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Diversity and abundance of water birds in the Guessabo wetland (Central-western Côte d'Ivoire)

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Abstract

In Côte d'Ivoire, waterbird data are mainly from coastal wetlands. To fill this gap in ornithological knowledge, a study on waterbirds was carried out in the GW in November 2019 (rainy season) and January 2020 (dry season) using the Point Index of Abundance (PIA) method. The objective of the study was to gain knowledge of the waterbird population in the GW. The results showed that this site contains a large population of water birds (3353 individuals) very little diversified with a specific richness (SR) of 28 species from 10 families belonging to six orders. The Charadriiformes order is the most important in terms of species richness and that of the Anseriformes in terms of abundance. The Ardeidae family is more represented at the level of species richness than at the level of abundance. The White-faced Whistling Duck (*Dendrocygna viduata)* is the best represented in terms of abundance of individuals. The H' index; E; DOI and IPA calculated are 2.17 respectively; 0.27; 71.95 and 106. These data also showed that the seasons considerably influence the abundance of waterbirds in the GW but very little on their diversity. In terms of vulnerability, only one species (Curlew Sandpiper *Calidris ferruginea*) of waterbirds, of the Near-Threatened category (NT) was observed on the GW. Also, total migratory species represent only 32% of the SR of waterbirds on this site. These results being preliminary, further studies are envisaged to acquire a reliable database on the diversity and dynamics of the population of waterbirds in the GW.

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Introduction

Biodiversity is the variability among living organisms from all sources including, among others, terrestrial and aquatic ecosystems and other ecological complexes of which they are part (United Nations, 1992). It provides the essential goods and services on which human life depends while maintaining the systems that preserve the biosphere. Unfortunately, this biological diversity is being rapidly degraded (Stattersfield *et al.*, 2013). Studies by Brooks *et al.* (2007) show that it is facing a serious extinction crisis with species losses reaching increasingly high levels. This is mainly due to certain anthropogenic activities which are accelerating its disappearance (N'Da *et al.*, 2008; CIFOR, 2012; Guiguindibaye *et al.*, 2013; Kouakou *et al.*, 2017; Bamba *et al.*, 2017; Béné *et al.*, 2018; Zean *et al.*, 2018). Wetlands, which are particularly threatened, often have a remarkable avifauna, marked by the presence of rare species. Indeed, ornithological studies in the locality of Grand-Bassam (Yaokokoré-Béibro *et al.*, 2010; Gueye, 2013; Odoukpé *et al*, 2014) have clearly shown the richness of the avifauna of the wetlands and the presence of species on the red list of the International Union for the Conservation of Nature (IUCN) such as the creek falcon Falco naumanni (Fleischer, 1818), the jaco parrot Psittacus erithacus (Linnaeus, 1758), the whale tern *Sterna balaenarum* (Strickland, 1852). However, except for the avifauna of the lakes of Yamoussoukro (Konan *et al.*, 2015), data on waterbirds in the majority of wetlands in the interior of Côte d'Ivoire, particularly in the west of the country, are poorly known. This is the case of the Guessabo wetland (GW) where there are no published data on waterbird diversity and abundance. However, waterbirds are good biological indicators of their quality and conservation status (Wetlands International, 2010). Through their presence or absence, waterbirds provide reliable and relevant information on the status of habitats (vegetation structure, level of degradation, the abundance of prey, disturbance, etc.). Monitoring populations of aquatic avifauna would allow early detection of threats to wetlands before they become obvious disasters for all (Brimont *et al.*, 2008; Secretariat Convention Ramsar, 2010). As a result, aquatic avifauna in wetlands has been the subject of much work around the world (Schepers *et al.*, 1998; El Agbani *et al.*, 2009; Bensaci *et al.*, 2013).

This study aims to provide for the first time data on waterbird populations in the GHA to provide a scientific basis for further studies. These data will be useful for the establishment of a sustainable management system for this ecosystem.

Materials and methods

Material

The material consists of biological material, technical material and data processing equipment. For this study, the biological material was waterbirds. The technical material consisted of a pair of binoculars which were used to visualize the birds, a digital camera for taking pictures, a GPS (Global Positioning System) to determine the geographical coordinates of listening and observation points, identification guides by Serle and Morel (1993) and Barlow and Dodman (2015) for the identification of unknown species. The data were processed using the Microsoft Office Excel spreadsheet and statistical software R 2.8.0 and Statistica 7.1.

