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Diversity and structure of Ardeidae population in the international wetland of South-East Benin (Ramsar site 1018)

Donald S Sossou and Jacques B Adjakpa

Abstract
Ardeidae constitute one of most encountered bird groups in wetlands. But there are few data on the diversity and structure of their population in the South-East of Benin. In order to characterize their population, a monthly counting has been carried out between January 2015 and December 2016 on LN, SR, PL, OR and OL. Direct counting and fix station technics were applied. A total of 12 Ardeidae species distributed into 7 genuses were inventoried. The total bird number varied from 23026 to 40600 individuals between 2015 and 2016. The abundance of OR population was significantly (P<0.05) upper than those in OL, PL, SR and lower than that of NL. The monthly specific richness varied between 10 and 12 over the two years. From 2015 to 2016, it varied between 12 and 11 species (NL), 11 and 12 species (PL and SR) and 8 and 7 species (OL). The Shannon-Weaver index and its equitability were 2.31 bits and 0.64 (2015) and 2.10 bits and 0.59 (2016). The highest in 2015 and 2016 were reached respectively in July (2.81 bits and 0.79) and August (2.68 bits and 0.75) with respective minima in November (1.52 bit and 0.42) and June (0.82 bit and 0.23). The diversity of OR is too low and lowly equal-distributed. On the contrary, it was low and meanly equal-distributed in LN, OL, SR and OL.

Keywords: Ardeidae, diversity, wetland, South-East, Benin

1. Introduction
Ardeidae are species belonging to wet ecosystems and considered as bio-indicator of environmental evaluation (Yiqun *et al.,* 2011) [1]. They occupy the LC status, minor preoccupation (IUCN, 2018). It's one of the most remarkable families due to its abundance in the wetland of South-East Benin (Adjakpa *et al.,* 2017) [2]. Most of them are considered as game birds and are hunted by people till certain are considered vulnerable or quasi-threatened in Benin (Neuenschwander *et al.,* 2011) [3]. Threats influencing bird species are tied to wetlands degradation in Benin due to the use of prohibited fishing technics, increasing urbanization, deforestation, the use of fire wood, capture of game birds and the use of pesticides (Neuenschwander *et al.,* 2011) [3]. Several ornithological studies were carried out in the South-East wetland of Benin. Existing studies on wetland are those of Jacques B. Adjakpa *et al.,* (1996) [4]; Schockert (1998) [5]; Nago (2003) [6]; Laudelout and Libois (2003) [7]; Libois and Laudelout (2004) [8] ; Dowsett-Lemaire and Dowsett (2009) [9] ; Adjakpa *et al.,* (2016) [10]; Adjakpa *et al.,* (2017) [2] and Chaffra *et al.,* (2020) [11]. But these studies were consecrated to nest building, diversity and distribution of birds. It's in this context that the current study aims to characterize the population of Ardeidae in the South-East wetland of Benin.

2. Material and Methods
2.1 Study area
The study area is located between 6°21' and 6°47' North latitude; 2°20' and 2°47 East longitude (Fig. 1). Soils are hydromorphic and halomorphic and based on clay land of continental terminal (Volkoff, 1976; Volkoff and Willaime, 1976) [12, 13]. The water system is mainly made of Nokoué Lake, Porto-Novo lagoon, old lagoons, Ouémé River and Sô River. The wetland includes vast flooded plains and swamps. The climate is sub-equatorial with two rainy seasons from March to July and from September to October and two dry seasons from November to February and in August. The mean annual pluviometry reached 1187 mm at Cotonou. Minimal and maximal temperatures are respectively 24.4°C and 30.2°C. Vegetation is made of swamp mosaic and mangroves (Adjakpa *et al.,* 2016 and Adjakpa *et al.,* 2017) [10, 2].

