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Assessment of wild bird diversity in a lake ecosystem under agricultural pressure during drought in Northern Côte d'Ivoire

Ekoun Michaël Konan*[1], Coffi Jean Magloire Niamien[1], Valerie Florence Guétondé[1], Amari Diane Prisca Baka[1], Kouassi Hilaire Yaokokoré-Béibro[2]

[1]*Department of Animal Biology, UFR Biological Sciences, Peleforo Gon Coulibaly University, Korhogo, Côte d'Ivoire*

[2]*Laboratory of natural environments and biodiversity conservation, UFR Biosciences, Félix Houphouët-Boigny University, Abidjan, Côte d'Ivoire*

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ABSTRACT

The bird community of the Nindjo dam of Fodonition was studied for the first time, from January to May 2022. This study aimed to contribute to a better knowledge of the ecology of birds in rural lake environments in the commune of Korhogo in order to preserve them better. To do this, direct observations using the method of punctuated route transects stopping for about 15 minutes were carried out and the threats were assessed. The results indicate that this community is made up of 73 species belonging to 61 genera, divided into 38 families and 17 orders. The order of the Passeriformes and the families of the Ardeidea as well as that of the Columbidae were the best represented. Resident species and those in open environments were dominant. A strong negative and significant correlation existed between the retreat of water and respectively the specific richness (r= - 0.81; $p < 0.05$) and the abundance of birds (r= - 0.87; $p < 0.001$). The distribution of bird species varied with environment and month. This potential breeding site is subject to anthropogenic threats, namely agriculture, fishing and poaching.

***Corresponding author:** Ekoun Michaël Konan ✉ micekoun@gmail.com
* https://orcid.org/0009-0000-0681-6383

INTRODUCTION

Wetlands contain a large number of species. Studying them helps to better understand how they function (Kouassi *et al.*, 2020). Northern Côte d'Ivoire boasts a series of artificial lakes, estimated at 210 in number (Le Guen, 2002). These dams were built from 1970 onwards, in order to reconcile agricultural and pastoral activities within the same spatial framework and overcome conflicts between farmers and herders (Fromageot, 2007). Far from the initial objectives of these dams, namely to resolve conflicts by settling pastoralists and their livestock, we have gradually witnessed the "agricultural" development of pastoral dams. In recent years, almost 50% of dams have seen the development of more or less intensive market gardening on their banks (Le Guen, 2004). The north of Côte d'Ivoire receives less rainfall than the south. It is subject to a two-season Sudanese climate with a very marked dry season, and a severe scarcity to near-absence of rain from November to April (Kanga and Kaudjhis, 2016). During this period, interest in the reservoirs was heightened, both for humans and for the surrounding fauna, particularly waterfowl. However, despite this interest, little ornithological monitoring has been carried out on the dam lakes in and around Korhogo.

The few studies carried out have focused on the Koko urban dam (Niamien *et al.*, 2019; 2020) and the Sologo dam (Ehouman *et al.*, 2023). This lack of interest in ornithological research affects the entire northern zone of the country, beyond the wetlands (Konan *et al.*, 2023). It is therefore essential to determine the avifaunal potential of these dam lakes. In addition, it is necessary to determine the impact of human activities on this avian fauna. The aim of this study is to determine the diversity of birds in the wetlands of northern Côte d'Ivoire, particularly those of the Nindjo dam lake in Fodonition, under the influence of agriculture and drought.

MATERIAL AND METHODS

Study area

The Nindjo dam in the village of Fodonition is located around 6 km from the town of Korhogo, capital of the Poro region in northern Côte d'Ivoire. Korhogo lies between parallels 8°26 and 10°27 N and 5°17 and 6°19 W. Korhogo's climate is tropical with two seasons, with a very hot, dry period from November to March marked by harmattan and a rainy period from April to October (Boko-Koiadia *et al.*, 2016). The rhythm of high and low water in the lakes is influenced by these two seasons.

