, 1980), reducing salinities that in general ranged between 0g/l and 40g/l (Hamil *et al.*, 2018). In addition, Lake Nokoué is connected to another brackish water, Lagoon of Porto-Novo that communicates with the lagoon of Lagos in Nigeria Republic. Because of its location near Cotonou, the most densely populated city of the country, Lake Nokoué has suffered, since 1960, from major anthropogenic disturbances that have profoundly affected its ecology, hydrology, salinity and its ichthyological diversity (Welcomme, 1972). Also, a couple of decades ago, Lake Nokoué was bordered by mangroves forest comprising mainly plant species such as *Avicennia* and *Rizophora* that provided the lake with nutrient enrichment from decomposition. Also, the mangrove forests serve as spawning substrates for fish and play an important role of limiting shoreline erosion. Yet, these mangroves were progressively destroyed by the increasing population of fishermen inhabiting the surroundings of this lake. Today, only very few mangroves are encountered and has resulted in multiple ecological concerns.

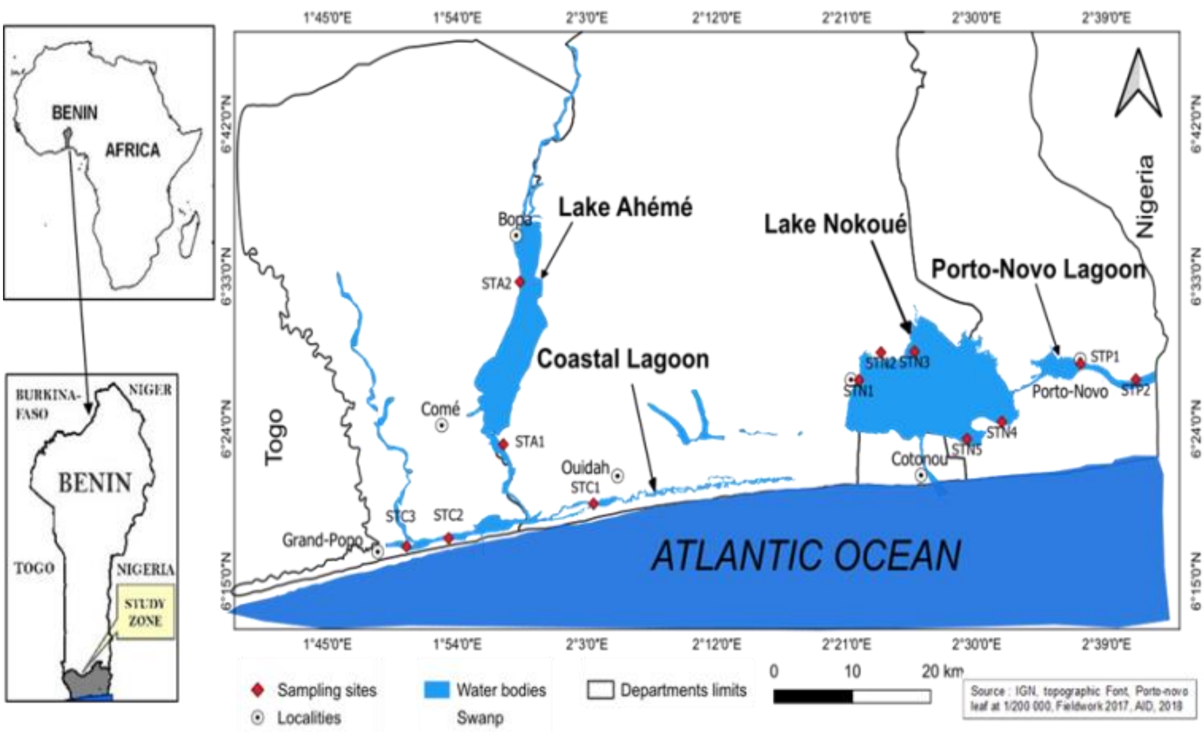

Fig. 1. Map showing coastal waters (South-Benin) and the twelve study locations. STN=Sites of Lake Nokoué, STP=Sites of Porto-Novo Lagoon, STC= Sites of Coastal Lagoon, STA=Sites of Lake Ahémé.

Porto-Novo Lagoon

Located between 6°25'and 6°30'N, and between 2°30'and 2°38E, Porto-Novo Lagoon extended on 35 km² and communicates with Lake Nokoué to the west through Totchè canal. At the East, this low-salinity (0 - 7.3‰) brackish water communicates with the lagoon of Lagos (Nigeria) by a channel of approximately 100 km length and 20 - 50 m width (Gnohossou, 2006). The prominence of water hyacinth (*Echhornia crassipes*) that covers water surface coupled with the dumping of domestic wastes led to high water pollution with acid to neutral pH varying between 4.6 - 7.2 and reduced dissolved oxygen ranging from 0 to 0.58mg/l during high colonization of floating plants.

Coastal Lagoon

The coastal lagoon extended on about 130 km, and in contrast with Lake Nokoué, covers about 3000 ha of mangrove associated with 6000 ha of swamps during flooding (Fig. 1). As brackish water, the coastal lagoon receives the salty water from Atlantic Ocean and the freshwater from Mono River (527 km) that supports a hydro electrical dam. Annual salinities ranged between 0-35‰, depths varied between 0.5-4.47 m and transparencies between 3-150cm, water temperatures between 25.3˚C-35.2˚C, pH between 5.5 - 8.7, dissolved oxygen between 0.1-8.5mg/l (Adite *et al.*, 2013). Mangrove species such as *Rizophora racemosa, Avicennia africana* and grasses *(Cyperus articulatus, Paspalum vaginatum*) were the dominant plant community. The fish fauna included about 51 species dominated by families such as Eleotridae, Cichlidae, Mugilidae, Clupeidae, Gereidae, Claroteidae and shrimps *(Macrobrachiun sp., Penaeus sp)* crabs *(Callinectes sp, Cardiosoma sp.)* and mangrove oysters *(Crassostrea sp.)* that were permanently exploited. Yet the hydroelectric dam greatly affects the hydrological regimes, salinities, nutrient cycles and the biological resources of the coastal waters.

Lake Ahémé

Located in Southwestern Benin between 6.20° and 6.40°N and between 1.55° and 2°E, Lake Ahémé is a brackish water that receives freshwater from Couffo stream and salty water from Atlantic Ocean. It covers about 80 km² (Lalèyè *et al.*, 2004), but reach 100 km² during the rainy season. Lake Ahémé linked southward to coastal lagoon via the 10 km-long Aho Channel. Water temperature varied between 28°C - 31°C, pH between 6.65 – 10.51, dissolved oxygen between 3.66mg/l – 8.16mg/l and peak salinities varied from 21g/l to 31g/l. Mangrove species have been destroyed and are now limited to some plantation of *Rizophora racemosa* and *Avicennia Africana*. As reported by Gnacadja (2000), about 71 fish species dominated by cichlids, mullets etc. have been recorded in Lake Ahémé where fishing activity is very intense. Because Lake Nokoue, Lagoon of Porto-Novo, Coastal lagoon and Lake Ahémé are all located on the Southern Benin, they displayed the same hot and humid climate throughout the year, with two (2) rainy seasons (April-July; September-October) and two (2) dry periods (December-March; August-September). Annual rainfall averaged 1150 mm with peaks occurring in June.