Methods

Presentation of the study area

The present study was carried out in the Guessabo River located in the Haut-Sassandra region (central-western Côte d'Ivoire), 440 km from Abidjan. This zone is located between 6.70° and 7° West longitude and between 6.64° and 6.87° North latitude (Fig. 1). The sub-prefecture of Guessabo is drained on the west side by the Sassandra river basin. In Guessabo, the Sassandra extends over a catchment area of 35400 Km², with a flow rate of about 7.5 to 9 L/S/Km (Touchebeuf and Girad., 1962). The flow deficits vary between 1280 and 1350 mm for an average of 1300 mm. According to (Touchebeuf and Girad, 1962), two types of the hydrological regime are observed according to the rainfall of the year, notably the transitional tropical regime and the attenuated transitional equatorial regime.

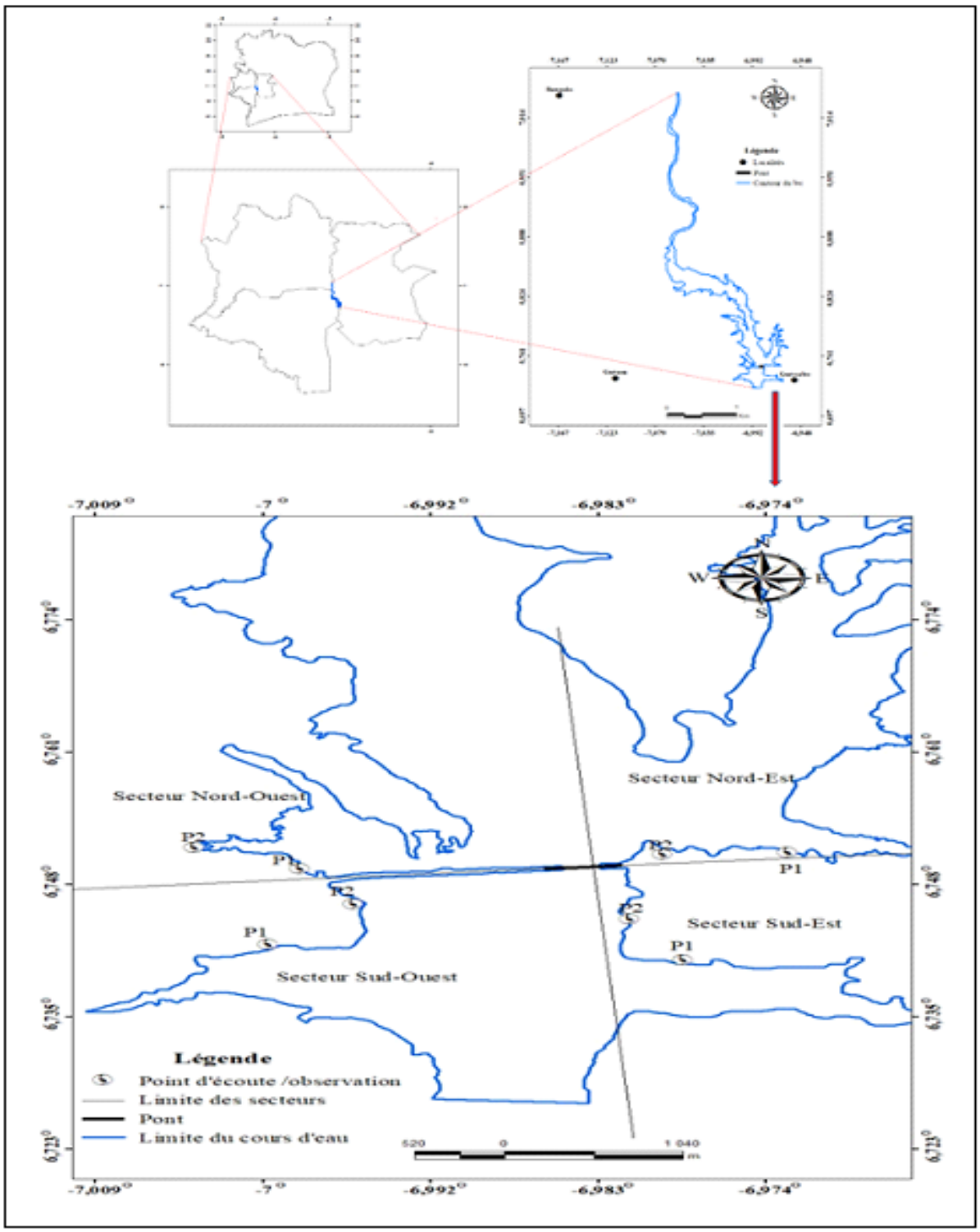

Fig. 1. Map of the location of the Guessabo wetland in Côte d'Ivoire showing the bird study areas.