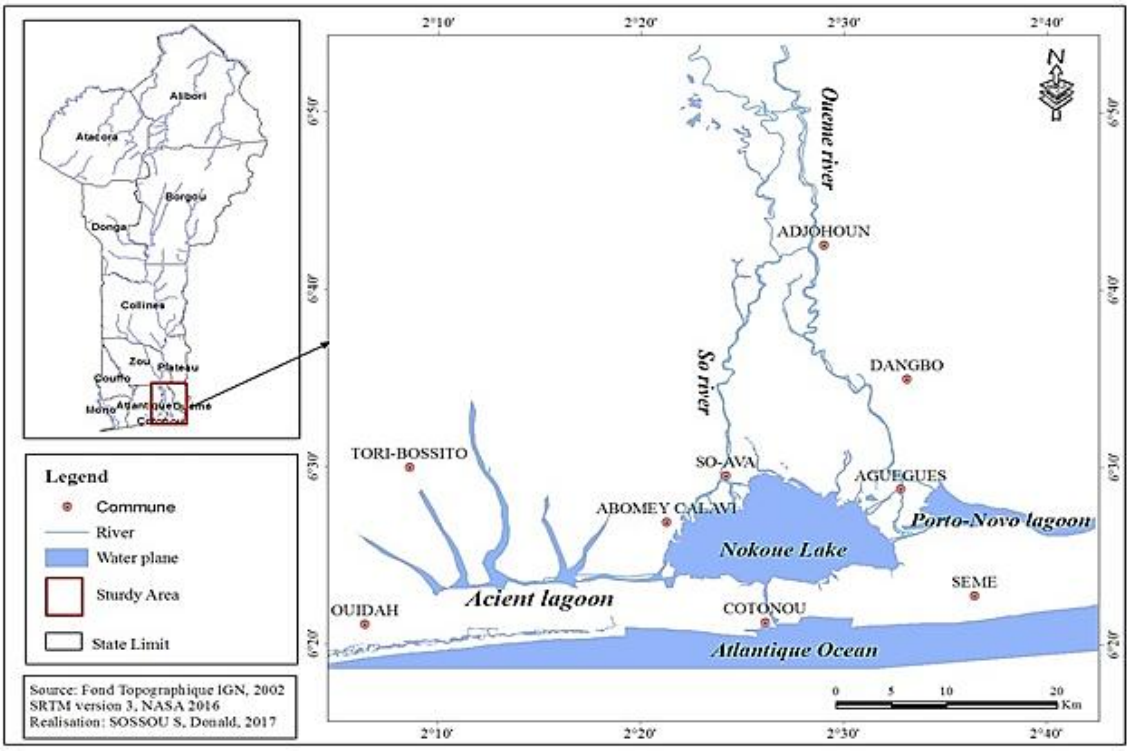


Fig 1: geographical location of the study area.

2.2 Material

The biological material is made of Ardeidae population. The technical material constitutes mainly pairs of binoculars (Zeiss 10 x 40, Minolta 7 x 50), telescope (Opthoyth 30-60) for birds observation, GPS (Garmin Drive 51 SE LMT-S), motorized and non-motorized pirogues for transport on the water. Nomenclature, phylogenic order, bio-geographical status and preferred habitat of each species were adopted and used from (Borrow and Demey, 2015) [14]. The statute of conservation used is that of the IUCN (2018) [15].

2.3 Methods

Monthly birds counting were carried out in stations [Nokoué Lake (NL), Porto-Novo Lagoon (PL), Sô River (SR), Ouémé River (OR) and Old Lagoons (OL)] between January 2015 and December 2016. Stations were chosen based on their accessibility and their abundance and richness in term of birds (Adjakpa *et al.*, 2016 and Adjakpa *et al.*, 2017) [10, 2]. Direct counting technics on transect and by fix station were used. A total of 102 observation points were chosen. Observations were performed in open time especially from 7 am to 6 pm corresponding to the highly active birds period (Bibby *et al.*, 1992; Gibbons and Gregory, 2006]; Yaokokoré-Béibro, 2010) [16, 17, 18]. Counting of observed bird species by station was systematic, exhaustive and carried out by pirogue or by foot. If bird group contains a least 200 individuals and near the observation point, they were counted individually. On the contrary, if bird group or population is far and numerous, counting was carried out by visual estimation (Blondel, 1975; Girard *et al.*, 1998; Seddik *et al.*, 2010; Yaokokoré-Béibro, 2010) [19, 20, 21, 18].

To appreciate more the diversity and structure of Ardeidae population, the abundance (Ab), specific richness (S) corresponding to the total number of species in the whole wetland and per station, the Shannon-Weaver diversity index (H') and Piélou equitability (J) were determined:

- $Ab = ni$ (Equation 1)

Where ni (abundance) is the number of individuals of the species i in a given habitat.

- $H' - \sum \left(\frac{ni}{N}\right) log_2(\frac{ni}{N})$ (Equation 2)

Where H' (in bits) equals 0 if there is only one species and maximal if all species are present in the same proportion. N (total abundance) is the number of individuals of the whole species observed in the same habitat. It enables to express the diversity considering species number and the abundance of individuals in each of these species. Thus, a community dominated by only one species will have a coefficient lower than a community though all species are co-dominant (Khodja, 2016) [22]. The diversity is: low when H' < 3 bits, mean for 3 bits ≤ H < 4 bits and high when H ≥ 4 bits (Legendre et Legendre, 1984) [23]. Extreme values are comprised between 0.5 bits (very low diversity) and average 4.5 bits (Guimbo *et al.*, 2010) [24].

- $J = H'/Hmax$ (Equation 3)

With $H' max = log_2(S)$,, where H'max is the maximal value of H' and S the specific richness.

J tends to 0 when the quasi totality of numbers represents only one species of the population (with dominance); tends to 1 when each species is represented by similar number of individuals (without dominance) (Hill, 1973) [25]. It considers the distribution of individuals among species of the population.

The variation of these diversity indexes according to stations (fix factor) and months (random factor) of each year, was

studied thanks to a general linear model or generalized with mixed effect by using the package *nlme* (Pinheiro *et al.*, 2017) [26] and the package lmerTest in the R 3.4.0 software (Team, 2017) [27].

3. Results

3.1 Diversity

A total of 12 bird species distributed into 7 genuses were inventoried (Table 1). The most represented genus in term of species were *Egretta* (5 species) and *Ardea* (2 species). Genuses *Ixobrychus*, *Nycticorax*, *Ardeola*, *Bubulcus* and *Butorides* were mono-specific.

These birds were distributed according to their bio-geographical status (Table 1): an exclusive sedentary species (*Butorides striata*), sedentary species and Palearctic migratory (*Ixobrychus minutus*, *Nycticorax nycticorax*, *Ardeola ralloides*, *Ardea purpurea* and *Ardea cinerea*), sedentary species and intra-African migratory (*Bubulcus ibis*, *Egretta ardesiaca*, *Egretta gularis* and *Egretta intermedia*) and sedentary species, intra-African and Palearctic migratory (*Egretta garzetta* and *Egretta alba*). According to frequented habitats, the quasi-totality of species are from aquatic media (E) though *Bubulcus ibis* were observed in open media (O). All Ardeidae species inventoried are less concerned (LC).