Sampling locations

Twelve (12) sampling sites were selected for this ichtyological survey (Fig. 1): five (5) on Lake Nokoue (STN1=Calavi city, STN2= Ganvié village, STN3=Agblangandan village, STN4=Ekpè village, STN5=Ketonou village), two (2) on Porto-Novo Lagoon (STP1=Djassin town, STP2= Agbomey Takplikpo village), three (3) on Coastal Lagoon (STC1=Dégouè village, STC2=Hèvè village, STC3=Avlo village) and two (2) on Lake Ahémé (STA1=Guézin village, STA2=Cokponawa village). These locations were chosen according to accessibility, variability of habitats and the importance of fishing activities. Two (2) major habitats, the "open water" habitat showing high depths and high water velocities, and the "aquatic vegetation" habitat characterized by low depths and relatively dense vegetation, were sampled at each collecting site.

Evaluation of environmental quality

To assess the quality of the coastal waters, physicochemical parameters such as depth, transparency, temperature, pH, dissolved oxygen concentration, percentage of dissolved oxygen saturation and water velocity were measured monthly in situ in open water and aquatic vegetation habitats of all sampling sites. The depth was measured to the nearest 1cm using a graduated rope attached to a water sampler and the transparency was measured to the nearest 1cm using a Secchi disc.

Temperatures, dissolved oxygen and O_2 percentages of saturation were measured to the nearest 0.1°C, 0.1mg/l and 1% O2, respectively using a digital multi-probe (HANNA model 9150 waterproof). pH was measured to the nearest 0.1 using a pH meter "model 3150 waterproof". Water salinity was evaluated to the nearest 1‰ using a model VISTA refractometer while water velocity was measured to the nearest 1cm by observing the horizontal displacement of a float over a calibrated distance (Konan *et al.*, 2007). Sediments (pebbles, sand and mud) and substrate types were identified by sampling the bottom (mud) with visual assessment in situ. Sampling of the sediment was carried out using an Eckman grab of 15cm x 15cm size (Odountan *et al.*, 2019). Aquatic plants were sampled, preserved and identified in "Herbier National" of the Faculty of Sciences and Technics, University of Abomey-Calavi.

Fish collection and identification

Eleotrid fishes were sampled monthly for 18 months (April 2017 - September 2018) at all sampling sites in the "aquatic vegetation" habitat and in the "open water" habitat using various fishing gears such as cast net (3m-diameter, 10 mm-mesh), seine (3 - 20 mm-mesh) and traps. Experimental seining was done in the marginal aquatic vegetation by setting the seine stationary, and kicking the vegetation to drive the fish into the net (Adite and Winemiller, 1997). Eight (8) to ten (10) seine hauls on about 10 meters were done at each sampling site (Adite *et al.,* 2017). Samplings were also made in artisanal catches of local fishermen to add species that were not caught during experimental samplings (Hauber *et al.*, 2011). To approach the diversity of the whole Eleotridae, a non-selective fishing techniques, the ''Acadjavi" (park of branches installed in the lake to attract fish) was used. Eleotrid samplings from fisherman captures were made on the basis of one third of species abundance when this latter exceeded 50 individuals. For species abundances less than 50, all individuals of this species were considered for the sample (Kakpo, 2011; Okpeicha, 2011). After collection, the fish individuals were identified in situ using references such as Leveque *et al.* (1992) and Pezold *et al.* (2002) on freshwater and brackish water fishes of West Africa. After identification, the fish individuals were preserved in a cooler and transported to the Laboratory of Ecology and Management of Aquatic Ecosystems (LEMEA)" of the Faculty of Sciences and Technics to confirm species names using Fishbase. In the laboratory, each fish individual was measured, weighted and preserved in 10% formalin and latter in 70% alcohol. Total length (TL), standard length (SL) of each individual were then measured to the nearest 0.1cm using an ichthyometer and the individual weight (W) was measured to the nearest 0.01g using an electronic scale (CAMRY 0.1g / 500g; AWS).

Data analysis

Physicochemical parameters and morphometric (TL, SL, W) data of eleotrid fishes were recorded in SPSS 21 (Morgan *et al.,* 2001) spread sheets. Average values and ranges of physicochemical parameters were computed by sampling site using SPSS (Morgan *et al.,* 2001) software. One-way analysis of variance (ANOVA) was used to evaluate spatial and seasonal variabilities. Also, the fish community structure indexes such as species richness, relative abundances, species diversity, and equitability indexes were computed using SPSS 21 software. The species richness was calculated using Margalef (1968) index (d):

$$d = (S - 1)/\ln N$$

where S is the number of species, N is the number of individuals in the sample. The Eleotridae diversity was computed using Shannon and Weaver (1963) diversity index (H'):

$$H' = -\sum_{i=1}^{n} [Pi * \log_2(pi)]$$

where *H'* is the index of species diversity, pi = ni/N, the proportion of total sample belonging to i species, ni the number of individuals of each species in the sample, N the total number of individuals in the sample. The evenness measure (E') of Shannon and Weaver (1963) was calculated following the formula:

$$E' = H' / \log_2 S$$

where (E') is the evenness measure, H′ is the Shannon & Weaver index of diversity, S is the number of species in the sample. The relationships between relative abundances of eleotrid species and water physicochemical parameters were assessed through spearman correlation coefficients using SPSS 21 (Morgan *et al.,* 2001) and the Canonical Correspondence Analysis (CCA) using CANOCO software, version 4.5. Spatial, seasonal and biometric data including total length (TL), standard length (SL) and fish individual weight (W) were recorded in spread sheets generated from SPSS computer software (Morgan *et al.*, 2001).

Results

Habitat characteristics

Trends of water quality

Table 1 shows means, minimum and maximum values of water features across sampling sites of the four (4) coastal waters. Lower mean temperature (28.94±0.27°C) was recorded in Lake Nokoué whereas the highest mean value (30.8±0.25°C) was recorded in Lake Ahémé. The Coastal Lagoon showed the lowest mean depth (138.8±36.15cm) while the highest mean value (225.3±29.56cm) was recorded in Porto-Novo Lagoon. Transparencies were reduced in Lake Nokoué (mean: 52.5±18.8cm), but peaked in Porto-Novo Lagoon with mean= 68.5±17.8cm. Mean dissolved oxygen concentrations in the four (4) coastal waters were moderate and ranged between 3.2±0.38 and 4.5±0.42mg/l with a higher value (9.8mg/l) recorded in the Coastal Lagoon. Lower mean pH (6.5±0.65) was recorded in Lake Ahémé whereas the highest mean value (7.5±0.71) was recorded in the Coastal Lagoon. Mean salinity in the four (4) coastal waters ranged between 6.2±3.50 and 7.7±4.32‰ with a higher value (30‰) recorded in the Coastal Lagoon. In general, water velocities in the four (4) coastal waters were reduced and ranged between 0.021±0.004 and 0.034±0.002 m/s. Regardless of seasons and sites, the four (4) coastal waters fail to show any significant differences in water quality. Indeed, one-way ANOVA on physicochemical parameters did not show any significant (p>0.05) variation for depth ($F_{3,71}$=1.51, p=0.220), transparency ($F_{3,71}$=1.417, p=0.245), water temperature ($F_{3,71}$=1.543, p=0.211), dissolved oxygen (DO) ($F_{3,71}$=0.74, p=0.914), percentage of DO saturation ($F_{3,71}$=0.867, p=0.463), salinity ($F_{3,71}$=0.344, p=0.794), pH ($F_{3,71}$=0.915, p=0.438), and water velocity ($F_{3,71}$=0.573, p=0. 635).