The study environment is characterized by a tropical climate with a monthly rainfall of more than 100 mm spread out between April and November, with maximum heights generally occurring in September. Seven months can be considered as wettest, this is the interval from March to October (Ossey *et al*., 2008). The main activities of the population of Guessabo are fishing and agriculture.

Choice of sampling sites

The study area, being very large, was divided into four sectors to get an idea of the representativeness of the waterbird population over the entire area. For this purpose, the Guessabo Bridge was chosen as the first

reference which divides the river or site into two sectors, north and south. Subsequently, each of these two sectors was split in two from a virtual east-west axis, giving four study sectors named following the four cardinal points. These four sectors were respectively named SE for the South-East sector, NE for the North-East sector, SW for the South-West sector and NW for the North-West sector. Fig. 2 shows partial views of these different sectors according to the two seasons. In each of these four defined sectors, two fixed observation points, P1 and P2, were chosen for bird observation and identification.

Data collection

Observations were made in two seasons: the rainy season in November 2019 and the dry season in January 2020. Sampling generally took place between 06:30 and 09:30 and between 15:30 and 18:30. These times correspond to the peak of bird activity. Indeed, Niandou *et al.* (2016) and Pellerin (2015) stipulate that it is preferable to avoid hours that are too early or too late for bird watching. For each season, the field sampling duration was 16 days due to two days per listening point.

The main methodology adopted is that of bird counts from a fixed observation or listening point within a fixed period or the Punctual Index of Abundance (PIA) method developed by Blondel *et al.* (1970) as defined by Bibby *et al.*, (1998). This method consists, of two separate counting sessions, noting all the birds observed or heard during 20 min from a fixed point in the territory. Qualitative and quantitative analyses and statistical treatments were carried out based on the data collected. For each of the species listed, the conservation status according to Birdlife International (2019) and IUCN (2019) and the biogeographical or migratory status according to Borrow and Demey (2008) were defined.

The orders, families, genera and scientific names of bird species follow the systematic order of species according to the Handbook of the Birds of the Word Alive and BirdLife International as proposed by Lepage (2018).

Results

Bird diversity

In two seasons, all four sectors sampled in the GW yielded 28 species of waterbirds in 10 families of six orders (Table 1 and 2). Fig. 3 shows photographs of some of the bird species inventoried. Shannon's diversity index (H') and the Equitability index (E) are 2.17 and 0.27 respectively. The order Charadriiformes is the most represented with four families and 13 species. The family Ardeidae with nine species is the most diverse. It contains almost a third of the number of waterbird species in the GW. Of the four inventoried areas, the most represented in terms of SR are SE and NW with 20 species each.

The highest Shannon's Diversity Index (H') and Equitability Index (E') come from the SE sector with H'= 2.43 and E = 0.79 respectively. The analysis of variance (ANOVA) carried out using the Newman-Keuls test (ddl=3; F=4 and P= 0.9) revealed that there is no significant difference between species richness (Fig. 1). These sectors are all homogeneous.

In the rainy season, 20 species and in the dry season 23 species were inventoried. The H' and E diversity index are respectively 1.98 and 1.33 for H' and 0.66 and 0.42 for E. The Newman-Keuls test (ddl = 1; F = 26.07 and p = 0.07) revealed that there is no significant difference between the number of species in any season.

Abundance of birds

In terms of abundance, the four sectors sampled in two seasons in this study yielded 3353 bird individuals (Tables 1 and 2). The dominance index (DOI) and the Punctual Index of Abundance (PIA) for this study area are 72.02 and 106 respectively. The order Anseriformes presents the largest number of individuals with 2229 individuals, i.e. 66.72% of the population. At the family level, the largest in the Anatidae with 2229 individuals representing more than two-thirds of the waterbird individuals observed in this study area.

Table 1. List and seasonal abundance of waterbirds species recorded in the GW.

