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# Ardeidae of the South-East Benin wetland (Ramsar site 1018): Phenology and indicator species of seasons and stations

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**Abstract**
The wetland of South-East Benin is a potential site for migratory water birds. In order to study the phenology of bird species belonging to Ardeidae family, a monthly monitoring has been carried out between January 2015 and December 2016 in Nokoué Lake, Sô River, Porto-Novo lagoon, Ouémé River and old Lagoons. For birds observation and counting, technics based on transect and fix station were used. A total of 12 species were inventoried. Among them, *Ixobrychus minutus*, *Ardeola ralloides*, *Ardea cinerea* are sedentary and palearctic migratory, *Nycticorax nycticorax* is a palearctic migratory, *Bubulcus ibis*, *Butorides striatus*, *Egretta intermedia* are sedentary and intra-African migratory though *Egretta garzetta*, *Ardea purpurea* et *Egretta alba* are sedentary, intra-African migratory and palearctic migratory and *Egretta ardesiaca*, *Egretta gularis* are intra-African migratory. The specific richness varied significantly neither as a function of years nor in relation to months contrary to the abundance of the population.
Specifically, the time of arrival and departure differs from species to others. A positive and significant biserial correlation and indicator value were noticed among *Ardea cinerea*, *Egretta intermedia*, *E. alba*, *Ardeola ralloides*, *E. garzetta*, *E. ardesiaca*, *A. purpurea*, *Butorides striatus* are tied to Lake Nokoué station (NL) and are its indicator species. Thus, *Nycticorax nycticorax* is an indicator of Porto-Novo Lagoon (PL) and *Bubulcus ibis* that of the Ouémé River (OR). Indeed, *E. alba*, *A. cinerea*, *A. purpurea*, *E. intermedia*, *B. ibis* are indicators of the short dry season (SDS) while, *Nycticorax nycticorax* and *Ardeola ralloides* are indicators of the long dry season (LDS). No species correlate with the Sô River (SR) and the old lagoons (OL) and neither with the long rainy season (LRS) and the short rainy season (SRS). These last stations and seasons have no indicator species.

**Keywords:** Ardeidae, phenology, wetland, South-East, Benin

## 1. Introduction
The wetland of South-East Benin is ecologically important with preservation status since January 24th 2000 (Ramsar, 2019) [1]. Through its ecological qualities and the diversity of its habitats (forests, flooded savanna, prairies, mangroves, plantations, swamps, farm and fallows), it constitutes an ideal medium for sedentary, wintering, native, migratory, occasional and accidental bird species (Adjakpa *et al*., 2017) [2].
The ornithological studies carried out in this zone were focused on food diet of *Alcedo cristata* and *Ceryle rudis* (Libois and Laudelout, 2004) [3], ecology of *Francolinus bicalcaratus* (Codjia et *al.,* 2003) [4] , diversity and spacio-temporal distribution of water birds (Adjakpa et *al.,* 1996 [5]; Adjakpa in Dodman and Diagana, 2003 [6]; Diagana and Dodman, 2006 [7]; Adjakpa et *al.,* 2016, 2017 [8][2]; Azonningbo *et al.,* 2019, 2020 [9][10]. It results that Ardeidae is one of the most abundant water birds families in this wetland. But few studies were carried out on this family. The only existing studies are those of Chaffra (2020) [11] who studied nidification of resident Ardeidae in some swamps and mangroves of Southern Benin and Sossou and Adjakpa (2020) [12] who characterized the Ardeidae population in the wetland of South-East Benin. Thus, the phenology of Ardeidae species is still to be clarified. It will enable to know the arrival and departure of migratory Ardeidae species.
The current study aims at describing the phenology of Ardeidae population in the wetland of South-East Benin and indicator species for preservation of the site.

## 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 longitudes (Fig.1). Soils are hydromorphic and halomorphic based on clay land, alluvial of the continental terminal (Volkoff, 1976 [13]; Volkoff and Willaine, 1976 [14]). The hydrographic network is mainly made of the 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 September to October and two dry seasons from November to February and August. The average yearly pluviometry reached 1187 mm at Cotonou. Minimal and maximal temperatures are respectively 24.4°C and 30.2°C. The vegetation is made of swamp mosaic and mangroves (Adjakpa *et al.,* 2016 [8] and Adjakpa *et al.,* 2017) [2].