Spatial and seasonal variations of physicochemical parameters

With regard to stations, in Lake Nokoué, the largest lagoon in Benin, there were insignificant (p>0.05) spatial variations of physicochemical parameters for transparency ($F_{4,89}$=1.549, p=0.195), water temperature ($F_{4,89}$=1.076, p=0.373), DO ($F_{4,89}$=0.172, p=0.952), percentage of DO saturation ($F_{4,89}$=0.601, p=0.663) and pH ($F_{4,89}$=0.556, p=0.695). Inversely, depth ($F_{4,89}$=8.372, p=0.000), salinity ($F_{4,89}$=2.396, p=0.047) and water velocity ($F_{4,89}$=0.2976, p=0.024) showed significant (p<0.05) spatial variations. Also, in Lake Ahémé, there were significant (p<0.05) spatial variations of physicochemical parameters for depth ($F_{1,34}$=45.463, p=0.000), transparency ($F_{1,34}$=5.119, p=0.030) and salinity ($F_{1,34}$=31,216 p=0.000) while temperature ($F_{1,34}$=1.014, p=0.321), DO ($F_{1,34}$=0,142, p=0.708), percentage of DO saturation ($F_{1,34}$=0.046, p=0.831), pH ($F_{1,34}$=1.347, p=0.254) and water velocity ($F_{1,34}$=0.4015, p=0.053) were not significantly different (p>0.05). In Porto-Novo Lagoon and Coastal Lagoon, only depth exhibited a significant (p<0.05) spatial variations. Associated ANOVA statistics were $F_{1,34}$=6.661, p=0.014 and $F_{1,34}$= 8.073, p=0.001, respectively.

Table 1. Mean values of physicochemical parameters measured in the Benin coastal waters (South-Benin) from April 2017 to September 2018.

Parameters	Lake Nokoué	Porto-Novo Lagoon	Coastal Lagoon	Lake Ahémé	p-value
	Mean±SD	Mean±SD	Mean±SD	Mean±SD	
Water temperature (°C)	28.94±0.27	29.1±0.31	30.2±0.23	30.8±0.25	0.211
Depth (cm)	185.5±30.21	225.3±29.56	138.8±36.15	221.7±47.23	0.22
Transparency (cm)	52.5±18.8	68.5±17.8	59.8±12.8	58.2±10.45	0.245
Dissolved oxygen (DO) (mg /l)	3.2±0.38	4.1±0.48	4.5±0.42	3.7±0.35	0.914
% DO	48.8±21.32	55.8±18.48	61.5±23.56	50.1±31.52	0.463
pH	6.8±0.56	7.3±0.35	7.5±0.71	6.5±0.65	0.438
Salinity (‰)	7.7±4.32	5.2±4.90	8.9±3.79	6.2±3.50	0.794
Water velocity (m/s)	0.034±0.002	0.024±0.003	0.032±0.002	0.021±0.004	0.635

Seasonally, one-way ANOVA run on water physicochemical features of Lake Nokoué showed significant (p<0.05) seasonal variations for depth ($F_{2,17}$=11.847, p=0.001), transparency ($F_{2,17}$=6.516, p=0.009), salinity ($F_{2,17}$=26.102, p=0.000) and water velocity ($F_{2,17}$=29.353, p=0.000). In contrast, water temperature ($F_{2,17}$=0.385, p=0.687), dissolved oxygen (DO) ($F_{2,17}$=0.470, p=0. 634), DO saturation ($F_{2,17}$=0.903, p=0. 426) and pH ($F_{2,17}$ =0.474, p=0. 632) displayed insignificant (p>0.05) seasonal variations. In Lagoon of Porto-Novo, only depth ($F_{2,17}$=5.491, p=0.016), salinity ($F_{2,17}$=15.112, p=0.000) and water velocity ($F_{2,17}$=20.299, p=0.000) exhibited significant (p<0.05) seasonal variations. Likewise, Lake Ahémé showed significant (p<0.05) seasonal variations for depth ($F_{2,17}$=8.568, p=0.003), salinity ($F_{2,17}$=7.944, p=0.004) and water velocity ($F_{2,17}$=15.604, p=0.000) while transparency, water temperature, DO, DO saturation and pH did not show any significant (p>0.05) variation in these two coastal waters (lagoon of Porto-Novo, Lake Ahémé). In Coastal Lagoon, physicochemical parameters such as depth ($F_{2,17}$ =11.06, p=0.001), transparency ($F_{2,17}$ =4.73, p=0.025), salinity ($F_{2,17}$ =86.30, p=0.000) and water velocity ($F_{2,17}$ =15.54, p=0.000) exhibited significant (p<0.05) seasonal variations while non-significant (p>0.05) seasonal variations were recorded for temperature ($F_{2,17}$ =1.06, p=0.371), DO ($F_{2,17}$ =0.24, p=0.791), DO saturation ($F_{2,17}$=0.04, p=0.965) and pH ($F_{2,17}$ =0.13, p=0.876). Nevertheless, the lower values of dissolved oxygen (0.55 – 0.85mg/l) could be damageable to fishes.

Species composition, abundances and sizes

Among a total of 7225 Eleotrid individuals collected during the (18) months in the four (4) coastal waters of Benin, five (5) species, *Dormitator lebretonis, Eleotris vittata, Eleotris daganensis, Eleotris senegalensis* and *Bostrychus africanus* (Fig. 2-6) belonging to 3 genera were inventoried in Lake Nokoué, Porto-Novo Lagoon and in the Coastal Lagoon. The species *Bostrychus africanus* were not recorded in Lake Ahémé. In all four (4) ecosystems, the most speciose genus was *Eleotris* with (3) species, *E. vittata*, *E. daganensis* and *E. senegalensis*. Numerically, *D. lebretonis* was the most abundant species in all 4 coastal waters examined and made 58.60% of the eleotrids in Lake Nokoué, 57.91% in Porto-Novo Lagoon, 76.05% in the Coastal Lagoon and 87.39% in Lake Ahémé. *Eleotris vittata* followed with 30.17% in Lake Nokoué, 23.85% in Porto-Novo Lagoon, 16.91% in Coastal Lagoon, and 8.69% in Lake Ahémé. Though of reduced abundances, *Eleotris daganensis* was common in all 4 coastal waters and made 2.66% of eleotrids in Lake Nokoué, 7.91% in Porto-Novo Lagoon, 4.98% in Coastal Lagoon and 3.69% in Lake Ahémé. Also, *Eleotris senegalensis* was well represented in Porto-Novo Lagoon (8.42%) and in Lake Nokoué (4.28%), but was trivial in Coastal Lagoon (0.76%) and in Lake Ahémé (0.22%). *Bostrychus africanus* was common in Lake Nokoué (4.29%), but was less represented in the Coastal Lagoon (1.27%) and in Porto-Novo Lagoon (1.90%), and absent in Lake Ahémé (Table 2-5).

Fig. 2. *Dormitator lebretonis* (Gill, 1862).

Fig. 3. *Eleotris vittata* (Duméril, 1858).

Fig. 4. *Eleotris daganensis* (Steindachner, 1870).

Fig. 5. *Eleotris senegalensis* (Steindachner, 1870).

Fig. 6. *Brostrychus africanus* (Steindachner, 1880).

Table 2. Abundances, sizes and weights of eleotrid fishes sampled in Lake Nokoué (South-Benin) from April 2017-September 2018.