Table 1: List of inventoried bird species in the wetland of South-East Benin. S: sedentary; P: Palearctic migratory; M: intra-African migratory; LC: less concern species; E: aquatic medium; O: open medium.

Species	English Names	Bio-geographical status	Preferred Habitat	UICN status
Ixobrychus minutus	Little Bittern	S/P	E	LC
Nycticorax nycticorax	BLack-crowned Night Heron	S/P	E	LC
Ardeola ralloides	Squacco Heron	S/P	E	LC
Bubulcus ibis	Cattle Egret	S/M	O	LC
Butorides striata	Green Heron	S	E	LC
Egretta ardesiaca	BLack Heron	S/M	E	LC
Egretta gularis	Western Reef Heron	S/M	E	LC
Egretta garzetta	Little Egret	S/M/P	E	LC
Egretta intermedia	Yellow-billed Egret	S/M	E	LC
Egretta alba	Great Egret	S/M/P	E	LC
Ardea purpurea	Purple Heron	S/P	E	LC
Ardea cinerea	Grey Heron	S/P	E	LC

3.2 Population structure

3.2.1 Variability of diversity among stations, years and months.

3.2.2 Abundance

Birds number fluctuated from 23026 individuals in 2015 to 40600 individuals in 2016. This increase is tied to the number of *Nycticorax nycticorax*, *Ardeola ralloides*, *Bubulcus ibis*, *Butorides striatus*, *Egretta ardesiaca*, *Egretta gularis*, *Egretta garzetta*, *Egretta intermedia* and *Egretta alba* in 2016. Maxima recorded in 2015 and 2016 were respectively 3289 individuals (February 2015) and 8485 individuals (January 2016) and respective minimum de 473 individuals (September 2015) and 453 individuals (August 2016). In relation to years, the total birds number varied from 9588 individuals to 14974 individuals in Nokoué Lake, 3548 individuals to 8307 individuals in Porto-Novo lagoon, 2808 individuals to 3177 individuals in River Sô, 6780 individuals to 13896 individuals in Ouémé River and 302 individuals to 246 individuals in old lagoons. Based on the total number obtained per site over the two years, Nokoué Lake sheltered more Ardeidae individuals. It's followed by Ouémé River, Porto-Novo lagoon, River Sô and old lagoons.

In 2015, birds number in Ouémé River (565 ± 547 individuals) was significantly higher ($P < 0.05$) than that of old lagoons (25 ± 17 individuals), Porto-Novo lagoon (296 ± 248 individuals) and River Sô (234 ± 207 individuals) (Table 2). On the contrary, it was lower ($P < 0.001$) than that of Nokoué Lake (799 ± 395 individuals). This significant variation of birds abundance in stations is not tied to the random effect of month (marginal R^2 is lower than conditional R^2).

Considering the abundance of each species in 2015 (Fig. 2), in Nokoué Lake, *Bubulcus ibis* is the most abundant species (3274 individuals), followed by *Egretta garzetta* (1995 individuals) and *Ardeola ralloides* (1132 individuals). Porto-Novo lagoon is characterized by the abundance of *Egretta garzetta* (1102 individuals), followed by *Bubulcus ibis* (972 individuals) and *Egretta alba* (538 individuals). *Bubulcus ibis* also showed the highest abundance in River Sô (2054 individuals), Ouémé River (6021 individuals) and old lagoons (202 individuals).

Figures (3a) show monthly variation of the abundance among stations in 2015. Two high abundance periods were generally observed. The first spreads from January to May for Nokoué Lake and Porto-Novo lagoon, from February to May for old lagoons, from January to April for River Sô and Ouémé River. The second period spreads from November to December for all stations except old lagoons who sheltered high number in November. During these two periods, birds number fluctuated between 249 and 1559 individuals (Nokoué Lake), 154 and 738 individuals (Porto-Novo lagoon), 45 and 57 individuals (old lagoons), 290 and 1635 individuals (Ouémé River) and 96 and 634 individuals (River Sô).

Lowest numbers were recorded in September and October in Nokoué Lake (293 and 240 individuals), between August and September in Porto-Novo lagoon (43 and 69 individuals), May and October in Ouémé River (129 and 167 individuals), January and June in old lagoons (8 and 13 individuals).

In 2016, the same significant variations ($P < 0.05$) were also obtained in 2015. Abundances recorded were 1158 ± 1434 individuals (Ouémé River), 20 ± 12 individuals (old lagoons), 692 ± 738 individuals (Porto-Novo lagoon), 265 ± 311 individuals (River Sô) and 1248 ± 1295 individuals (Nokoué Lake) (Table 2).

In 2016, *Bubulcus ibis* (7983 individuals) was the most abundant species in Nokoué Lake. It was followed by *Egretta garzetta* (3112 individuals), *Egretta alba* (1331 individuals) and *Ardeola ralloides* (531 individuals). In Porto-Novo lagoon, *Nycticorax nycticorax* (4206 individuals), *Bubulcus*

ibis (1389 individuals), *Egretta garzetta* (1134 individuals) and *Egretta alba* (502 individuals) were the most abundant. In River Sô, *Bubulcus ibis* was the most abundant species (1764 individuals). It was followed by *Egretta gularis* (563 individuals), *Egretta garzetta* (547 individuals) and *Ardeola ralloides* (274 individuals). In Ouémé River, *Bubulcus ibis* (12661 individuals) and *Nycticorax nycticorax* (746 individuals) were the most abundant. Old lagoons were characterized by high number of *Bubulcus ibis* (168 individuals).