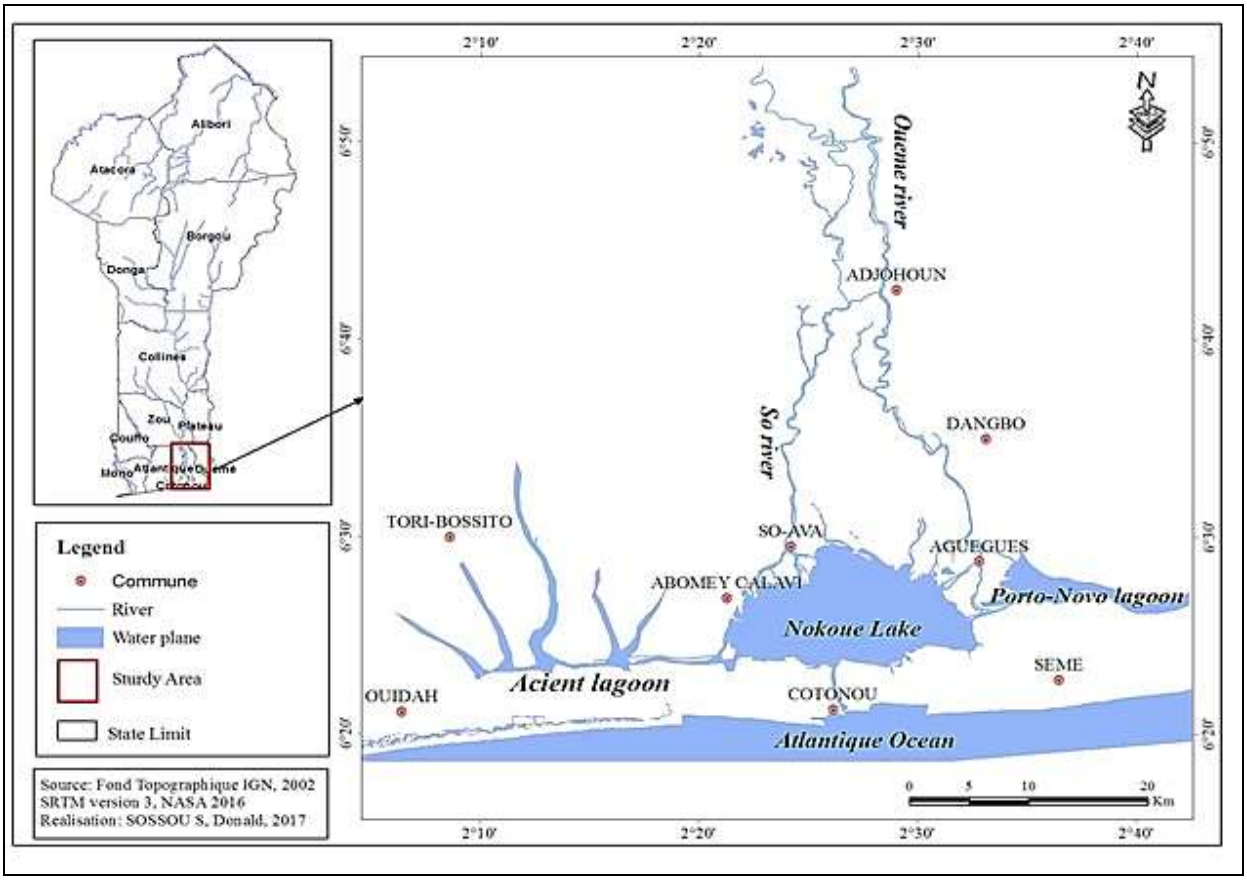


**Fig 1:** Geographical location of the study area.

### 2.2 Material

The biological material is made of Ardeidae population. The technical material includes mainly pairs of binoculars (Zeiss 10 x 40, Minolta 7 x 50), a telescope (Opthoyth 30-60) for observation, a GPS (Garmin Drive 51 SE LMT-S) and pirogues (motorized and with oar) for transport through water. The used nomenclature, phylogenetic order, bio-geographical status and preferred habitat are those of Borrow and Demey (2015) [15].

### 2.3 Methods

#### 2.3.1 Bird species counting

Bird counting has been carried out between January 2015 and December 2016. They were carried out twice a month in the stations. These different stations were pre-defined based on their accessibility and bird species abundance (Adjakpa *et al.*, 2016 [8] and Adjakpa *et al.*, 2017) [2]. Transect counting was done on water bodies with a slow and steady progression. Fixed post counting for 15 to 30 minutes was done in associated habitats. A total of 102 observation points were chosen. Observations were carried out in the day time especially from 7 am to 6 pm corresponding to the period of high birds activity (Bibby *et al*., 1992 [16]; Gibbons et Gregory, 2006 [17]; Yaokokoré-Béibro, 2010 [18]). Counting of individuals per species and per station was systematical, exhaustive and carried out by pirogue or by foot. If bird group contains less than 200 individuals and is nearby the observation point, they are counted individually. On the contrary, if bird population is far and contains an important number, counting is carried out by visual estimation (Blondel, 1975 [19]; Girard, 1998 [20]; Seddik *et al.*, 2010 [21]; Yakokoré-Beibro *et al.*, 2010 [18]).