		Wet season (WP)						Dry season (DS)								
Scientific name	Name in English	SE	NE	SW	NW	EC	Fr (%)	SE	NE	SW	NW	EC	FR (%)	EFF total	Fr total	CS	BS
ANSERIFORMES																	
ANATIDAE																	
Dendrocygna viduata (Linnaeus, 1766)	White-faced Whistling Duck	128	12	0	125	265	46,41	0	141 5	368	190	1973	70,92	2238	66,75	LC	R /M
Nettapus auritus (Boddaert, 1783)	African Pygmy Goose	0	0	0	0	0	0,00	0	0	0	3	3	0,11	3	0,09	LC	R
GRUIFORMES																	
RALLIDAE																	
Zapornia flavirostra (Scopoli, 1769)	Black Crake	0	0	0	0	0	0,00	0	0	0	2	2	0,07	2	0,06	LC	S
PELECANIFORMES																	
ARDEIDAE																	
Ardeola ralloides (Scopoli, 1769)	Squacco Heron	20	4	0	2	26	4,55	14	10	10	16	50	1,80	76	2,27	LC	S/P
Bubulcus ibis (Linnaeus, 1758)	Cattle Egret	12	8	12	25	57	9,98	0	5	0	10	15	0,54	72	2,15	LC	S/M
Butorides striata (Linnaeus, 1758)	Green-backed Heron	1	5	0	6	12	2,10	7	5	4	7	23	0,83	35	1,04	LC	S
Egretta ardesiaca (Wagler, 1827)	Black Heron	1	0	0	0	1	0,18	1	2	0	3	6	0,22	7	0,21	LC	S
Egretta gularis (Bosc, 1792)	Western Reef Egret	1	0	0	0	1	0,18	10	4	5	5	24	0,86	25	0,75	LC	S
Egretta garzetta (Linnaeus, 1766)	Little Egret	11	21	8	21	61	10,68	14	25	28	30	97	3,49	158	4,71	LC	S
Egretta intermedia (Wagler, 1829)	Intermediate Egret	14	8	0	0	22	3,85	50	45	27	34	156	5,61	178	5,31	LC	S
Egretta alba Linnaeus, 1758	Great Egret	0	0	0	0	0	0,00	7	18	20	0	45	1,62	45	1,34	LC	S
Ardea cinerea Linnaeus, 1758	Grey Heron	0	0	1	1	2	0,35	0	4	1	0	5	0,18	7	0,21	LC	S/P
SULIFORMES																	
PHALACROCORACIDAE																	
Microcarbo africanus (Gmelin, 1789)	Long-tailed Cormorant	0	0	0	1	1	0,18	7	14	20	12	53	1,91	54	1,61	LC	S
ANHINGIDAE																	
Anhinga rufa (Daudin, 1802)	African Darter	0	0	0	0	0	0,00	0	1	0	0	1	0,04	1	0,03	LC	S
CHARADRIIFORMES																	
CHARADRIIDAE																	
Charadrius dubius Scopoli, 1786	Little Ringed Plover	1	0	0	0	1	0,18	0	0	0	0	0	0,00	1	0,03	LC	P
Vanellus senegallus (Linnaeus, 1766)	African Wattled Lapwing	18	0	0	0	18	3,15	0	0	0	0	0	0,00	18	0,54	LC	S
Vanellus albiceps Gould, 1834	White-headed Lapwing	10	0	0	0	10	1,75	0	0	0	0	0	0,00	10	0,30	LC	S
Vanellus spinosus (Linnaeus, 1758)	Spur-winged Lapwing	23	0	0	0	23	4,03	22	14	30	33	99	3,56	122	3,64	LC	M
ROSTRATULIDAE																	
Rostratula benghalensis (Linnaeus, 1758)	Greater Painted-snipe	2	0	0	0	2	0,35	0	0	0	0	0	0,00	2	0,06	LC	S
JACANIDAE																	
Actophilornis africanus (Gmelin, 1789)	African Jacana	15	8	7	10	40	7,01	33	35	21	32	121	4,35	161	4,80	LC	S
Microparra capensis (Smith, 1839)	Lesser Jacana	2	0	0	0	2	0,35	0	0	0	0	0	0,00	2	0,06	LC	M
SCOLOPACIDAE																	

Continued...