Figures (3b) show monthly variation of abundance among stations in 2015. The same periods like 2016 were identic to those of 2015 with number varying between 681 and 3798 individuals (Nokoué Lake), 252 and 2930 individuals (Porto-Novo lagoon), 8 and 52 individuals (old lagoons), 408 and 2763 individuals (Ouémé River) and 159 and 863 individuals (River Sô).

Periods of low numbers in 2016 were also identic to those of 2015 but made of some picks of 3798 individuals in May in Nokoué Lake, 950 individuals in Porto-Novo lagoon, 4111 individuals in Ouémé River in June, 797 individuals in River Sô in May and 10 individuals in old lagoons respectively in April and May. These picks are in accordance with the increase of *Bubulcus ibis* numbers among stations.

3.2.3 Specific richness

The global specific richness was 12 species for the two years in the whole wetland. It varied between 12 species (2015) and 11 species (2016) in Nokoué Lake, 11 species (2015) and 12 species (2016) in Porto-Novo lagoon and Sô River, 8 species (2015) and 7 species (2016) in old lagoons. That of Ouémé River was 12 species over the two years. This variation of the specific richness in relation to years is tied to the absence of *Egretta ardesiaca* (Nokoué Lake), *Egretta gularis* (Porto-Novo lagoon), *Ardea cinerea* (Sô River). In the old lagoons, we noticed the absence of *Nycticorax nycticorax*, *Egretta gularis*, *Egretta garzetta*, *Egretta intermedia* in 2015 and 2016. *Egretta ardesiaca* was more absent in 2016.

In 2015, the specific richness of Ouémé River (7.5 ± 1.73) was significantly lower ($P < 0.05$) than that of Nokoué Lake (10.42 ± 0.67), non-significantly lower ($P > 0.05$) than that of Porto-Novo lagoon (7.83 ± 1.40), significantly higher than that of old lagoons (3.5 ± 1.09) and non-significantly higher ($P > 0.05$) than that of Sô River (6.42 ± 2.11) (Table 2). The monthly specific richness varied from one station to another (Fig. 3c). The specific richness of Nokoué Lake, Porto-Novo lagoon, Sô River, Ouémé River and old lagoons varied respectively between 9 and 11 species (minimum in September and maximum in June, October, November and December), 6 and 10 species (minimum in January and September and maximum in November and December), 5 and 10 species (minimum in march, June, august and September and maximum in November and December), 5 and 11 species (minimum in September and maximum in February) and 2 and 5 (minimum in January, august, November and maximum in march, July).

In 2016, the specific richness of Ouémé River (7.83 ± 1.64) was non-significantly lower ($P > 0.05$) than that of Nokoué Lake (9.91 ± 1), that of Porto-Novo lagoon (9.33 ± 1.15) and significantly higher than that of old lagoons (3 ± 1.28) and non-significantly than that of Sô River (6.25 ± 2.17) (Table 2). The monthly variation of specific richness also varied from one station to another (Fig 3d). It varied in Nokoué Lake, Porto-Novo lagoon, Sô River, Ouémé River and old lagoons respectively with species number comprises between 9 and 11 (minimum in October and maximum in September, January, February and August), 6 and 10 (minimum in March and maximum in January, February, April, May, July, September and December), 4 and 10 (minimum in June, July, September and October and maximum in January); 6 and 10 (minimum in March, May, July, September and maximum in January) and 1 and 5 species (minimum February, March, and maximum in August).

3.2.4 Shannon-Weaver diversity index and Piélou equitability

The Shannon-Weaver index (H') and Piélou equitability (J) fluctuated respectively between (2.31 bits; 0.64) in 2015 and (2.10 bits; 0.59) in 2016. These values demonstrate generally that Ardeidae population was lowly diversified with individuals meanly equal-distributed in the population over the two years. The highest Shannon-Weaver index in 2015 and 2016 were respectively reached in July (2.81 bits) and August (2.68 bits) with respective minimum in November (1.52 bit) and June (0.82 bit). Its highest Piélou equitability in 2015 and 2016 was respectively 0.79 (July) and 0.75 (August) with respective minimum 0.42 (November) and 0.23 (June).

Regarding stations, from 2015 to 2016, the Shannon-Weaver diversity index and Piélou equitability fluctuated between (2.77 bits; 0.78) and (2.11 bits; 0.61) in Nokoué Lake, (2.63 bits; 0.76) and (2.27 bits; 0.63) in Porto-Novo lagoon, (1.57 bits; 0.45) and (2.07 bits; 0.58) in Sô River, (0.83 bits; 0.23) and (0.61 bits; 0.17) in Ouémé River and (1.67 bits; 0.50) and (1.43 bits; 0.51) in old lagoons. It results that diversity is low and meanly equal-distributed ($H' < 3$, $J \cong 0$) in Nokoué Lake, Porto-Novo lagoon, Sô River and old lagoons. On the contrary, in Ouémé River, diversity was very low and lowly equal-distributed ($H' < 1$, $J \cong 0$).