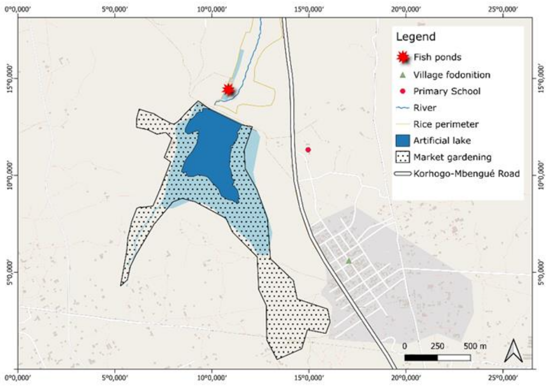

Fig. 1. Map of the Fodonition Nindjo dam

The Nindjo dam of Fodonition dam (Fig. 1) is a rural reservoir that supplies water to fish ponds, rice ponds and market gardens in the immediate vicinity. It is also used for cattle watering and fishing. Fishing takes many forms, depending on the lake's water level. In periods of high water, fishing is carried out using pirogues. However, when the water level is at its lowest, fishermen set up a net across the lake. There are also mango and cashew nut orchards drowned in savannah-type vegetation. During low-water periods, areas exposed by receding water are immediately transformed into agricultural plots (Fig. 2).

Fig. 2. Some facies of the Nindjo dam lake in Fodonition

Survey methods

The inventory of birds associated with the Nindjo dam lake in Fodonition took place from January to May 2022. Data was collected in six habitats: open water, aquatic shoreline vegetation, bare bank, market garden, grassland and wooded savannah. The method used is that of roving transects punctuated by 15-minute stops (Odoukpé *et al.*, 2014; Yaokokoré-Béibro *et al.*, 2015 a, b). This method involves walking slowly along the lakeshore with regular 15-minute stops in order to identify as many bird species as possible. All birds observed on the water body up to a distance of 50 meters beyond the bank were inventoried (Niamien *et al.*, 2020). Four surveys were carried out each month, for a total of 20 surveys over the entire study period. Surveys were carried out in the mornings, from 6:00 to 10:30 am, which represents the most intense period of bird activity (Bibby *et al.*, 1992; Yaokokoré-Béibro, 2001). All birds seen, heard, landed or in flight were observed with binoculars and identified using the West African Bird Identification Guide (Borrow and Demey, 2008). The songs and calls of unknown birds were recorded with a Dictaphone and identified using the CD-Rom of the songs and calls of African birds (Chappuis, 2000).

The effect of lower lake levels on the local bird community was assessed. To this end, weekly GPS readings of the lake water level were taken and the length of emerged land was measured.

Data analysis

The sequence of orders and families conforms to the systematic list of Borrow and Demey (2001). Scientific species nomenclatures are from Catalogue of life (Catalogue oflife.org) according to Bánki *et al.* (2021). Data analysis is based on species richness ($S = \sum$ species), the Shannon-Wiener diversity index ($H' = -\sum (ni/N) \times \ln(ni/N)$), the equitability index ($J = H'/H'max$) according to Barbault (1992) and Sorensen's similarity index ($Si = (2 \times C/(A + B)) \times 100$) according to Bibby *et al.* (1998). The characterization of bird populations is based on biogeographical status, preferred habitat, conservation status and frequency of occurrence.