		Wet season (WS)						Dry season (DS)								
Scientific name	English'name	SE	NE	SW	NW	EC	Fr (%)	SE	NE	SW	NW	EC	Fr (%)	EFF total	Fr total	CS	BS
Calidris ferruginea (Pontoppidan 1763)	Curlew Sandpiper	0	0	0	0	0	0,00	0	0	6	6	12	0,43	12	0,36	NT	P
Calidris alpina (Linnaeus, 1758)	Dunlin	0	0	0	0	0	0,00	0	0	6	0	6	0,22	6	0,18	LC	P
Tringa erythropus (Pallas, 1764)	Spotted Redshank	0	0	0	0	0	0,00	0	0	4	4	8	0,29	8	0,24	LC	P
Tringa ochropus Linnaeus, 1758	Green Sandpiper	0	0	0	0	0	0,00	0	0	0	2	2	0,07	2	0,06	LC	P
Tringa glareola Linnaeus, 1758	Wood Sandpiper	3	0	0	0	3	0,53	15	7	10	10	42	1,51	45	1,34	LC	P
Actitis hypoleucos Linnaeus, 1758	Common Sandpiper	4	5	3	4	16	2,80	13	0	1	4	18	0,65	34	1,01	LC	P
CORACIIFORMES																	
ALCEDINIDAE																	
Corythornis cristatus (Pallas, 1764)	Malachite Kingfisher	0	6	0	2	8	1,40	10	2	7	2	21	0,75	29	0,86	LC	S

SE : South - East Sector ; NE : North –East Sector ; SW : South-West Sector ; NW : North-West Sector ; EC : Number of birds per season; Fr (%) : Relative Frequency, EFF.Total : Number of birds in the four sectors in both seasons; Fr total : Total Frequency ; SC : Conservation Status.; BS : Biogeographic Status ; LC : Least Concern ; NT : Near-Threatened, S : Sedentary ; M : Intra-African migratory ; P : Palearctic migratory.

The Widowed Dendrocygna (Dendrocygna viduata) is the most abundant species with 2238 individuals, i.e. almost a third of the total abundance. Analysis of these data shows that for the three parameters assessed (IN; DOI and PIA), the NE sector seems to be the most important of the four sectors with values of 1683; 87.98% and 211. The least important sector is the SE sector with values of 469; 40.94% and 59

respectively. The Newman-Keuls test (ddl = 3; F = 1.3 and p = 0.32) carried out based on the number of individuals per sector shows that there is no significant difference between the sectors. The sectors are all homogeneous.

In terms of seasonal abundance, the dry season records the highest number of individuals (2782 individuals) compared to the rainy season (571 individuals). The dominance index and the calculated punctual index of abundance show the highest values in the dry season. The Newman-Keuls test (ddl = 1; F = 6.4 and p = 0.024) carried out based on the number of waterbird individuals per season shows that there is no significant difference between seasons. The seasons are therefore homogeneous.

Table 2. Summary of observations.

	Wet season (WS)						Dry season (DS)						
	SE	NE	SW	NW	EC	Fr (%)	SE	NE	SW	NW	EC	Fr(%)	EFF total
Number of Individuals (NI)	266	77	31	197	571	100	203	1606	568	405	2782	100	3353
Species richness (SR)	17	9	5	10	20		13	16	17	18	23		28
Number of Families (NF)	6	5	3	6	8		6	8	7	8	9		10
Shannon Diversity Index (H')	1,92	1,47	1,4	1,3	2,82		2,3	0,64	1,5	2	1,33		2 ,17
Equitability (E)	0,68	0,71	0,9	0,6	0,44		0,9	0,23	0,5	0,7	0,42		0,27
Dominance Index (DOI)	56,77	43,6	65	76	57,46		41	90,9	70	55	76,5		72,02
Punctual Index of Abundance (PIA)	67	20	8	50	37		51	402	142	102	175		106

EC : Number of birds per season; EFF.Total : Number of birds in the four sectors in both seasons; Fr (%) : Relative Frequency ; SE : South - East Sector ; NE : North –East Sector ; SW : South-West Sector ; NW : North-West Sector.

Stand characterization

In terms of biogeographical status, the GW is characterized by 69% sedentary and/or Intra-African migratory species (S/M), 22% sedentary species (S), 4% Intra-African migratory species (M), 3% Palearctic migratory species (P) and 2% sedentary and/or Palearctic migratory species (S/P). As for vulnerability, only the presence of the Curlew Sandpiper *Calidrius ferruginea* (Pontoppidan, 1763) of the Near-threatened category (NT) was observed on the GW site during the dry season.