The Shannon-Weaver diversity index and Piélou equitability determined from their monthly values in 2015 in old lagoons (1.33 ± 0.62 bits; 0.71 ± 0.25), Nokoué Lake (2.35 ± 0.45 bits; 0.70 ± 0.13), Porto-Novo lagoon (2.09 ± 0.36 bits; 0.72 ± 0.12) and Sô River (1.44 ± 0.52 bits; 0.56 ± 0.22) were higher than that of Ouémé River (1.10 ± 0.70 bits; 0.40 ± 0.24) (Table 2). These ecological indexes in 2015 didn't show the same monthly trend in the different stations (Fig. 3e). The Shannon-Weaver diversity index varied respectively in Nokoué Lake, Porto-Novo lagoon, Sô River, Ouémé River, old lagoons between 1.52 bits (October) and 2.95 bits (June), 1.32 bits (October) and 2.52 bits (August), 0.55 bits (August) and 2.1 bits (September), 0.29 bits (April) and 2.66 bits (August) and 0.31 bits (May) and 2.10 bits (July). The equitability fluctuated between 0.45 (October) and 0.85 (June) in Nokoué Lake, 0.47 (October) and 0.89 (August) in Porto-Novo lagoon, 0.23 (August) and 0.91 (May) in Sô River, 0.12 (December) and 0.92 (April) in Ouémé River and 0.19 (May) and 0.97 (April) in old lagoons.

Variations of Shannon-Weaver index among stations in 2016 were similar to those in 2015. The Shannon-Weaver index and its equitability (2016) in Nokoué Lake (1.98 ± 0.57 bits; 0.58 ± 0.20), Porto-Novo lagoon (1.88 ± 0.43 bits; 0.58 ± 0.13) and Sô River (1.55 ± 0.59 bits; 0.59 ± 0.21) were higher than that of Ouémé River (1.07 ± 0.76 bits; 0.37 ± 0.25). It was similar for old lagoons (1 ± 0.64 bits; 0.58 ± 0.35) though values were almost higher than that of Ouémé River (1.07 ±

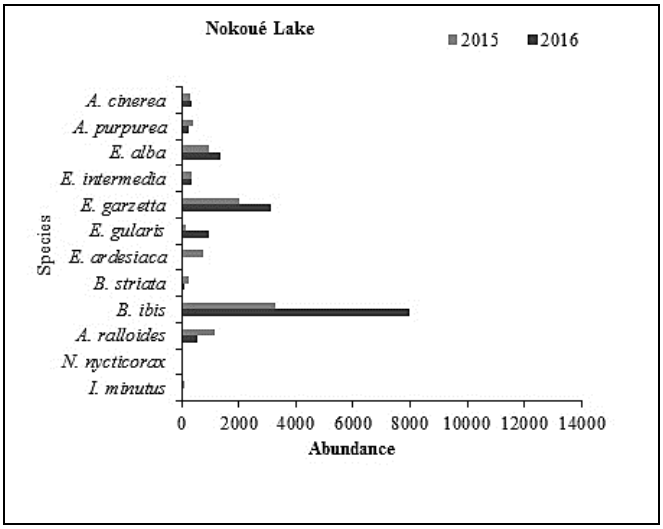
0.76 bits; 0.37 ± 0.25) (Fig 3f).

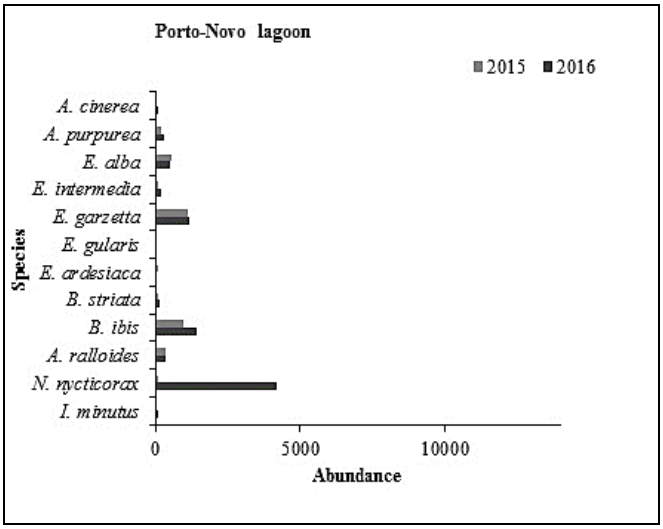
The monthly Shannon-Weaver index fluctuated respectively in Nokoué Lake, Porto-Novo lagoon, Sô River, Ouémé River and old lagoons between 0.52 bits (May) and 2.87 bits (August), 0.97 bits (December) and 2.33 bits (September), 0.68 bits (March) and 2.69 bits (November), 0.17 (June) and 2.86 bits (August) and 0 (February and March) and 1.80 bits (May). Though the Piélou equitability varied between 0.15 (May) and 0.83 (August) in Nokoué Lake, 0.30 (December), and 0.70 (September) in Porto-Novo lagoon, 0.26 (March), 0.89 (September) in Sô River, 0.15 (April) and 0.90 (August) in Ouémé River and 0 (February) and 0.97 (April) in old lagoons.

Table 2 shows results of linear model with mixed effect on the abundance of species per station, their specific richness, Shannon-Weaver index and their Piélou equitability index.

Table 2: Synthesis of generalized linear model with mixed. Richness: specific richness, H': Shannon-Weaver index, J: Pielou equitability index, Coef: Coefficient, SE: Standard error, Prob: probability, Z: Statistical quantity and t: student t distribution.