Biogeographical status (Borrow and Demey, 2001) has made it possible to identify resident and migratory species, including Palearctic and intra-African migrants. On the basis of preferred habitat, three categories have been distinguished (Yaokokoré-Béibro, 2001). These are wetland species, openland species and forest species. Species conservation status was determined according to IUCN (2024). Frequencies of occurrence ($Fo = Si/St \times 100$) were determined according to Dajoz (1985), who distinguishes five classes: omnipresent species ($Fo = 100\%$); constant species ($75\% \le Fo < 100\%$); regular species ($50\% \le Fo < 75\%$); accessory species ($25\% \le Fo < 50\%$); accidental species ($Fo < 25\%$). Quantitative data were used to determine the relative frequencies ($Fr = ni/N \times 100$) of each bird species. Relative frequency was used to characterize the stand on the basis of abundance indices. Thiollay (1971) determines the following categories: dominant species ($Fr \ge 5\%$); regular species ($1\% \le Fr < 5\%$); rare species ($0.2\% \le Fr < 1\%$); accidental species ($Fr < 0.2\%$). A number of statistical analyses were carried out using Past 1.0. Analyses of variance, hierarchical ascending classification, factorial correspondence analysis, Spearman's Rank correlation test and Generalized Linear Model were performed.

RESULTS

Specific richness

Five months of avifauna monitoring at the Nindjo dam in Fodonition identified 73 bird species, belonging to 36 families and 16 orders (Table 1). Together, these species represent an overall abundance of 1,251 birds.

Species occurrence

The population includes two omnipresent species, Actophilornis africana and Milvus migrans, which were observed in the environment at every survey session, with a frequency of occurrence of 100%. Twelve species are constant (*Dendrocygna viduata*, *Streptopelia semitorquata*, *Streptopelia vinacea*, *Butorides striata*, *Ardeola ralloides*, *Bubulcus ibis*, *Egretta garzetta*, *Microcarbo africanus*, *Vanellus spinosus*, *Actitis hypoleucos*, *Corvus albus*, *Anthus leucophrys*). There are also 13 regular species, nine accessory species and 37 accidental species (Fig. 3).

Table 1. Qualitative assessment of bird species observed on the Fodonition Nindjo dam from January to March 2022

Orders/Families/ Species	Biogeo	Habitat	IUCN	Fo (%)	JAN	FEV	MAR	APR	MAY	Fr	MET
Galliformes											
Odontophoridae											
Ptilopachus petrosus (J. F. Gmelin, 1789)	R	f.	LC	5,56	2	-	-	-	-	0,16	0,4 ± 0,89
Anseriformes											
Anatidae											
Dendrocygna viduata (Linné, 1766)	R/M	E	LC	88,89	27	8	42	28	2	3,36	21,4 ± 16,24
Nettapus auritus (Boddaert, 1783)	R	E	LC	27,78	6	5	2	-	-	0,48	2,6 ± 2,79
Columbiformes											
Columbidae											
Columba guinea Linné, 1758	R	f.	LC	50,00	-	-	5	6	22	1,76	6,6 ± 9,04
Streptopelia semitorquata (Ruppell, 1837)	R	f.	LC	77,78	3	4	7	3	2	0,56	3,8 ± 1,92
Streptopelia vinacea (Gmelin, 1789)	R	f.	LC	88,89	10	6	9	22	-	1,76	9,4 ± 8,05
Spilopelia senegalensis (Linné, 1766)	R	f.	LC	50,00	3	3	2	-	-	0,24	1,6 ± 1,52
Turtur abyssinicus (Sharpe, 1902)	R	f.	LC	50,00	2	1	1	1	-	0,16	1 ± 0,71
Streptopelia decipiens (Hartlaub & Finsch, 1870)			LC	16,67	1	1	-	-	-	0,08	0,4 ± 0,55
Apodiformes											
Apodidae											
Cypsiurus parvus (Lichtenstein, 1823)	R	f.	LC	22,22	3	2	2	-	-	0,24	1,4 ± 1,34
Apus affinis (J. E. Gray, 1830)	R	f.	LC	5,56	30	-	-	-	-	2,40	6 ± 13,42
Cuculiformes											
Cuculidae											
Centropus senegalensis (Linné, 1766)	R	f.	LC	66,67	2	2	5	2	1	0,40	2,4 ± 1,52
Clamator levaillantii (Swainson, 1829)	M	f.	LC	5,56	-	-	1	-	-	0,08	0,2 ± 0,45
Chrysococcyx klaas (Stephens, 1815)	R	f.	LC	5,56	1	-	-	-	-	0,08	0,2 ± 0,45
Cuculus gularis Stephens, 1815	M	f.	LC	11,11	-	-	-	1	-	0,08	0,2 ± 0,45
Gruiformes											
Rallidae											
Crex egregia (W. Peters, 1854)	M/R	f.	LC	11,11	-	-	-	-	2	0,16	0,4 ± 0,89
Zapornia flavirostra (Swainson, 1837)	R	E	LC	33,33	2	2	1	-	2	0,16	1,4 ± 0,89
Porphyrio alleni Thomson, 1842	M/R	E	LC	16,67	1	-	2	-	1	0,16	0,8 ± 0,84
Gallinula chloropus (Linné, 1758)	R/P	E	LC	16,67	-	1	2	-	-	0,16	0,6 ± 0,89
Musophagiformes											
Musophagidae											
Crinifer piscator (Boddaert, 1783)	R	f.	LC	61,11	2	3	2	4	2	0,32	2,6 ± 0,89
Tauraco violaceus (Isert, 1788)	R	f.	LC	22,22	2	2	2	2	-	0,16	1,6 ± 0,89
Pelecaniformes											
Ardeidae											