Discussion

Analysis of the waterbird population in the GW revealed a species richness (SR) of 28 species, 23 in the dry season and 20 in the rainy season, belonging to 10 families of six orders with an abundance of 3353 waterbird individuals.

In terms of diversity, the waterbird SR of this site represents 17.83% of that indicated in the global waterbird database of 157 species (Wetlands International, 2010). Based on this global waterbird list, the waterbird SR of the GW represents 28.58% of that observed on Ivorian territory (Ahon, 2016). This waterbird SR of the Guessabo site is below those inventoried by Kouadio *et al.* (2014), Odoukpé *et al.* (2014), Konan *et al.* (2015) and Koné *et al.* (2020), who respectively recorded 30 species in the N'ganda N'ganda wetland, 50 species in the Grand-Bassam wetland, 33 species in the Yamoussoukro lakes and 47 species in the Ebrié lagoon.

This difference could undoubtedly be explained by the duration of sampling and, above all, by the geographical location of the study sites. Indeed, although they are wetlands with similar characteristics to the Guessabo site, the study sites of these authors are located in the coastal zone of Côte d'Ivoire. The index of waterbird diversity H' and Equitability E of the Guessabo site are respectively 2.17 and 0.27, which indicates on the one hand that waterbirds in the GW are more or less poorly diverse and on the other hand that they are moderately distributed over this site. The results of this study also indicated that the order Charadriiformes (13 species) and the family Ardeidae (9 species) are best represented in the GW.