Species	Abundance	Relative Abundance (%)	SL Mean (cm)	SL range (Cm)	Weight Mean (g)	Weight Range (g)	Total weight (g)	% Weight
Dormitator lebretonis	1911	58.60	3.79±1.25	1.5-9.6	3.83±3.52	0.4-14.84	37668.84	35.54
Eleotris vittata	984	30.17	6.81±2.53	3-17	11.67±7.51	0.5-191	37958.34	35.81
Eleotris senegalensis	139	4.28	6.97±1.82	4.7-14.5	8.6±8.25	2.1-130.2	19993.08	18.86
Eleotris daganensis	87	2.66	6.93±1.33	4.3-16	11.14±9.25	3-163.16	3676.51	3.46
Bostrychus africanus	140	4.29	11.2±0.65	9-15	47.43±5.28	11.64-63.3	6688.82	6.33
Total	3261	100					105985.5	100

Table 3. Abundances, sizes and weights of eleotrid fishes sampled in Porto-Novo Lagoon (South-Benin) from April 2017-September 2018.

Species	Abundance	Relative Abundance (%)	SL Mean (cm)	SL range (Cm)	Weight Mean (g)	Weight Range (g)	Total weight (g)	% Weight
Dormitator lebretonis	578	57.91	4.27±1.22	2-9.6	4.46±2.15	0.44-17.5	2584.16	17.43
Eleotris vittata	238	23.84	9.24±2.65	2.8-18	26.93±10.3	0.76-182.3	6435.92	43.43
Eleotris senegalensis	84	8.44	9.75±2.92	2.5-16.5	34.12±8.12	2.16-139.1	2900.86	19.59
Eleotris daganensis	79	7.91	9.31±2.32	5-17	28.26±9.12	2-119.7	2232.9	15.06
Bostrychus africanus	19	1.90	10.83±0.3	8.5-14	35.03±6.25	15.32-6.68	666.58	4.49
Total	998	100					14820.4	100

Table 4. Abundances, sizes and weights of eleotrid fishes sampled in the Coastal Lagoon (South-Benin) from April 2017-September 2018.

Species	Abundance	Relative Abundance (%)	SL Mean (cm)	SL range (Cm)	Weight Mean (g)	Weight Range (g)	Total weight (g)	% Weight
Dormitator lebretonis	1556	76.05	3.58±1.2	1.2-7.8	3.59±3.8	0.35-14.4	5584.6	43.14
Eleotris vittata	346	16.91	7.47±3.2	1.4-19	15.86±5.2	2.4-22	5490.1	42.41
Eleotris senegalensis	16	0.78	7.64±2.4	4-12.33	21.45±7.23	2.06-77.6	343.32	2.65
Eleotris daganensis	102	4.98	5.75±1.2	1.5-9.4	6.68±4.25	0.1-21.04	681.76	5.26
Bostrychus africanus	26	1.27	10.4±0.4	8.6-13	32.51±3.24	15.2-57.9	845.5	6.54
Total	2046	100					12945	100

Table 5. Abundances, sizes and weights of eleotrid fishes sampled in Lake Ahémé (South-Benin) from April 2017-September 2018.

Species	Abundance	Relative Abundance (%)	SL Mean (cm)	SL range (Cm)	Weight Mean (g)	Weight Range (g)	Total weight (g)	% Weight
Dormitator lebretonis	804	87.39	7.19±1.7	6.5-11.3	4.08±2.1	3.4-13.44	3278.8	47.63
Eleotris vittata	80	8.69	9.32±2.6	1.6-21	37.65±12.2	0.18-140.4	3012.62	43.76
Eleotris senegalensis	2	0.23	10.9±0.2	10.5-11.3	34.44±0.2	32.44-36.4	68.88	1.0
Eleotris daganensis	34	3.69	7.8±1.12	5.9-13	15.4±8.7	2.8-68.18	523.6	7.61
Total	920	100					6883.9	100

In the current study, the highest mean standard length (HMSL) (HMSL=4.27±1.22cm) of the most abundant eleotrid, *Dormitator lebretonis*, was recorded in Porto-Novo Lagoon. For the second most abundant species (*Eleotris vittata*), the highest mean standard length (HMSL=9.32±2.57cm) was recorded in Lake Ahémé. Those of less abundant species, *Eleotris daganensis* (HMSL=9.31±2.32cm), *Eleotris senegalensis* (HMSL=10.9±2.92cm) and *Bostrychus africanus* (HMSL=11.2±0.65cm) were recorded in Lake Ahémé, Porto-Novo Lagoon, and Lake Nokoue, respectively. Also, the highest mean weight (HMW) (HMW=4.46±2.15 g) of *Dormitator lebretonis* was recorded in Porto-Novo Lagoon and that of *Eleotris vittata* (HMW=37.65±12.23 g) was recorded in Lake Ahémé. The highest mean weight of less abundant species, *Eleotris senegalensis* (HMW=34.44±0.21 g), *Eleotris daganensis* (HMW=28.26±9.12 g) and *Bostrychus africanus* (HMW=47.43±5.28 g) were recorded in Lake Ahémé, Porto-Novo Lagoon and Lake Nokoue, respectively.

Diversity indices

Table 6 and 7 showed the matrix of Margalef (d) index of species richness, Shannon-Weaver diversity indices (H') and evenness measures (E) of Eleotridae by habitats types (open water, aquatic vegetation) and seasons (dry, wet, flood) for each of the coastal water studied.

Table 6. Diversity indices by seasons of eleotrid fishes sampled in the Benin coastal waters from April 2017 - September 2018.

Seasons /Indices	Taxa S	Margalef	Shannon-weaver (H')	Evenness (E)
Lake Nokoué				
Dry	5	0.8	3.55	0.58
Wet	5	0.6	3.20	0.54
Flood	5	0.5	3.52	0.57
Total	5	0.56	3.47	0.56
Porto-Novo Lagoon				
Dry	5	0.89	3.95	0.70
Wet	5	0.67	3.69	0.60
Flood	5	0.63	3.88	0.64
Total	5	0.57	3.82	0.63
Coastal lagoon				
Dry	5	0.79	2.64	0.55
Wet	5	0.63	2.31	0.4
Flood	5	0.55	2.59	0.43
Total	5	0.52	2.55	0.43
Lake Ahémé				
Dry	4	0.72	1.71	0.55
Wet	3	0.33	1.56	0.53
Flood	3	0.32	1.43	0.38
Total	4	0.43	1.54	0.39

Margalef (1968) index of species richness (d)

Porto-Novo Lagoon displayed the highest Eleotrid richness with d = 0.57, followed by the Coastal Lagoon (d = 0.52), Lake Nokoué (d = 0.49) and Lake Ahémé (d=0.43). Except Lake Ahémé, the open water habitat exhibited the highest species richness with a peak value (d=0.78) recorded in Porto-Novo Lagoon (Table 7). Overall, t-test fail to show any significant spatial variation of the species richness (d) with t values varying between -1.18 and 0.71 and *p*-values between 0.245 and 0.481. In general, there were no seasonal variations in species richness for Porto-Novo Lagoon ($F_{2,17}$ =0.17, p =0.842), Lake Nokoué ($F_{2,17}$ =3.19, p =0.100) and Coastal Lagoon ($F_{2,17}$ =0.14, p =0.871). In contrast, only Lake Ahémé exhibited significant ($F_{2,17}$ =6.90, p =0.007) seasonal variations in species richness with a peak d = 0.72 occurring in dry season.