Nycticorax nycticorax (Linné, 1758)	R/P	E	LC	5,56	1	-	-	-	-	0,08	0,2 ± 0,45
Butorides striata (Linné, 1758)	R	E	LC	94,44	5	6	9	3	3	0,72	5,2 ± 2,49
Ardeola ralloides (Scopoli, 1769)	R/M	E	LC	77,78	24	20	8	1	1	1,92	10,8 ± 10,71
Ardea ibis (Linné, 1758)	R/M	E	LC	94,44	462	320	17	108	54	36,93	192,2 ± 191,06
Ardea purpurea Linné, 1766	R/P	E	LC	5,56	1	-	-	-	-	0,08	0,2 ± 0,45
Ardea brachyrhyncha (Brehm, AE, 1854)	R/M	E	LC	5,56	1	-	-	-	-	0,08	0,2 ± 0,45
Egretta garzetta (Linné, 1766)	R/M	E	LC	94,44	4	5	4	12	3	0,96	5,6 ± 3,65
Scopidae											
Scopus umbretta Gmelin, 1789	R	E	LC	33,33	1	-	-	5	1	0,40	1,4 ± 2,07
Suliformes											
Phalacrocoracidae											
Microcarbo africanus (Gmelin, 1789)	R	E	LC	77,78	4	1	8	2	1	0,64	3,2 ± 2,95
Charadriiformes											
Burhinidae											
Burhinus senegalensis (Swainson, 1837)	R	E	LC	22,22	-	2	-	1	6	0,48	1,8 ± 2,49
Charadriidae											
Vanellus spinosus (Linné, 1758)	R	E	LC	94,44	66	28	34	23	33	5,28	36,8 ± 16,90
Vanellus lugubris (Lesson, 1826)	M	E	LC	5,56	4	-	-	-	-	0,32	0,8 ± 1,79
Vanellus senegallus (Linné, 1766)	R/M	E	LC	55,56	8	5	18	9	4	1,44	8,8 ± 5,54
Rostratulidae											
Rostratula benghalensis (Linné, 1758)	R/M	E	LC	61,11	9	12	9	-	-	0,96	6 ± 5,61
Jacanidae											
Actophilornis africanus (J. F. Gmelin, 1789)	R	E	LC	100,00	18	29	28	46	45	3,68	33,2 ± 12,03
Scolopacidae											
Actitis hypoleucos (Linné, 1758)	P	E	LC	88,89	10	13	16	4	-	1,28	8,6 ± 6,54
Tringa ochropus Linné, 1758	P	E	LC	5,56	-	-	2	-	-	0,16	0,4 ± 0,89
Tringa nebularia (Gunnerus, 1767)	P	E	LC	38,89	3	1	1	2	1	0,24	1,6 ± 0,89
Tringa glareola Linné, 1758	P	E	LC	5,56	3	-	-	-	-	0,24	0,6 ± 1,34
Accipitriformes											
Accipitridae											
Elanus caeruleus (Desfontaines, 1789)	R	f.	LC	22,22	1	-	-	1	-	0,08	0,4 ± 0,55
Kaupifalco monogrammicus (Temminck, 1824)	R	f.	LC	11,11	-	1	1	-	-	0,08	0,4 ± 0,55
Milvus migrans (Boddaert, 1783)	M/P	f.	LC	100,00	12	16	20	48	4	3,84	20 ± 16,73
Bucerotiformes											
Bucerotidae											
Lophoceros nasutus (Linné, 1766)	R	f.	LC	44,44	3	4	2	1	-	0,32	2 ± 1,58
Lophoceros semifasciatus (Hartlaub, 1855)	R	F	LC	5,56	1	-	-	-	-	0,08	0,2 ± 0,45
Coraciiformes											