#### 2.3.1. Data treatment and analysis

In order to validate the fluctuation of the monthly abundance of each species and to know their departure and arrival period in the wetland, some statistical analyses were carried out. So, the R software version R 3.4.0 (Team, 2017) [22] was used to test the significance ($p < 0.05$) of monthly fluctuations of population abundance and its specific richness on the one hand and the abundance of each species on the other hand by a generalized linear model (GLM) of fish family. The preference and avoidance degree of a species (bi-serial correlation coefficient) vis-à-vis a station or season has been determined by calculating the bi-serial correlation coefficient using the multipatt package and the r.g function. This coefficient varies between -1 (avoidance) and +1 (preference) (De Caceres *et al.*, 2008 [23]; De Caceres and Legendre, 2009 [24]).

Bird species indicators of seasons or stations were also identified. That was based on the calculation of the indicative value of species (Eq.1) which significance has been analyzed by permutation tests (Dufrêne and Legendre, 1997) [25].

IndVal = A * B (Eq. 1)

(where A: specificity of the species to a station or season and B: faithfulness of the species).

This value measures the probability level for a species as an indicator of ecological conditions in a given station or characteristics of a season (De Caceres and Legendre, 2009) [24]. The identification of single species was carried out using the indicspecies package (De Caceres and Legendre,

2009) [24] of the R software (R Core Team 2017) [22].

## 3. Results

### 3.1. Phenology of Ardeidae species

Figure 2 (A, B, C, D, E, F, G, H, I, J, K and L) shows the monthly variation of abundance of each Ardeidae species. This variation shows the arrival and departure period of different species in the South-East wetland of Benin.

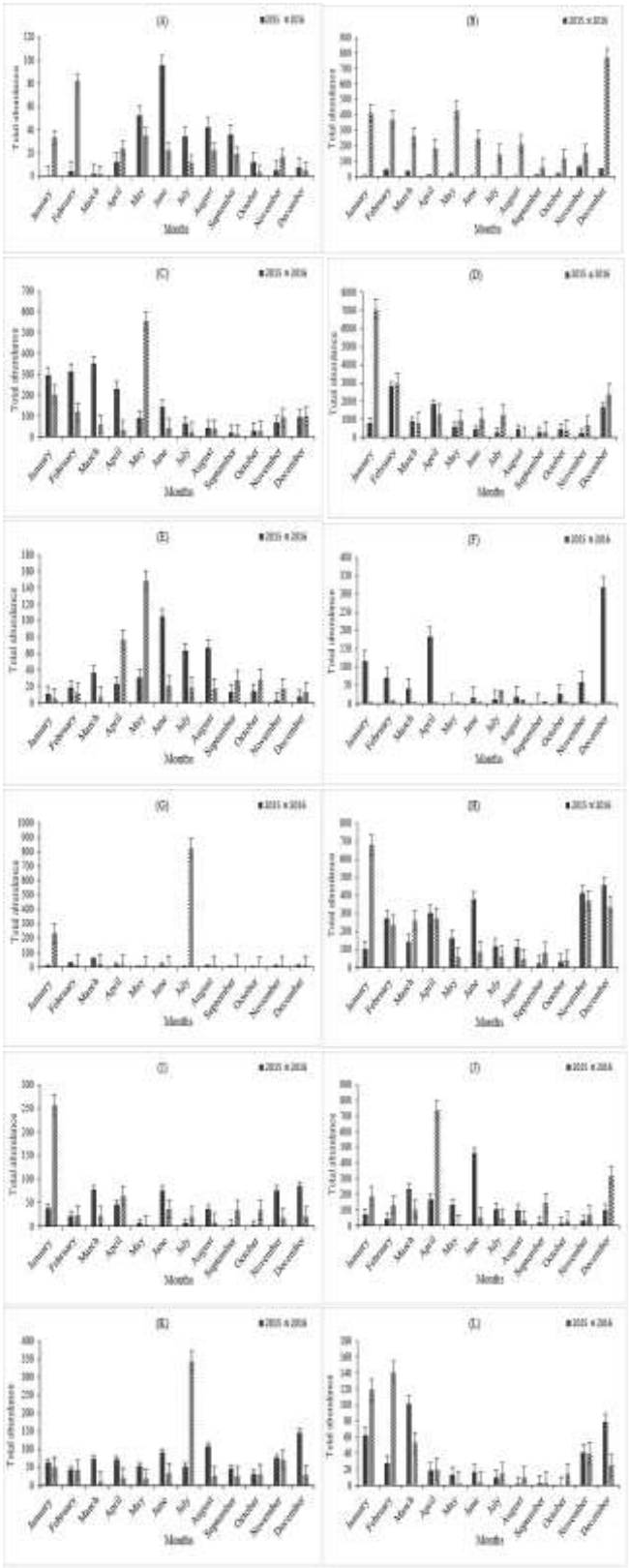

**Fig 2:** (A, B, C, D, E, F, G, H, I, J, K, L): Progression of the abundance of each Ardeidae species in the South-East wetland of Benin from January 2015 to December 2016.