Table 7. Diversity indices by habitat types of eleotrid fishes collected in the Benin coastal waters from April 2017 - September 2018.

Habitat / Indices	Taxa S	Margalef	Shannon-weaver (H')	Evenness (E)
Lake Nokoué				
Open water	5	0.59	3.28	0.53
Aquatic vegetation	5	0.54	3.69	0.60
Acadjavi	5	0.58	2.93	0.48
Total	5	0.49	3.47	0.56
Porto-Novo Lagoon				

Open water	5	0.78	3.21	0.52
Aquatic vegetation	5	0.59	3.98	0.66
Total	5	0.57	3.82	0.63
Coastal lagoon				
Open water	5	0.64	2.31	0.50
Aquatic vegetation	5	0.54	2.62	0.44
Total	5	0.52	2.55	0.43
Lake Ahémé				
Open water	3	0.35	1.87	0.58
Aquatic vegetation	4	0.46	1.98	0.67
Total	4	0.43	1.54	0.39

Shannon & Weaver index of diversity (H')

The highest Shannon & Weaver index of diversity (H' = 3.82) was recorded in Porto-Novo Lagoon, then followed Lake Nokoué with H' = 3.47, Coastal Lagoon (H' = 2.55) and Lake Ahémé (H' = 1.54) (Table 6). In general, in each of the 4 coastal waters, there were no significant spatial variations of the diversity index (H'): t (t-test) values ranged between -1.25 and 0.73 and *p*-values between 0.221 and 0.469. Nevertheless, in all 4 coastal waters, the aquatic vegetation habitats exhibited the highest Eleotrid diversity with the peak (H'=3.98) recorded in Porto-Novo Lagoon (Table 7). Also, there were no significant ($p > 0.05$) seasonal variations in the diversity index (H') of the 4 coastal waters. Indeed, one-way ANOVA statistics for Porto-Novo Lagoon were $F_{2,17}$ =0.58, p =0.573, Lake Nokoué ($F_{2,17}$ = 3.01, p =0.080), Coastal Lagoon ($F_{2,17}$ =0.71, p =0.508) and Lake Ahémé ($F_{2,17}$=3.63, p =0.051). Nevertheless, dry season exhibited the highest H' in all 4 coastal waters.

Evenness measures (E)

Porto-Novo Lagoon exhibited the highest evenness E=0.63 whereas the lower value E=0.39 was recorded in Lake Ahémé (Table 6 and 7). Spatially, the higher evenness was mostly recorded in aquatic vegetation habitat with a peak E=0.67 occurring in Lake Ahémé (Table 6). Seasonally, the Evenness (E) were higher during the dry season with a peak E=0.70 recorded in Porto-Novo Lagoon (Table 7).

Environmental correlates

Overall, regressions between species abundances and water physicochemical parameters of Lake Nokoué gave correlation coefficients (r) ranging between -0.45 and 0.76 (Table 8). Similar trends were recorded for Porto-Novo Lagoon with (r) between -0.47 and 0.62 (Table 9), Coastal Lagoon ($-0.40 \leq r \leq 0.58$) and Lake Ahémé ($-0.45 \leq r \leq 0.78$). Canonical Correspondence Analysis (CCA) run between water features and Eleotrid abundances showed the existence of two groups of correlation in each of the 4 coastal waters examined (Fig. 8A, Fig. 8B, Fig. 8C and Fig. 8D).

Table 8. Matrix of correlation coefficients (r) obtained from the regressions between water parameters and species abundance of eleotrid fishes sampled in Lake Nokoué (South - Benin) from April 2017 to September 2018.

Water parameters	*D. lebretonis*	*E. vittata*	*E. daganensis*	*E. senegalensis*	*B. africanus*
Depth (cm)	0.41	0.01	0.10	-0.03	-0.20
Transparency (cm)	0.76**	0.24	0.40	0.23	0.10
Water temperature (°C)	-0.39	0.08	-0.25	0.28	-0.26
Dissolved oxygen (mg/l)	0.15	0.25	0.19	0.29	0.27
% O_2	0.25	0.11	0.17	0.04	-0.14
Salinity (‰)	-0.45	-0.36	-0.46	-0.31	-0.26
pH	0.12	0.19	0.09	0.02	0.11
Water velocity (m/s)	0.49*	0.34	0.40	0.36	0.16

** Correlation is significant at the 0.01 level.

* Correlation is significant at the 0.05 level.

Table 9. Matrix of correlation coefficients (r) obtained from the regressions between water parameters and species abundance of eleotrid fishes sampled in Porto-Novo Lagoon (South-Benin) from April 2017 to September 2018.

Water parameters	*D. lebretonis*	*E. vittata*	*E. daganensis*	*E. senegalensis*	*B. africanus*
Depth (cm)	0.548*	-0.185	-0.027	0.067	-0.191
Transparency (cm)	0.362	-0.190	-0.083	0.015	0.132
Water temperature (°C)	0.225	0.325	-0.077	-0.128	-0.386
Dissolved oxygen (mg/l)	0.276	0.193	-0.012	-0.064	-0.505*
% O_2	0.227	0.219	0.240	-0.081	-0.465
Salinity (‰)	-0.215	0.137	-0.189	-0.146	0.060
pH	0.137	0.016	-0.376	0.525*	0.324
Water velocity (m/s)	0.624**	-0.131	-0.393	0.038	0.002

** Correlation is significant at the 0.01 level.

* Correlation is significant at the 0.05 level.

Table 10. Matrix of correlation coefficients (r) obtained from the regressions between water parameters and species abundance of eleotrid fishes sampled in the Coastal Lagoon (South-Benin) from April 2017 to September 2018.

Water parameters	*D. lebretonis*	*E. vittata*	*E. daganensis*	*E. senegalensis*	*B. africanus*
Depth (cm)	-0.11	0.18	-0.168	-0.057	-0.070
Transparency (cm)	-0.40	-0.054	-0.119	-0.372	-0.088
Water temperature (°C)	0.02	0.164	-0.073	0.165	-0.003
Dissolved oxygen (mg/l)	0.14	-0.114	0.318	0.203	-0.015
% O_2	-0.01	-0.183	0.397	0.162	-0.029
Salinity (‰)	-0.23	0.109	-0.206	0.002	-0.046
pH	-0.04	-0.158	0.207	0.317	0.267
Water velocity (m/s)	0.58*	0.114	-0.052	0.040	0.197

* Correlation is significant at the 0.05 level.

Table 11. Matrix of correlation coefficients (r) obtained from the regressions between water parameters and species abundance of Eleotrid fishes sampled in Lake Ahémé (South-Benin) from April 2017 to September 2018.

Water parameters	*D. lebretonis*	*E. vittata*	*E. daganensis*	*E. senegalensis*
Depth (cm)	0.328	-0.210	0.068	-0.006
Transparency (cm)	0.160	-0.477*	0.530*	-0.171
Water temperature (°C)	-0.054	0.305	-0.305	-0.255
Dissolved oxygen (mg/l)	-0.468*	-0.198	0.098	-0.287
% O_2	-0.364	-0.019	0.185	-0.094
Salinity (‰)	-0.356	-0.183	0.785**	-0.054
pH	0.145	-0.201	-0.192	-0.303
Water velocity (m/s)	0.180	0.215	-0.330	0.169

** Correlation is significant at the 0.01 level.

* Correlation is significant at the 0.05 level.