Meropidae											
Merops nubicus Gmelin, 1788	M	f.	LC	5,56	13	-	-	-	-	1,04	2,6 ± 5,81
Coraciidae											
Coracias abyssinicus Hermann, 1783	M	f.	LC	55,56	2	1	1	2	-	0,16	1,2 ± 0,84
Alcedinidae											
Corythornis cristatus (Pallas, 1764)	R	f.	LC	72,22	10	8	10	1	-	0,80	5,8 ± 4,92
Halcyon leucocephala (Statius Muller, 1776)	M	f.	LC	38,89	4	3	1	-	-	0,32	1,6 ± 1,82
Halcyon malimbica (Shaw, 1811)	R	F	LC	11,11	-	1	1	-	-	0,08	0,4 ± 0,55
Falconiformes											
Falconidae											
Falco cuvierii A. Smith, 1830	R	f.	LC	5,56	1	-	-	-	-	0,08	0,2 ± 0,45
Psittaciformes											
Psittacidae											
Poicephalus senegalus (Linné, 1766)	R	f.	LC	5,56	-	1	-	-	-	0,08	0,2 ± 0,45
Passeriformes											
Malaconotidae											
Laniarius barbarus (Linné, 1766)	R	f.	LC	72,22	2	3	4	2	3	0,32	2,8 ± 0,84
Terpsiphone rufiventer (Swainson, 1837)	R	F	LC	5,56	1	-	-	-	-	0,08	0,2 ± 0,45
Laniidae											
Lanius corvinus (Shaw, 1809)	R	f.	LC	33,33	1	2	-	6	-	0,48	1,8 ± 2,49
Corvidae											
Corvus albus Statius Muller, 1776	R	f.	LC	77,78	8	26	14	30	-	2,40	15,6 ± 12,44
Cisticolidae											
Cisticola cantans (Heuglin, 1869)	R	f.	LC	22,22	2	-	3	1	-	0,24	1,2 ± 1,30
Cisticola guinea Lynes, 1930	R	f.	LC	11,11	-	-	-	-	6	0,48	1,2 ± 2,68
Prinia subflava (J. F. Gmelin, 1789)	R	f.	LC	5,56	-	2	-	-	-	0,16	0,4 ± 0,89
Acrocephalidae											
Acrocephalus schoenobaenus (Linné, 1758)	P	E	LC	66,67	16	16	8	-	-	1,28	8 ± 8,00
Hirundinidae											
Hirundo smithii Leach, 1818	R	E	LC	22,22	3	1	2	-	-	0,24	1,2 ± 1,30
Pycnonotidae											
Atimastillas flavicollis (Swainson, 1837)	R	F	LC	5,56	4	-	-	-	-	0,32	0,8 ± 1,79
Pycnonotus barbatus (Desfontaines, 1789)	R	f.	LC	27,78	5	2	-	4	-	0,40	2,2 ± 2,28
Sturnidae											
Lamprotornis caudatus (Muller, 1776)	R	f.	LC	5,56	-	-	-	3	-	0,24	0,6 ± 1,34
Turdidae											
Turdus pelios Bonaparte, 1850	R	f.	LC	5,56	1	-	-	-	-	0,08	0,2 ± 0,45
Nectariniidae											
Chalcomitra senegalensis (Linné, 1766)	R	f.	LC	5,56	-	-	-	1	-	0,08	0,2 ± 0,45
Ploceidae											
Euplectes franciscanus (Isert, 1789)	M	f.	LC	27,78	71	16	23	-	-	5,68	22 ± 29,2