***Ixobrychus minutus* (Linnaeus, 1766) (A)**

*Ixobrychus minutus* is observed almost along the year. In 2015, it appears from February with progressive increase of number of individuals that reached a maximum of 96 individuals in June 2015. A progressive decrease of the number was then observed till November (5 individuals). From December 2015, the abundance of the species increased progressively and reached a pick of 82 individuals in February 2016. With the same trend in 2015, this abundance decreased gradually till December 2016. These observed variations are highly significant according to months (GLM: Pr (>Chi) = 0.00054) but non-significant in relation to years (GLM: Pr (> Chi) = 0.74422). We can conclude that the arrival periods of the species in 2015 and 2016 were respectively between February and June 2015 and between December 2015 and February 2016. The departure periods in 2015 and 2016 were respectively between July and November and between March and December (Fig. 2A).

***Nycticorax nycticorax* (Linnaeus, 1758) (B)**

From January to February 2015, we recorded an increase of its number from 2 to 40 individuals marked by the arrival of new individuals followed by a progressive decrease reaching 2 individuals. It was absent from July to August in the same year and reappeared in September (6 individuals) with another pick in December (61 individuals).

It was fully present in 2016 with monthly numbers fluctuating between 60 individuals (September) and 771 individuals (December). Lowest numbers varying between 154 and 243 individuals were recorded between June and November though highest were obtained among January, May and December with values fluctuating between 260 and 771 individuals. Monthly numbers varied significantly during both years (GLM: Pr (>Chi) = 2.2e-16) and according to months (GLM: Pr (>Chi) = 0.00058).

According monthly variations of abundance through the two years, the species is sedentary and migratory (Fig. 2B).

***Ardeola ralloides* (Scopoli, 1769) (C)**

*Ardeola ralloides* was fully present in the wetland. Its lowest numbers were obtained during September with 19 individuals in 2015 and 11 individuals in 2016. From January to March 2015, the species number passed from 295 to 351 individuals. From March to September 2015, the population abundance decreased progressively and reached the lowest value of 19 individuals. From November 2015, the population increased gradually and reached a small pick of 205 individuals in January 2016. The highest pick was reached in May 2016 and decreased suddenly till September 2016 (as it was observed during the previous year) and slightly increased till December. The arrival periods of the species in 2015 and 2016 were respectively situated between January and March and between October 2015 and May 2016. Besides, there is another arrival period between November 2016 and December 2016. Departures in 2015 and 2016 happened respectively between April and September 2015 and between June and September 2016. Its abundance varied significantly in relation to months (GLM: Pr (>Chi) = 1.471e-12) and not according to years (GLM: Pr (>Chi) = 0.1385). The appreciation of the abundance of *Ardeola ralloides* is same during both years (Fig. 2C).

***Bubulcus ibis* (Linnaeus, 1758) (D)**
As Indo-African origin, it is permanently present in the wetland with low abundance of 25 individuals in August 2016. Generally, its abundance increased from October and reached a pick of 2805 individuals in February 2015 and then decreased suddenly to reach a low value maintained constant from June to November 2015. Some individuals arrived in the wetland in December 2015 and a high pick was obtained in January 2016 followed by a progressive decrease until September 2016. The arrival periods of the species in 2015 and 2016 in November. Departures in 2015 and 2016 happened respectively between June and September 2015 and between February and October 2016 (Fig. 2D). It's also noteworthy that the abundance of the species varied significantly in relation to months (GLM: Pr (>Chi) = 2.11e-11) and significantly according to both years (GLM: Pr (>Chi) = 0.0171).

***Butorides striatus* (Linnaeus, 1758) (E)**
Its abundance increased and reached a pick of 105 individuals in June 2015. It decreased progressively from June to reach a minimal value of 3 individuals in November 2015. From December 2015, we noticed a progressive increase and a pick in May 2016 (149 individuals). The number of individuals decreased progressively from June to December (13 individuals). So, the low abundance period of the species is from June to November. Besides, the abundance of the species varied significantly in relation to months (GLM: Pr (> Chi) = 3.396e-05) and not according to years (GLM: Pr (> Chi) = 0.9912). The arrival periods of the species in 2015 and 2016 were respectively situated between January and June 2015 and between February and May 2016. Departures in 2015 and 2016 happened respectively between June and November 2015 and between June and December 2016 (Fig. 2E).