In Lake Nokoué, the increase in the abundances of *E. vittata*, *E. senegalensis*, *E. daganensis* and *B. africanus* was associated with the increase in dissolved oxygen, pH, water temperature, and the decrease of salinity, velocity, transparency and depth. *Dormitator lebretonis*, alone, displayed the opposite trends (Fig. 8A). In Porto-Novo Lagoon, the increase in the abundances of *E. vittata*, *E. senegalensis*, *E. daganensis* and *B. africanus* was associated with the increase of salinity only, and the decrease of the other physicochemical parameters (DO, pH, T°, water velocity, transparency, depth).

Inversely, the increase in the abundance of *D. lebretonis* was associated with the increase in depth, transparency, water temperature, water velocity, dissolved oxygen, pH, and the decrease of salinity (Fig. 8B). In the Coastal Lagoon, in contrast with *E. vittata*, the abundance of *D. lebretonis, E. daganensis, E. senegalensis*, and *B. africanus* increased with dissolved oxygen and pH, but decreased with salinity, water temperature, depth and transparency (Fig. 8C). In Lake Ahémé, the increase in the abundance of *D. lebretonis* was associated with the increase in depth, temperature, water velocity, and pH (Fig. 8D).

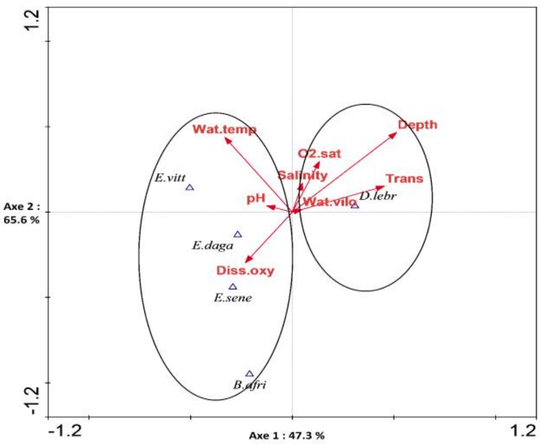

Fig. 8A. Canonical Correspondence Analysis (CCA) of water features and the abundance of the 5 eleotrid species of Lake Nokoué (South-Benin).

D.lebr =Dormitator lebretonis, E.vitt=Eleotris vittata, E.daga=Eleotris daganensis, E.sen= Eleotris senegalensis, B.afri= Bostruchus africanus, Wat.Temp= Water temperature, O2.sat= percentage of oxygen saturation, Wat.vilo= Water velocity, Trans= Water transparency, Diss.oxy= Dissolved oxygen.

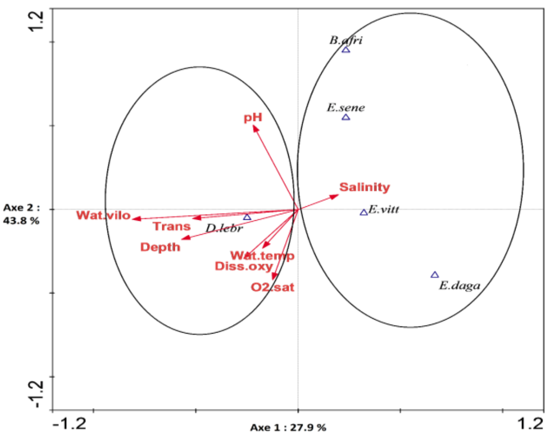

Fig. 8B. Canonical Correspondence Analysis (CCA) of water features and the abundance of the 5 eleotrid species of Porto-Novo Lagoon (South-Benin).

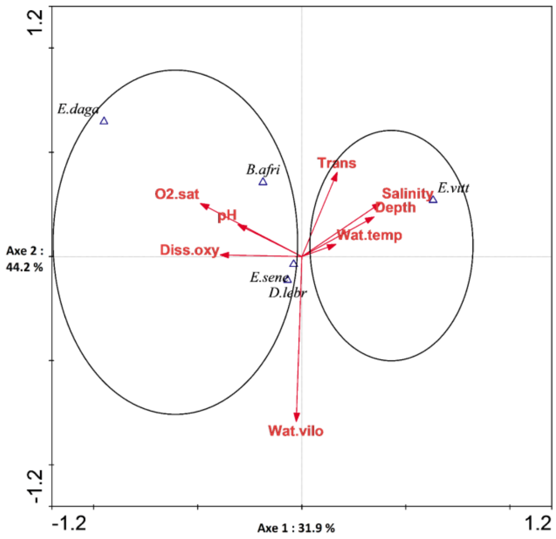

Fig. 8C. Canonical Correspondence Analysis (CCA) of water features and the abundance of the 5 eleotrid species of the Coastal lagoon (South-Benin).

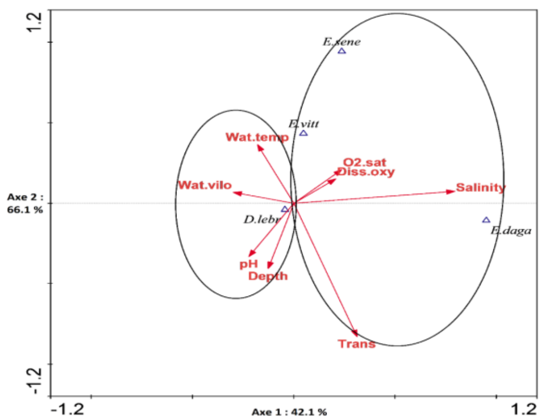

Fig. 8D. Canonical Correspondence Analysis (CCA) of water features and the abundance of the 4 eleotrid species of Lake Ahémé (South- Benin).

Discussion

Overall, the four (4) coastal waters examined exhibited relatively suitable water quality for the survival and growth of the eleotrid species inventoried. Indeed, average depth (225.3±29.56cm), temperature (30.2±0.23°C), transparency (68.5±17.8cm), dissolved oxygen (4.5±0.42mg/l), salinity (8.9±37.21‰) and pH (7.5±0.71) showed favourable ranges that agree with those reported by Laleye *et al.* (2004), Adite (2013) and Hamil *et al.* (2018). Nevertheless, the critical lower values of dissolved oxygen (0.55 – 0.85mg/l) recorded in all the coastal waters surveyed could be damageable to dwelling Eleotridae that rather utilize air breathing organs to cope with hypoxia and anoxia (Kramer *et al.*,1983). Also, significant (p<0.05) seasonal variations of physicochemical parameters were recorded mainly for depth, transparency, salinity and water velocity because of the periodic flooding from Sô River for Lake Nokoué, from Oueme River for Porto-Novo Lagoon, from Mono River for the Coastal Lagoon and from Couffo stream for Lake Ahémé. These seasonal floodings consistently affect the hydrological regime and the water quality (mainly salinity) of the coastal waters. Various anthropogenic disturbances such as the invasion of floating plants (water hyacinth), the presence of the hydro electrical dam constructed on the Mono River, the use of chemical fertilizers and pesticides for adjacent agriculture, the destruction of mangroves, the discharges of domestic wastes etc., constitute some major threats that could negatively affect the water quality and the integrity of these estuarine ecosystems (Adite, 2013; Agbohessi *et al.*, 2014).