				Year 2015								
	Abundance			**Richness**			**H'**			**J**		
	Coef (se)	Z	Prob	Coef (se)	z	Prob	Coef (se)	t	Prob	Coef (se)	t	Prob
Intercept (Ouémé River)	6.14 (0.19)	31.69	<0.001	2.01 (0.11)	19.12	<0.001	1.10 (0.16)	7.03	<0.001	0.39 (0.06)	6.77	<0.001
Site : Old lagoons	-3.11 (0.06)	-52.91	<0.001	-0.76 (0.19)	-4.08	<0.001	0.22 (0.22)	0.99	>0.05	0.31 (0.08)	3.87	<0.001
Site : Nokoué Lake	0.35 (0.02)	21.84	<0.001	0.33 (0.14)	2.38	<0.05	1.25 (0.22)	5.63	<0.001	0.30 (0.08)	3.76	<0.001
Site : Porto-Novo lagoon	-0.65 (0.02)	-31.26	<0.001	0.04 (0.15)	0.30	>0.05	0.99 (0.22)	4.45	<0.001	0.32 (0.08)	4.01	<0.001
Site : Sô River	-0.88 (0.02)	-39.29	<0.001	-0.16 (0.15)	-1.01	>0.05	0.33 (0.22)	1.50	>0.05	0.17 (0.08)	2.05	<0.05
Variance of random effect of months	0.45			0			0.00			0.00		
Variance of residual	-			-			0.30			0.04		
R² marginal (%)	0.67			0.49			0.44			0.28		
R² conditional (%)	0.83			0.49			0.44			0.31		
	Year 2016											
	Coef (se)	Z	Prob	Coef (se)	z	Prob	Coef (se)	t	Prob	Coef (se)	t	Prob
Intercept (Ouémé River)	6.67 (0.27)	24.77	<0.001	2.06 (0.10)	19.95	<0.001	1.07 (0.18)	6.05	<0.001	0.37 (0.07)	5.33	<0.001
Site : Old lagoons	-4.03 (0.06)	-62.72	<0.001	-0.96 (0.19)	-4.89	<0.001	-0.07 (0.24)	-0.28	>0.05	0.22 (0.09)	2.32	<0.05
Site : Nokoué Lake	0.07 (0.01)	6.34	<0.001	0.24 (0.14)	1.70	>0.05	0.91 (0.24)	3.82	<0.001	0.21 (0.09)	2.27	<0.05
Site : Porto-Novo lagoon	-0.51 (0.01)	-37.10	<0.001	0.18 (0.14)	1.25	>0.05	0.81 (0.24)	3.40	<0.01	0.22 (0.09)	2.30	<0.05
Site : Sô River	-1.47 (0.02)	-75.04	<0.001	-0.23 (0.15)	-1.45	>0.05	0.48 (0.24)	2.03	<0.05	0.23 (0.09)	2.41	<0.05
Variance of random effect of months	0.87			0;00			0.03			0.00		
Variance of residual	-			-			0.34			0.05		
R² marginal (%)	0.60			0.58			0.31			0.12		
R² conditional (%)	0.75			0.58			0.36			0.17		