***Egretta ardesiaca* (Wagler, 1827) (F)**
It was more present in 2015 than 2016. In 2015, it was absent during May and September. Though it was absent in January, from March to June 2016 and from September to December in the same year. A pick was observed in December 2015 (319 individuals) and another in July 2016 (83 individuals). Two arrival periods of the species in 2015 though one between January and April 2015 and the other between October and December 2015. In 2016, the species visited the wetland in July and was absent from August to December. Departures in 2015 and 2016 happened respectively between May and September 2015 and between January and July 2016 (Fig. 2F). The period of absence from September to December is also noteworthy. Monthly and annual variations of the abundance of *Egretta ardesiaca* were respectively highly significant (GLM: Pr (>Chi) = 0.00379) and (GLM: Pr (>Chi) = 2.019e-07).

***Egretta gularis* (Bosc, 1792) (G)**
Its presence is more remarkable in 2015 than 2016. Its abundance increased from January to March 2015 and reached a pick of 57 individuals. It was null in July and from September to October 2015. A similar progression was also observed from November to May 2016 with a mean pick in January (232 individuals). Especially in July 2016, 824 individuals were present in the wetland. The arrival periods of the species in 2015 and 2016 were respectively situated between January and March 2015 and between November 2015 and January 2016. Another arrival was noticed in July 2016. Departures in 2015 and 2016 happened respectively between April and October 2015 and between February and June 2016. Another departure from August to December was also noticed (Fig. 2G). The abundance varied significantly in relation to months (GLM: Pr (> Chi) = 4.567e-08) and years (GLM: Pr (> Chi) = 2.180e-06).

***Egretta garzetta* (Linnaeus, 1766) (H)**
The species stayed full time in the wetland. But we notice a progression by jerks and jumps of its abundance from January (103 individuals) June 2015 (374 individuals) and a decrease starting from July (116 individuals) and reached 20 and 31 individuals respectively in September and October 2015.The abundance increased from November 2015 (413 individuals) and reached a pick in January 2016 (679 individuals). Then, the population number decreased till 47 individuals in August 2016. The arrival periods of the species in 2015 and 2016 were respectively situated between January and June 2015 and between November 2015 and January 2016. Especially, we noticed another arrival period between November and December 2016. Departures in 2015 and 2016 happened respectively between July and October and between February and October (Fig. 2H). Its abundance varied significantly in relation to months (GLM: Pr (> Chi) = 3.766e-10) and non-significantly according to years (GLM: Pr (> Chi) = 0.34).

***Egretta intermedia* (Wagler, 1829) (I)**
The species is encountered at full time in the wetland. The lowest abundances were obtained in September (3 individuals) and October 2015 (2individuals). Its abundance pattern is too fluctuating. A pick was observed in March 2015 with 77 individuals, though in January 2016 (258 individuals). These different picks show that there are certain individuals that come periodically to the wetland. That is the reason of low abundances at given moments (I). The arrival periods of the species in 2015 and 2016 were respectively situated between January 2015 and June 2015 and between November 2015 and January 2016. Departures in 2015 and 2016 happened respectively between July and October and between February and December 2016 (Fig. 2I). Variations of abundance were highly significant in relation to months (GLM: Pr (>Chi) = 0.0002228), but not according to years (GLM: Pr (>Chi) = 0.59).

***Egretta alba* (Linnaeus, 1758) (J)**
The abundance picks obtained in June 2015 (460 individuals) and April 2016 (737 individuals) were reached during the heavy rainy season. That prove the species is migratory. Indeed, the arrival periods of the species in 2015 and 2016 were respectively situated between January and June 2015 and between December 2015 and April 2016. Especially, another arrival period was observed between September and December 2016. Departures in 2015 and 2016 happened respectively between July and November and between May and August (Fig. 2J). Monthly variations of abundance were significant according to months (GLM: Pr (>Chi) = 0.0003394) and not in relation to years (GLM: Pr (>Chi) = 0.3410232).

***Ardea purpurea* (Linnaeus, 1766) (K)**
It's fully present in the wetland. From January to December

2015, the population abundance fluctuated between 43 and 147 individuals with a pick in December 2015. On the contrary in 2016, it fluctuates between lower values (12 and 72 individuals) except in July that we remarked a sudden increase of its abundance till 344 individuals. The monthly fluctuation of the abundance didn't enable the definition of arrival and departure periods of the species (Fig. 2K). Its monthly abundance varied significantly in relation to months (GLM: Pr (>Chi) = 2.441e-05) and not according to years (GLM: Pr (>Chi) = 0.3204).