Given the numerous samplings carried out during 18 consecutive months at different locations of the coastal waters and the use of various fishing gears, it is probable that all species of Eleotridae have been identified. Overall, a total of five (5) species, *Dormitator lebretonis, Eleotris vittata*, *Eleotris daganensis, Eleotris senegalensis* and *Bostrychus africanus* have been recorded. Though relatively less speciose in Benin, the sleeper gobies are common and well distributed in the coastal waters studied, Lake Nokoué (5 species), Porto-Novo Lagoon (5 species), Coastal Lagoon (5 species) and Lake Ahémé (4 species). The large distribution of eleotrid fishes in these four (4) coastal brackish waters of salinities ranging between 0 and 30‰ indicated that the sleeper gobies are euryhaline species and hence, are able to support a large variation of salinity (Nordlie, 1978).

In a salt-tolerance experiment, Sonon *et al.* (in press) reported a high survival (100%) of *Dormitator lebretonis* reared in a water of salinity ranging between 0 - 25‰. This euryhaline behaviour coupled with the adaptive air breathing strategy explains the wide distribution of squeaker in coastal brackish waters and in critical habitats such as swamps (Nordlie, 1981).

In the current study, the squeakers species recorded in the Coastal Lagoon are similar to those reported by Adite *et al.* (2013). However, the species *Bostrychus africanus* found in the current fish assemblages was absent in 2013 survey, and the freshwater eleotrid, *Kribia nana* reported in 2013 survey is absent in the current records. In Lake Nokoué, Laleye *et al.* (2004) and Hamil *et al.* (2018) reported the same species, *B. africanus, D. lebretonis, E. senegalensis* and *E. vittata*, except *Eleotris daganensis* recorded in the current finding.

Also, Laderoun *et al.* (2015) reported 5 eleotrids in the Mono river estuary while Hazoume *et al.* (2017) inventoried lower richness (2 species) in the Sô river. The relatively reduced eleotrid richness was also reported by Teugels *et al.* (1992) in Nigerian coastal waters where 4 species, *B. africanus*, *D. lebretonis*, *E. vittata* and *E. daganensis* were inventoried. In Western African freshwaters and brackish waters from Senegal to Angola, Harrison *et al.* (1992) reported five (5) genera with nine (9) species of Eleotridae indicating that, though of relatively reduced richness, eleotrid fishes are well distributed in West Africa. Differential fishing efforts exerted during ichtyological surveys, anthropogenic disturbances, species migration, environment stochasticity, seasons and evolutionary ecology process could have affected the eleotrid richness and diversity in the degrading tropical coastal waters.

Seasonally, the five (5) eleotrid species inventoried were recorded during all seasons (wet, flood, dry) regardless of coastal waters probably because the sleeper gobies possesses an accessory breathing organ that allows them to cope with hard environmental conditions especially during dry season where water volume is reduced leading to high temperature and low dissolved oxygen content (Kramer *et al.,* 1983). In addition, *D. lebretonis*, the most abundant eleotrid in the coastal waters of Benin probably support harsh condition because this species possesses a highly vascularised skin. Overall, eleotrids have evolved to develop various adaptive strategies for air breathing (Todd, 1973):

For example, the genus *Eleotris*, without water, opens their mouth to expose directly their gills to air contact (personal observation). Fenwick and Lam (1988) reported that the species *Oxyeleotris marmorata* (Eleotridae) uses aquatic surface respiration (ASR) in hypoxic water by holding air in its mouth. Likewise, *D. latifrons* uses the frontal head surface that serves as facultative air breathing organs (ABO) (John, 1986).

Among the five (5) eleotrid fishes inventoried in the coastal waters of Benin, *D. lebretonis* was the most abundant species in the four (4) ecosystems making 58.60% in Lake Nokoué, 57.91% in Porto-Novo Lagoon, 76.05% in Coastal Lagoon and 87.39% in Lake Ahémé, followed by *E. vittata* that made less than 35% of the squeaker assemblages of each lagoon. Because Porto-Novo Lagoon was relatively less degraded, this coastal water displayed the highest Shannon-Weaver index of species diversity (H'=3.82), whereas Lake Ahémé, a highly degraded coastal water, showed a lowest Shannon-Weaver index (H'=1.54). In contrast with the open water, the aquatic vegetation habitat showed the highest Shannon-Weaver diversity index in all four (4) lagoons, reaching H'=3.69 in Lake Nokoué, H'=3.98 in Porto-Novo Lagoon, H'=2.62 in Coastal Lagoon and H'=1.98 in Lake Ahémé with insignificant variation (p>0.05) of H'. Indeed, in aquatic vegetation, the high availability of food resources (insects, detritus etc.) led to the proliferation of eleotrid (Nordlie, 1978). As recorded for species richness, the dry season exhibited the highest H' (1.71 - 3.95) due to the concentration of eleotrids in vegetation and mangroves. The large distribution of the eleotrid in the Benin coastal waters is probably due to their high tolerance to water conditions because of the presence of accessory respiration organs (Todd, 1973). The absence of *Bostrychus africanus* in Lake Ahémé, a degraded habitat, is probably the results of its low tolerance to habitat variability and the low capacity of recolonization as for species displaying a k-selected demographic strategy (Pianka, 1994).

With regard to environmental correlates, regression between eleotrid abundances and physicochemical parameters combined with the results of Canonical Correspondence Analyses (CCA) indicated that the five (5) eleotrids inventoried showed high tolerance to water quality (Sidi Imorou *et al.,* 2019). Indeed, for each coastal water examined, most physicochemical parameters showed insignificant (p>0.05) correlations with eleotrid abundance. In particular, the insignificant (p>0.05) correlations between salinity and eleotrid abundance indicated that the species inventoried are euryhaline and consequently tolerate a wide range of salinity. Also, the insignificant (p>0.05) correlations recorded between dissolved and the abundance of most eleotrid examined indicated a high tolerance to hypoxia because of the numerous adaptive air breathing organs (Graham *et al.,* 2010). These facultative adaptive air breathing strategies may be a result of evolutionary process (Lefevre *et al.*, 2014). Nevertheless, some physicochemical features such as transparency in Lakes Nokoué and Ahémé, depth in Porto-Novo Lagoon, dissolved oxygen in Lake Ahémé and Porto-Novo Lagoon, pH and water velocity (Table 8-11) showed significant ($p \leq 0.05$) correlations with eleotrid abundances.

Conclusion

The current fish biodiversity survey indicated that the coastal waters of Benin comprised five (5) Eleotrids, *Dormitator lebretonis, Eleotris vittata, Eleotris daganensis, Eleotris senegalensis* and *Bostrychus africanus* that were well-distributed in Lake Nokoué, Porto-Novo Lagoon, Coastal Lagoon and Lake Ahémé. The euryhaline behaviour of these species and their adaptive air breathing strategy explain the wide distribution of squeaker in these degrading coastal brackish waters and in critical habitats such as swamps. *Dormitator lebretonis* was the most abundant eleotrid in all four (4) coastal waters examined and made 57.91–87.39% of the squeaker assemblages. A sustainable exploitation of these taxa requires a holistic approach of coastal waters management including species conservation and valorization, habitat restoration and protection and ecological follow-up.

References

Adite A, Winemiller KO. 1997. Trophic Ecology and Ecomorphology of Fish Assemblages in Coastal Lakes of Benin, West Africa. Ecoscience **4,** 6-23.

Adite A, Imorou Toko I, Gbankoto A. 2013. Fish Assemblages in the Degraded Mangrove Ecosystems of the Coastal Zone, Benin, West Africa: Implications for Ecosystem Restoration and Resources Conservation. Journal of Environmental Protection **4,** 1461-1475.

Adite A, Gbaguidi HMAG, Ibikounle M. 2017. Growth patterns and Fulton's condition factor of the silver catfish *Chrysichthys nigrodigitatus* (Actinopterygii: Siluriformes: Claroteidae) from a sand dragged man-made lake of Benin. African Journal of Agricultural Research **12(27),** 2283-2294.