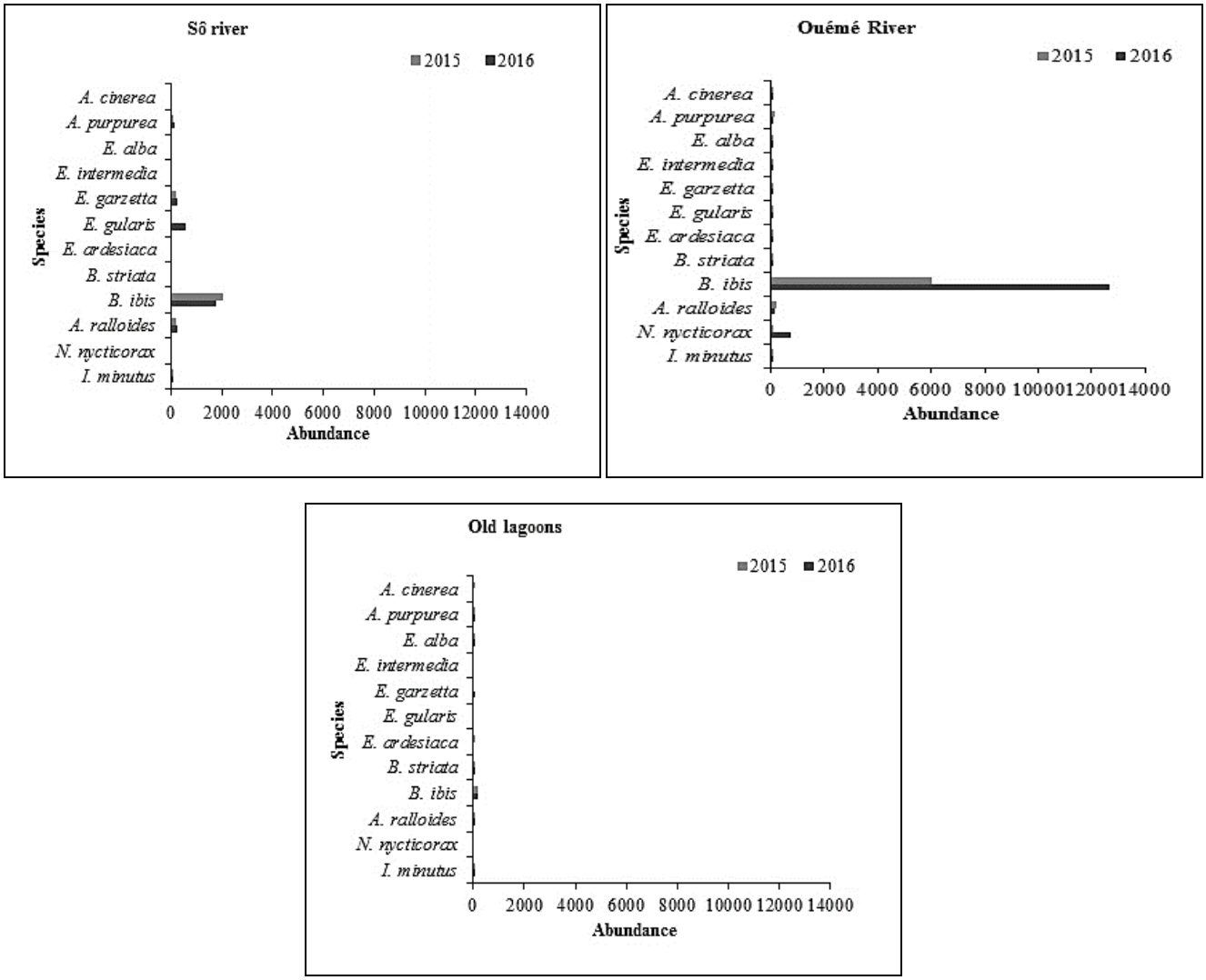
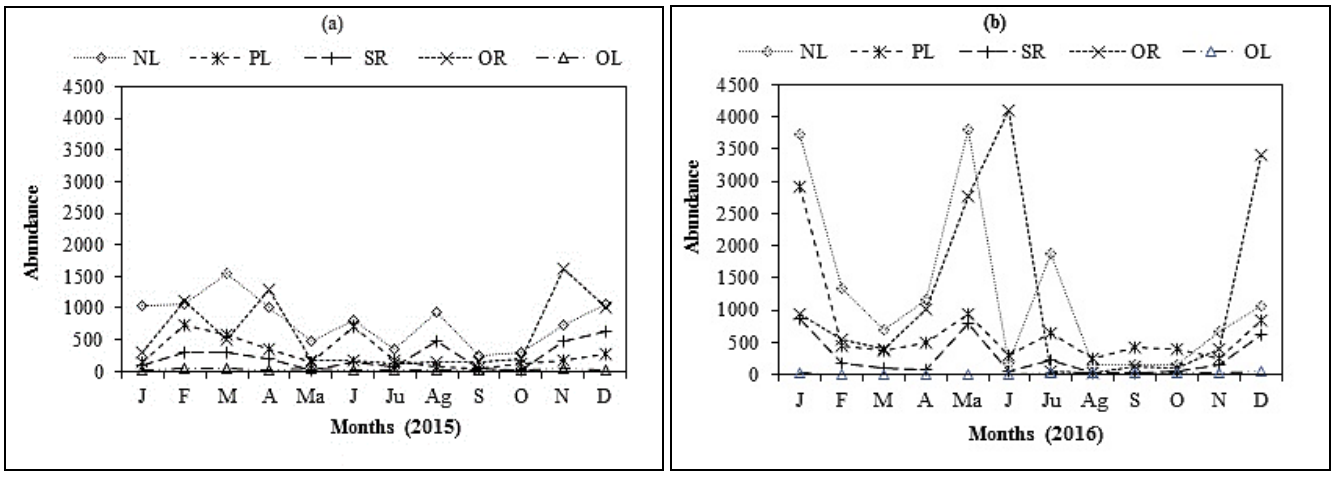


Fig 2: Abundance of Ardeidae species per station and per year.

Figure 3 shows temporal variation per year and per station of abundance (a, b), specific richness (c, d), Shannon diversity index (e, f) and Pielou equitability index (g, h).