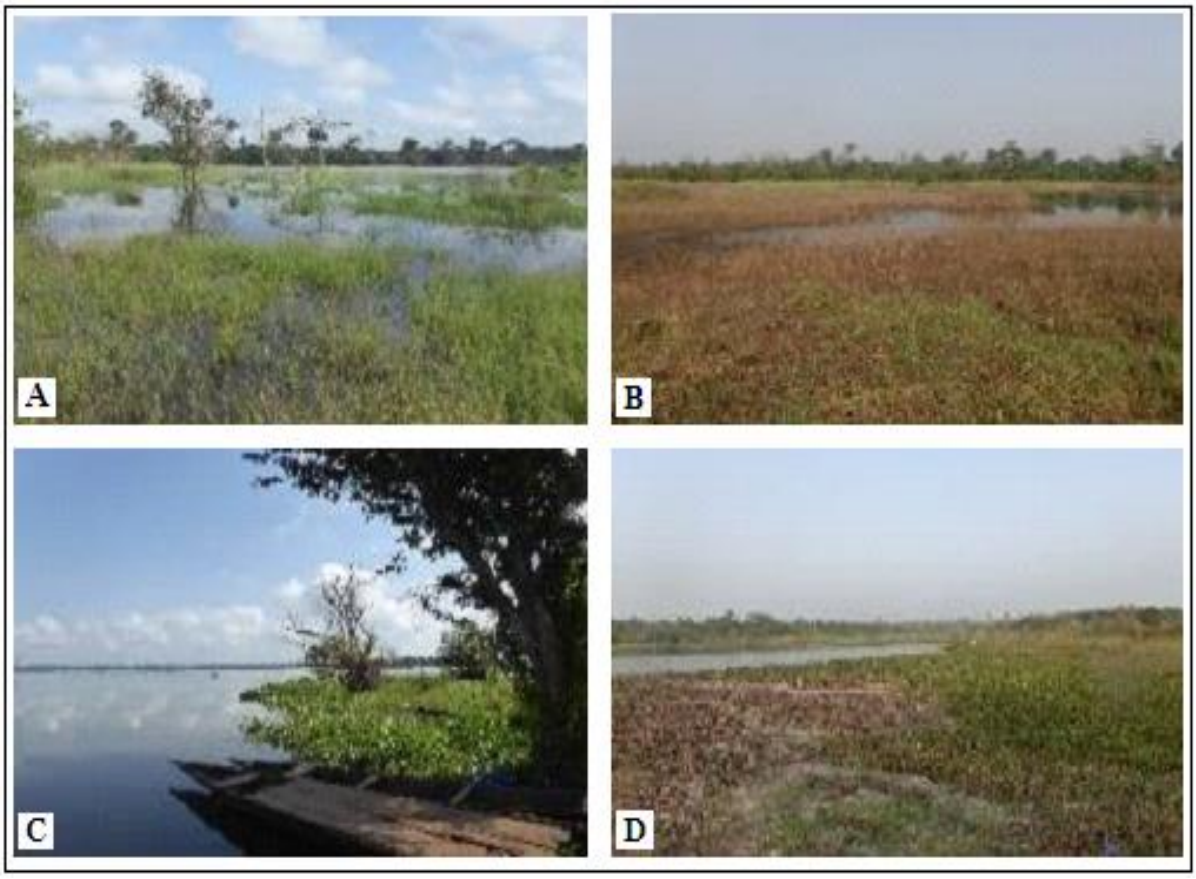

Fig. 2. Partial views of the few bird watching sectors according to the seasons (A: South-East sector in the rainy season; B: South-East sector in the dry season; C: North-East sector in the rainy season; D: North-East sector in the dry season).

These results are consistent, at least in terms of the representativeness of the different bird families according to Odoukpé *et al.* (2014) and that of the orders according to Koné *et al.* (2020). Indeed, these authors respectively showed that the Ardeidae family (13 species) was the most represented in the Grand-Bassam wetland and the Charadriiformes order (22 species) was the most diversified in the Ebrié lagoon. However, these data are different from those of Ouarab *et al.* (2018) in the Oued wetland in Algeria, which states that the Anatidae family was the best represented.

In terms of seasons, our results showed that, although dry season SR in waterbirds is higher than that of the rainy season, the species are more diverse and more evenly distributed than those of the dry season. As far as SR is concerned, the arrival of a few migratory species in the dry season could justify this superiority of species for this season. In terms of abundance, 3353 bird individuals, 2782 in the dry season and 571 in the rainy season, were counted from this study. The DOI and IPA indices of water birds on this site are 72.05% and 106 respectively. In terms of orders, families and species, Anseriformes, Anatidae and Widowed Dendrocygna (*Dendrocygna viduata*) are the most abundant with more than two-thirds of the waterbird population in the GW. This could be explained by the specific biology and ecology of the Dendrocygna *viduata*. Indeed, this species has a gregarious behavior. As such, it can be found in large numbers where it is less threatened and if the climatic conditions are favorable.

In terms of season, the values of the parameters evaluated are highest in the dry season (Number of individuals = 2782, DOI = 76.5 and PIA = 175). The comparative analysis of the waterbird SR of this dry season as well as the statistical analysis showed a significant difference between these two seasons.

Fig. 3. Photographs of some waterbirds species encountered in the GW (Photo: Ahon, 2018).

This would probably be attributed to the large population of *Dendrocygna viduata* and the few individuals of migratory waterbird species observed in the dry season. Indeed, the dry season inventory period corresponds to the most favorable season for the majority of migratory birds in Côte d'Ivoire, which peaks in January (Thiollay, 1985). Also, the mixed biogeographical status of the *Dendrocygna viduata* which is sedentary and/or intra-African migratory (Borow and Demey, 2008) also justifies this large difference in waterbird population between the two inventory seasons.

Conclusion

The study of the waterbird population in the GW revealed the presence of a large population of poorly diversified waterbirds. In terms of diversity, a SR of 28 waterbird species divided into 10 families and 6 orders was inventoried. The H' and E index for this site are 2.17 and 0.27 respectively. Charadriiformes at the order level and Ardeidae at the family level are the most represented with respectively 4.42% (i.e. 13 species) and 32.14% (i.e. 9 species) of the waterbird SR of the GW. Among these bird species, only the Curlew Sandpiper *Calidrius ferruginea* in the Near-Threatened category (NT) benefits from the protection of global interest. Fully migratory bird species in the GW represent only 32% of this SR as waterbirds. At the seasonal level, although the comparative analysis of waterbird SR data indicates that the dry season is the most favorable for waterbirds, statistical analysis of the same data showed that there is no significant difference between the two seasons. In terms of abundance, of the 3,353 waterbirds counted, Anseriformes (at order level) and Anatidae (for families) are the most abundant with more than two-thirds of the site's waterbird population. Seasonally, waterbird individuals in the GW are most numerous in the dry season. The values of the parameters assessed in the dry season (Number of individuals = 2782, DOI = 76.5 and PIA = 175) are higher than those obtained in the wetter season.

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