Agbohessi TP, Toko II, N'tcha I, Geay Florian A, Mandiki SNM, Kestemont P. 2014. Exposure to agricultural pesticides impairs growth, feed utilization and energy budget in African Catfish *Clarias gariepinus* (Burchell, 1822) fingerlings. International Aquatic Research **6,** 229-243.

Babatounde A. 2015. Eléments d'écologie et de biologie de *Dormitator lebretonis* (Eleotridae) à la lagune côtière du Bénin. Master thesis, University of Abomey-Calavi, Benin, 7-49.

Berra T. 2001. Freshwater Fish distribution. Academic Press, San Diego, California, USA.

Berger WH, Parker FL. 1970. Diversity of planktonic foraminifera in deep-sea sediments. Science **168,** 1345-1347. https://doi.org/10.1126/ science. 168.3937. 1345.

Ekpo EI, Essien-Ibok MA, Effiong EE. 2015. Biology of bigmouth sleeper, *Eleotris vittata* (Dumaèril, 1861) (Pisces ; Eleotridae) in the lower Cross River, Nigeria. International Journal of Fisheries and Aquatic Studies **3(2),** 346-352.

Gnohossou PM. 2006. La faune benthique d'une lagune ouest africaine (le lac Nokoue au Benin), diversité, abondance, variations temporelles et spatiales, place dans la chaine trophique. PhD thesis, Institut National Polytechnique de Toulouse, France 17-153.

Graham JB, Wegner NC. 2010. Respiratory Physiology of Vertebrates: Life with and without oxygen. Cambridge University Press.

Hamil S, Arab S, Arab A. 2018. Assessment of surface water quality using multivariate statistical analysis techniques: a case study from Ghrib dam, Algeria. Arabian Journal of Geosciences **11,** 1-14.

Hazoume RUS. 2017. Diversité organisation trophique et exploitation des poissons de la rivière Sô au Benin (Afrique de l'Ouest). PhD thesis, University of Abomey-Calavi, Benin, 92-142.

Hazoume RUS, Chikou A, Koudenoukpo C, Houndonougbo P, Adite A, Bonou CA, Mensah GA. 2016. Length-weight relationships of 30 species of fish of the river Sô in Benin (West Africa). Journal of Agriculture and Environmental Sciences **5,** 78-83.

Hauber ME. 2011. Description and Improvement of the 'Whedo'- Aquaculture - System in Malanville (North of Benin). PhD thesis, University of Würzburg, Germany 78-108.

John HG. 1986. Buoyancy control of four species of eleotrid fishes during aquatic surface respiration Environmental Biology of Fishes **16,** 269-278.

Kakpo E. 2011. Biodiversité et exploitation des poissons du Bas-Mono: Implications pour la conservation et la gestion durable des ressources halieutiques. Master thesis, University of Abomey-Calavi, Benin 9-51.

Keith P, Lord C, Vigneux E. 2006. In vivo observation on post larval development of fresh water gobies and eleotrids from French Polynesia and New Caledonia. Ichthyological Exploration of Freshwater **17,** 187-191.

Kramer DL, Manley D, Bourgeois R. 1983. The effect of respiratory mode and oxygen concentration on the risk of aerial predation in fishes. Canadian Journal of Zoology **61,** 653-665.

Laleye PA, Chikou A, Philippart JC, Teugels G, Vandewalles P. 2004. Etude de la diversité ichtyologique du bassin du fleuve Ouémé au Bénin (Afrique de l'Ouest) Cybium **28(4),** 329-339.

Lalèyè PA, Niyonkuru C, Moreau J, Teugels GG. 2003. Spatial and seasonal distribution of the ichthyofauna of Lake Nokoué, Benin, west Africa. African Journal of Aquatic Sciences **28,** 151-161.

Lévêque C, Paugy D, Teugels GG. 1992. Faune des poissons d'eaux douces et saumâtres de l'Afrique de l'Ouest. Paris, ORSTOM press.

Lederoun D. 2015. Ichtyofaune du bassin du fleuve Mono (Benin et Togo) : diversité, écologie et impacts anthropiques. PhD thesis, University of Liège, Belgium, 78-285.

Margalef R. 1968. Perspective in Ecological Theory, University of Chicago Press. Chicago.

Morgan GA, Grieggo OV, Gloeckner GW. 2001. SPSS for Windows: An introduction to use and interpretation in research. Lawrence Erlbaum Associates. Mahwah, New Jersey.

Nelson JS. 1994. Fishes of world. Third Edition. John Wiley & Sons. Inc. New York.

Nordlie FG. 1981. Feeding and reproductive biology of Eleotrid fishes in a tropical estuary. Journal of Fish Biology **18,** 97-110.

Nordlie FG. 1978. Niche specificities of Eleotrid fishes in a tropical estuary. Revista de Biologia Tropical **27,** 35-50.

Odountan OH, Bisthoven LJ, Koudenoukpo CZ, Abou Y. 2019. Spatio-temporal variation of environmental variables and aquatic macroinvertebrate assemblages in Lake Nokoué, a RAMSAR site of Benin. African Journal of Aquatic Sciences **44(5),** 219-231.

Pezold F, Cage B. 2001. A review of the spinycheek sleepers, genus *Eleotris* (Teleostei; Eleotridae) of the Western hemisphere with comparison to the West African species. Tulane Studies in Zoology and Botany **32,** 1-12.

Pianka ER. 1994. Evolutionary ecology. 5th Edition. Harper Collins College Publishers. New York.

Rodriguez GA, Medina-Hernández EA, Velázquez-Sandoval JVL, Dabrowski K Gaxiola-Camacho E, Haws MC. 2012. Production of Chame (*Dormitator Latifrons*, Pisces: Eleotridae) larvae using GnRHa and LHRHa. Revista Colombiana de Ciencias Pecuarias **25,** 422-429.

Shannon C, Weaver E. 1963. The Mathematical Theory of Communication; University of Illinois Press, Urbana.

Sidi Imorou R, Adite A, Adjibade NK, Sonon SP, Arame H, Abou Y. 2019. Fish biodiversity and community structure of Okpara stream, Oueme River, Benin, West Africa: Risk of high predation and food-web alteration**.** Journal of Biodiversity and Environmental Sciences **14(6),** 272-289

Sonon PS, Adite A. 2021. Exposure to salinity of *Dormitator lebretonis* reared in tapolen tanks (summited to Aquatic Research).

Teugels GG, Reid GMG, King RF. 1992. Fishes of the Cross River Basin (Cameroon-Nigeria): Taxonomy, Zoogeography, Ecology and Conservation. Koninklijk Museum voor Midden-Afrika Tervuren, Belgium **260,** 112-132.

Todd ES. 1973. Positive buoyancy and air-breathing: A new piscine gas bladder function. Copeia **3,** 461-464.

Texier H, Dossou C, Colleuil B, Profizi JP. 1980. Le lac Nokoué, environnement du domaine margino-littoral Sud-Béninois : Bathymétrie-lithofaciès, salinités, mollusques et peuplements végétaux. Bulletin de l'Institut Géolologique du Bassin d'Aquitaine **28,** 115-142.

Welcomme RL. 1972. An evaluation of Acadja method of fishing as practiced in the coastal lagoons of Dahomey (West Africa). Journal of Fish Biology **4,** 39-55.