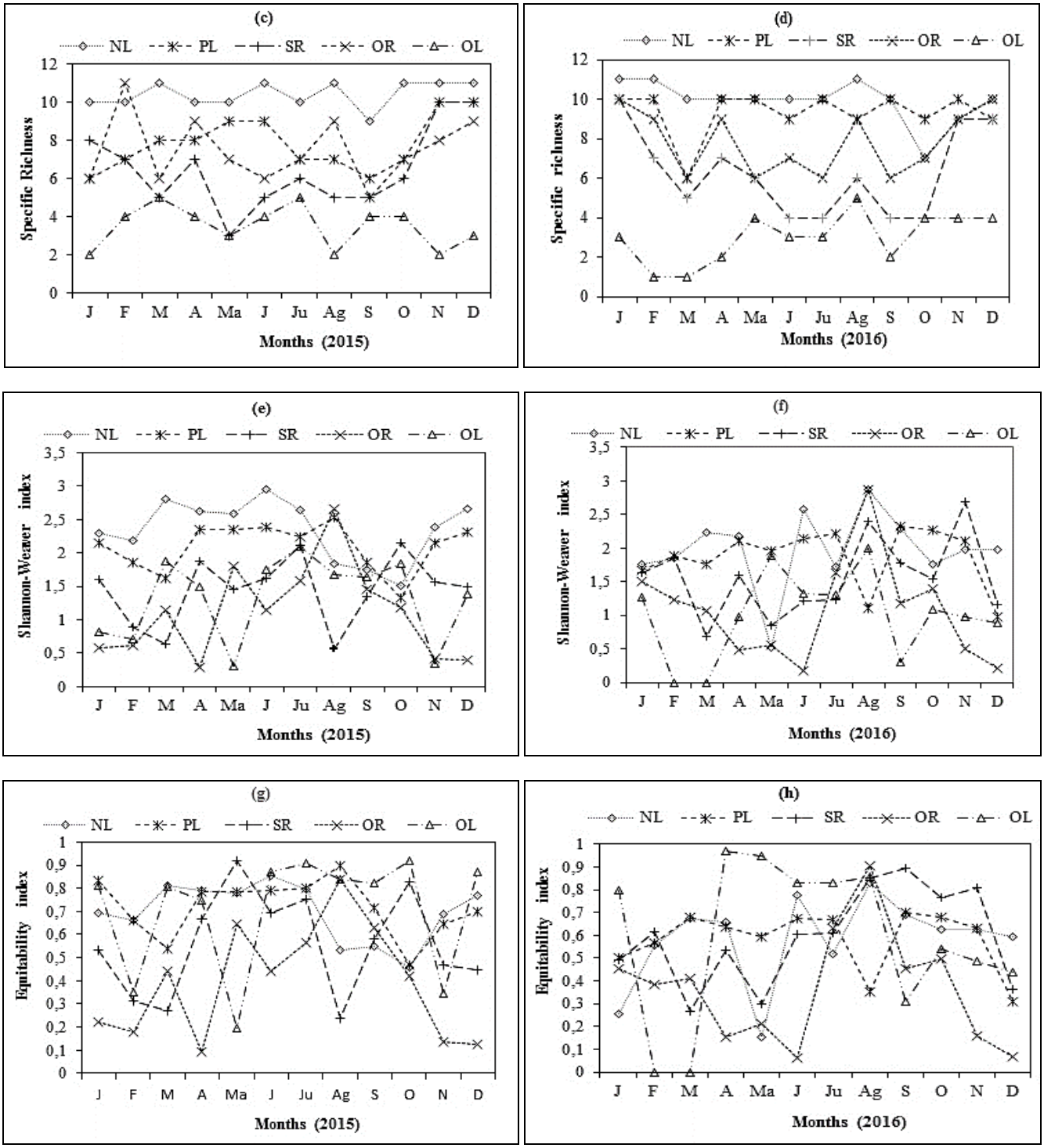


Fig 3: Temporal variation of diversity index per station and per year. NL : Nokoué Lake, PL : Porto-Novo lagoon, SR : Sô River, OR : Ouémé River, OL : Old lagoons, J : January, F : February, M : March, A : April, Ma : May, J : June, Ju : July, Ag : August, S : September, O : October, N : November and D : December. J : January, F : February, M : March, A : April, Ma : May, J : June, Ju : July, Ag : August, S : September, O : October, N : November and D : December.

4. Discussion

A total of 12 species of Ardeidae were inventoried. This specific richness equals to that obtained by (Dodman and Diagana, 2003, Diagana and Dodman, 2006) [27, 28] in Benin wetlands. On the contrary, it was lower than that of Jacques B. Adjakpa *et al.*, (2016) [10] and Adjakpa *et al.*, (2017) [2] who identified 15 species. This difference is due to the fact counting were carried out during 1998 to 2004 and 2008 to 2010. *Trigriornis leucolophus*, *Ardea malanocephala* and *Ardea goliath* were absent.

Bubulcus ibis, a species of open media (Borrow and Demey, 2015) [14], has higher number in the different stations and in the whole wetland of South-East Benin. This result confirms that of Diagana and Dodman (2006) [29] who also classified B*ubulcus ibis* among the most abundant species in Benin wetlands. Indeed, vast flooded plains characterizing the East complex of Southern Benin offers best conditions for species development. Concerning food resources availability favoring the expansion of *Bubulcus ibis* (Setbel, 2008; Lahrouz *et al.*, 2013) [30, 31].

Nokoué Lake sheltered more Ardeidae species than the other stations over the two years. This high number of Ardeidae species in Nokoué Lake is in accordance with its ichthyofauna potential (Lalèyè *et al.*, 2003) [32]. These Ardeidae species have rich food diet in fish and shrimps (Gwiazda and Amirowicz, 2006; Beltzer, 2007; Nedjah *et al.*, 2010; Gianuca *et al.*, 2012) [33, 34, 35, 36]. This result corroborates with that of (Diagana and Dodman, 2006) [29] who concluded that Nokoué Lake is the best site for resident and migratory birds fauna of the coastal zone of Benin.

The Shannon-Weaver diversity index and Pielou equitability are low and meanly equal-distributed in the Nokoué Lake, Porto-Novo lagoon, Sô River and old lagoons. On the contrary, in Ouémé River, diversity was very low and lowly equal-distributed. These results can be justified by the fact wetlands of Southern Benin are subject to high anthropic pressures because they shelter 60% of majorly poor population surviving from natural resources (Neuenschwander *et al.*, 2011; Ago *et al.*, 2005) [3, 37]. Diversity is lower in population where the environment is most subject to ecological constraints (Ramade, 2003) [38].

The monthly variation of ecological indexes varies from one station to another and a year to another. (Zhu, 2004) [39] Explains it by the fact that the structure of Ardeidae is influenced by the complexity of habitat structure. The different stations sampled didn't provide same trophic conditions in relation to time.

Picks obtained in 2016 in low number periods in 2015 (March to June) a part from those of water birds wintering, are tied to the increase of *Bubulcus ibis* number that is an intra-African migratory (Borrow and Demey, 2015) [14]. So, the species migrated from an area of the sub-region to the wetland of South-East Benin in 2016. That was not the same in 2015.

5. Conclusion

The best site for Ardeidae species are Nokoué Lake, Ouémé River and Porto-Novo lagoon. The Sô River and old lagoons sheltered fewer birds. However, the diversity of all sites is low with low equal-distribution of individuals among species. For that purpose, stations studied especially Sô River and old lagoons worth actions for species preservation due to their low abundance in Ardeidae species. It's similar for Ouémé River with its low Shannon-Weaver diversity index and Pielou equitability among stations.

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