Ploceus cucullatus (Statius Muller, 1776)	R	f.	LC	22,22	-	8	-	13	8	1,04	5,8 ± 5,67
Estrildidae											
Lagonosticta senegala (Linné, 1766)	R	V/f	LC	72,22	9	6	6	17	3	1,36	8,2 ± 5,36
Uraeginthus bengalus (Linné, 1766)	R	V/f	LC	11,11	3	-	-	-	-	0,24	0,6 ± 1,34
Lonchura cucullata (Swainson, 1837)	R	f.	LC	50,00	105	93	13	-	-	8,39	42,2 ± 52,3
Motacillidae											
Anthus leucophrys Vieillot, 1818	R	f.	LC	83,33	6	5	3	6	7	0,56	5,4 ± 1,52
Motacilla flava Linné, 1758	P	f.	LC	5,56	2	-	-	-	-	0,16	0,4 ± 0,89

Biogeo: biogeographical status; R: resident; M: intra-African migrant; P: Palearctic migrant; E: wetlands; F: secondary forests; V: anthropophilic species. IUCN: level of threat; LC: Least concern; Habitat: preferred habitat; Fo: frequency of occurrence; JAN: January; FEB: February; MAR: March; APR: April; MAY: May; Fr: relative frequency; MET: mean and Ecartype.

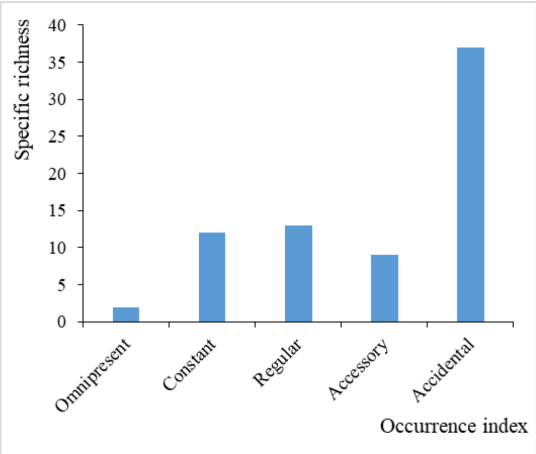

Fig. 3. Occurrence categories of birds at the Fodonition dam lake

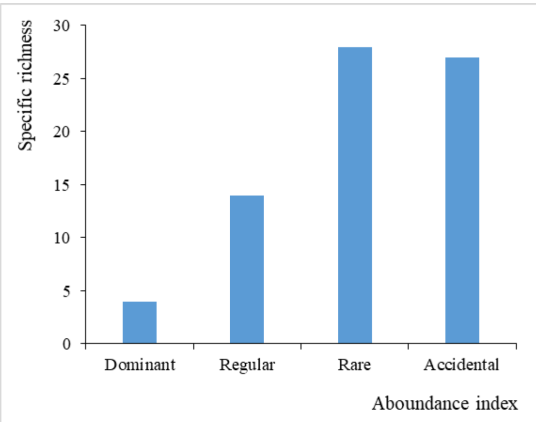

Fig. 4. Bird abundance categories at Fodonition dam lake

Bird relative abundance

The bird population is dominated by four species (Bubulcus ibis (192.2 ± 191.06), Vanellus spinosus (36.8 ± 16.90), Euplectes franciscanus (22 ± 29.18), Lonchura cucullata (42.2 ± 52.29)) with a relative frequency of over 5%. These four species alone account for 56.27% of the population, with a cumulative total of 704 individuals. Beyond these species, there are 14 regular species with a cumulative abundance of 357 individuals or 28.54%; 28 rare species with a total of 152 individuals or 12.15%; 27 accidental species with a total of 38 individuals or 3.04% (Fig. 4).