***Ardea cinerea* Linnaeus, 1758) (L)**

It's absent in October 2015. The global observation of the species abundance progression revealed that individuals arrive into the wetland from October or November of each year with a progressive abundance reaching a pick of 101 individuals in March 2015 and 141 individuals in February 2016. Then, the species abundance decreased suddenly and was null in October 2015 and reached a lower value in September 2016. The arrival periods of the species in 2015 and 2016 were respectively situated between January and March 2015 and between November 2015 and February 2016. Departures in 2015 and 2016 happened respectively between April and October and between March and December (Fig. 2L). The monthly fluctuation of the abundance was highly significant (GLM: Pr (>Chi) = 9.749e-16) though it was non-significant according to years (GLM: Pr (>Chi) = 0.3721).

### 3.2. Species dependence toward stations and seasons

Table 1 shows bi-serial correlation coefficients describing preference level of a species to a given station. At the alpha probability threshold (α = 5%), *Ardea cinerea, Egretta intermedia, Egretta alba, Ardeola ralloides, Egretta garzetta, Egretta ardesiaca, Ardea purpurea, Butorides striatus* are high tied to the Nokoué Lake (NL) though *Nycticorax nycticorax* has a high preference to Porto-Novo lagoon (PL) and *Bubulcus ibis* is tied to Ouémé River (OR). It's important to notice that *Ixobrychus minutus* and *Egretta gularis* haven't shown particular station preference.

**Table 1:** Bi-serial correlation coefficient between species and stations

| Stations | Species | Corr | P. value | Sig. |
|---|---|---|---|---|
| NL | *Ardea cinerea* | 0.629 | 0.001 | *** |
| | *Egretta intermedia* | 0.629 | 0.001 | *** |
| | *Egretta alba* | 0.568 | 0.001 | *** |
| | *Ardeola ralloides* | 0.567 | 0.001 | *** |
| | *Egretta garzetta* | 0.506 | 0.002 | ** |
| | *Egretta ardesiaca* | 0.488 | 0.001 | *** |
| | *Ardea purpurea* | 0.424 | 0.011 | * |
| | *Butorides striatus* | 0.402 | 0.016 | * |
| PL | *Nycticorax nycticorax* | 0.568 | 0.001 | *** |
| OR | *Bubulcus ibis* | 0.491 | 0.003 | ** |

Table 2 indicates bi-serial correlation coefficient between species and stations. *Egretta alba, Ardea purpurea, Egretta intermedia, Ardea cinerea* and *Bubulcus ibis* have significant correlation with the short dry season (SDS) though *Nycticorax nycticorax* and *Ardeola ralloides* have significant correlation with the long dry season (LDS). Compared to the short dry season, the long dry season presented less species having significant correlation. In addition, these correlations are lower than those of the short season.

**Table 2:** Bi-serial correlation coefficient between species and seasons

| Seasons | Species | Corr | P.value | Sig. |
|---|---|---|---|---|
| SDS | *Egretta alba* | 0.695 | 0.001 | *** |
| | *Ardea purpurea* | 0.651 | 0.001 | *** |
| | *Egretta intermedia* | 0.597 | 0.001 | *** |
| | *Ardea cinerea* | 0.512 | 0.006 | ** |
| | *Bubulcus ibis* | 0.393 | 0.039 | * |
| LDS | *Nycticorax nycticorax* | 0.383 | 0.038 | * |
| | *Ardeola ralloides* | 0.357 | 0.048 | * |

### 3.3 Species indicator of seasons and stations

Table 3 shows indicative values (IndVal) of species in relation to stations. No species have been found as station indicator of the Sô River (SR) and old Lagoons (OL) at 5% threshold. *Ardea cinerea, Egretta intermedia, Egretta ardesiaca, Egretta alba, Egretta garzetta, Egretta gularis, Ardeola ralloides, Butorides striatus* and *Ardea purpurea* were those characterizing Nokoué Lake (NL). Only *Butorides striatus* and *Ardea purpurea* have low indicative values (IndVal < 0.50). *Bubulcus ibis* and *Nycticorax nycticorax* characterized respectively Porto-Novo lagoon (PL) and Ouémé River (OR).

**Table 3:** Indicative value (IndVal) of species in relation to stations (A=Specificity, B= Faithfulness, Prob = Probability, Sig. Significance level).

| Stations | Species | A | B | IndVal | Prob. | Sig. |
|---|---|---|---|---|---|---|
| LN | *Ardea cinerea* | 0.8064 | 1 | 0.8064 | 0.001 | *** |
| | *Egretta intermedia* | 0.6938 | 1 | 0.6938 | 0.001 | *** |
| | *Egretta ardesiaca* | 0.815 | 0.8333 | 0.6791395 | 0.001 | *** |
| | *Egretta alba* | 0.6637 | 1 | 0.6637 | 0.001 | *** |
| | *Egretta garzetta* | 0.643 | 1 | 0.643 | 0.002 | ** |
| | *Egretta gularis* | 0.6311 | 0.9167 | 0.57852937 | 0.010 | ** |
| | *Ardeola ralloides* | 0.5177 | 1 | 0.5177 | 0.001 | *** |
| | *Butorides striatus* | 0.4125 | 1 | 0.4125 | 0.015 | * |
| | *Ardea purpurea* | 0.3976 | 1 | 0.3976 | 0.013 | * |
| PL | *Nycticorax nycticorax* | 0.8299 | 1 | 0.8299 | 0.001 | *** |
| OR | *Bubulcus ibis* | 0.512 | 1 | 0.512 | 0.003 | ** |

Table 4 shows indicative values of species for each season. Indeed, five (05) species were indicator of short dry season (SDS). It concerns *Egretta alba, Egretta intermedia, Ardea purpurea, Bubulcus ibis* and *Ardea cinerea*. Only the latter species has low indicative value (IndVal < 0.50). Besides, *Nycticorax nycticorax* and *Ardeola ralloides* are species indicator of long dry season (LDS). No season indicator species have been recorded in River Sô and old lagoons.

**Table 4:** indicative value of species in relation to stations (A=Specificity, B= Faithfulness, Prob = Probability, Sig. Significance level).

| Seasons | Species | A | B | IndVal | Prob. | Sig. |
|---|---|---|---|---|---|---|
| SDS | *Egretta alba* | 0.7791 | 1 | 0.7791 | 0.001 | *** |
| | *Egretta intermedia* | 0.7565 | 1 | 0.7565 | 0.001 | *** |
| | *Ardea purpurea* | 0.7071 | 1 | 0.7071 | 0.001 | *** |
| | *Bubulcus ibis* | 0.5694 | 1 | 0.5694 | 0.050 | * |
| | *Ardea cinerea* | 0.4771 | 1 | 0.4771 | 0.018 | * |
| LDS | *Nycticorax nycticorax* | 0.7818 | 0.96 | 0.750528 | 0.005 | ** |
| | *Ardeola ralloides* | 0.6201 | 0.96 | 0.595296 | 0.038 | * |

## 4. Discussion

### 4.1 Phenology of Ardeidae species in the wetland

The wetland of South-East Benin offers the best habitats to *Ixobrychus minutus*. According to Delelis and Boin, (2006) [26], it prefers habitats such as humid prairies, alluvial plains, salted coastal swamp, reservoirs and ponds in wooded zones or hunting areas. The periods of high number of the species (April to June 2015 and December 2015 to February 2016) correspond respectively to the heavy rainy season and the long dry season. This remark could be explained by the disturbance of seasonal rhytm of the wetland. Marion *et al.* (2006) [27] explained it by the fact that sever long dry season correspond to high decrease of the species abundance in wintering sites in Africa. The species is sedentary and Palearctic migratory and its presence is most remarked in the rainy season. This corroborate with the bio-geographical status proposed by Borrow and Demey, (2015) [15].

*Nycticorax nycticorax* was quasi absent in 2015 but its regular presence was remarkable in 2016. This remark could be tied to the fact that during migration, the species doesn't frequent necessarily the wetland of South-East Benin. In addition, the climate conditions of the medium could also justify the quasi-absence of the species in 2015. Besides, *Nycticorax nycticorax* spends winter in Africa and dwells in Europe (Marion, 2009) [28]. It's the reason why the species is qualified as sedentary and Palearctic migratory that is in accordance with its bio-geographical status defined by Borrow and Demey (2015) [15].

The arrival period of *Ardeola ralloides* corresponds to the wintering period of birds into the wetland. Marion, (2009) [28] reported that *Ardeola ralloides* dwells in France and winter in Africa. So, it's considered as sedentary and Palearctic migratory. Regarding the phenological status, our result is similar to that of Borrow and Demey (2015) [15].

The global appreciation of the abundance pattern of *Bubulcus ibis* reveals that other individuals come to the zone from December to May of each year. Their departure from the wetland starts in June but some individuals dwell permanently. Thus, it's sedentary and intra-African migratory (Borrow and Demey, 2015) [15]. Its temporal distribution rhythm is similar to that of *Ardeola ralloides* to the exception that picks have been reached in June 2015 and in May 2016. Rain intensity or the biological cycle of migrants could be probably a reason of departure of the species. So, meteorological events influence migratory movements of the species (Massa *et al.*, 2014) [29].

The arrival of *Butorides striatus* coincide majorly with the heavy rainy season and is late compared to that of wintering birds which starts generally in November. So, it's not a Palearctic species. According to Borrow and Demey (2015) [15], the species is sedentary of West-Africa. We can therefore conclude that it could be an intra-African migratory in the wetland of South-East Benin.

*Egretta ardesiaca* was almost absent in 2015 but its presence was remarkable in 2016. That is due to the fact that during migration, the species doesn't come necessarily to the wetland of South-East Benin. In addition, the climate conditions of the medium can justify the quasi-absence of the species in 2015. As the absence Ardeidae, its arrival in the wetland could be tied to the wintering period of water birds. The global trend of the progression of its abundance in 2015 and 2016 enables us to consider it as intra-African migratory (Borrow and Demey, 2015) [15].

The appearance moment of *Egretta gularis* in the wetland is in the same period than that of major part of Ardeidae species. Indeed, the pick obtained in July 2016 could be justified by the arrival of other individuals during their return from migration in the sub-region. Its migratory pattern demonstrates that *Egretta gularis* is an intra-African migratory (Borrow and Demey, 2015) [15].

Picks of *Egretta garzetta* that are not obtained in the same month according to years show the arrival of new individuals into the wetland. This difference of picks is due to the two types of migration (one intra-African and the other Palearctic) practiced by the species (Borrow and Demey, 2015) [15]. It's also sensitive to climate changes (Bennetts *et al.*, 2000) [30].

Picks of *Egretta intermedia* are obtained in dry seasons with high presence during whole months. So, it's sedentary and intra-African migratory (Borrow and Demey, 2015) [15].

The abundance of *Egretta alba* is most fluctuating in relation to time and reveals that this species is sedentary intra-African and Palearctic migratory (Borrow and Demey, 2015) [15] because it's present during the whole annual cycles. Picks were obtained in full rainy season.

The increase of *Ardea purpurea* number is tied to the arrival of other individuals coming from elsewhere. The best pick in 2015 was obtained in December (dry season) but that of 2016 was obtained in July (end of the heavy rainy season). The abundance fluctuation recorded doesn't enable us to determine the favorable season of the species in the wetland of South-East Benin. So, we estimate occasional individuals coming from other Benin wetlands or intra-African could help to explain the irregular migratory pattern obtained. It's Palearctic and African migrant though demographic parameters of dwelling place based in Europe are in accordance with the precipitation index of wintering area in Africa (Barbraud *et al.*, 2001 [31]; Winden *et al.*, 2010 [32]). Thus, the native population of the species increases in Europe with high autumn precipitations in the Sahel (Barbraud *et al.*, 2001) [31]. It dwells in Iran in reed with single or mixed colony of species (Scott, 2007) [33]. As no native individual was recorded, we can conclude that *Ardea purpurea* is sedentary, migratory and Palearctic wintering (Borrow and Demey, 2015) [15].

*Ardea cinerea* is fully present in the wetland. So, it's sedentary and Palearctic migratory (Borrow and Demey, 2015) [15].

### 4.2 Correlation and indicative value of species with stations

The significant correlation recorded among *Ardea cinerea, Egretta intermedia, Egretta alba, Ardeola ralloides, Egretta garzetta, Egretta ardesiaca, Ardea purpurea, Butorides striatus* and the station of Nokoué Lake (NL) could be explained by the fact that bird fauna diversity is generally concentrated in this water plan (Dodman and Diagana, 2003 [6]; Diagana and Dodman, 2006 [7]) as it offers environmental conditions and especially adequate food resources to birds. Also among Ardeidae, the above cited species are the best indicators of prevailing conditions over Lake Nokoué. This latter is little deep (1.25 m mean depth) with 0.51 m annual mean transparence.

*Nycticorax nycticorax* characterizes Porto-Novo lagoon. It's a species frequenting saline media (Johnsgard, 2009) [34].

*Bubulcus ibis* characterizes Ouémé River (OR) because it's a species of open media (Borrow and Demey, 2015) [15]. Ouémé River gives access to vast flooded plains.

### 4.3 Correlation and indicative value of species with seasons

*Egretta alba* (sedentary, intra-African and Palearctic migratory), *Ardea cinerea*, *Ardea purpurea* (sedentary and Palearctic migratory), *Egretta intermedia*, *Bubulcus ibis* (sedentary and intra-African migratory) (Borrow and Demey, 2015) [15] have significant bi-serial correlation with the short dry season (SDS) that starts in August after the heavy rainy season. August doesn't correspond to Palearctic birds wintering period of the wetland. Otherwise, the significant correlation obtained could be tied to the sedentary character of these species. Besides, *Egretta alba*, *Egretta intermedia*, *Ardea purpurea*, *Bubulcus ibis* have indicative values upper than 0.50. So, they are the best indicator species of the short dry season (SDS). *Nycticorax nycticorax* and *Ardeola ralloides* (all sedentary and Palearctic migratory) have significant bi-serial correlation with the long dry season (LDS) that spreads from November to March corresponding to birds wintering period in the wetland.

## 5. Conclusion

The South-East wetland of Benin gathers important Ardeidae population though certain species are sedentary and/or migratory. For the major part of Ardeidae, migration to Ramsar Site 1018 happens from November corresponding to birds wintering period. Many species have correlation with stations and seasons.

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