Biogeographic status

Based on biogeographical origin, 48 species are resident, i.e. 65.75% of overall species richness, for a total of 557 individuals (44.52%); six species are intra-African migrants (8.22%) with 25 individuals (2%) and six species are Palearctic migrants (8.22%) with a total of 42 individuals (3.36%). These are *Actitis hypoleucos*, *Tringa ochropus*, *Tringa nebularia*, *Tringa glareola*, *Acrocephalus schoenobaenus* and *Motacilla flava*. Thirteen species have a mixed status. Of these, nine species (12.33%) have resident populations plus intra-African migratory populations (R/M). These are *Ardeola ralloides*, *Bubulcus ibis*, *Egretta garzetta*, *Ardea brachyrhyncha*, *Dendrocygna viduata*, *Crex egregia*, *Prophyrio alleni*, *Rostratula benghalensis* and *Vanellus senegallus*. Together, these species account for 575 individuals (45.96%). Three species are both resident and migratory in the Palearctic (R/P), with a total of four individuals (0.32%). These are *Gallinula* *chloropus*, *Ardea purpurea* and *Nycticorax nycticorax*. One species, *Milvus migrans*, is an intra-African migrant and Palearctic migrant (M/P) (1.37%), with an abundance of 48 individuals (3.84%) (Table 1).

Preferred habitat and conservation status

Of all the species in the area, 26 are waterbirds (35.62%), which means they have a special relationship with the lake. Together, these waterbirds number 772 individuals, or 61.71% of overall abundance. Most of the species present (41 species; 56.16%) prefer to live in open environments, with a bird load of 452 individuals (36.13%). Four other species (5.48%) prefer wooded to forested environments, with a total of seven individuals (0.56%). In addition, two species, *Lagonosticta senegala* and *Ureaginthus bengalus*, which are more anthropophilic, also frequent the dam lake, with a total of 20 individuals (1.60%).

All the species inventoried on the site are of minor concern according to the IUCN red list (LC). The bird community therefore includes no internationally threatened species.

Temporal variations in the bird community

There is considerable variation in the bird community over the months. Species richness and abundance decrease with their highest values observed in January (58 species; 1007 individuals). The lowest values are observed in May, with 25 species and 217 individuals (Fig. 5).

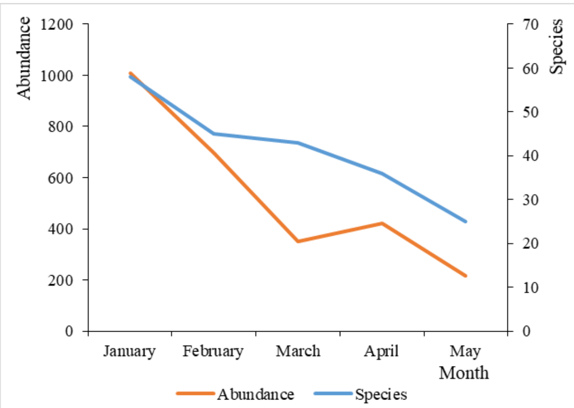

Fig. 5. Variations in bird species richness and abundance over the months on the Nindjo dam lake from January to May 2022

Diversity indices are relatively low. Indeed, the most diverse month is March with H' = 3.23 and J = 0.86, followed by April (H' = 2.69; J = 0.75). The month with the lowest Shannon index is February (H' = 2.31). However, the lowest equitability value was recorded in January (J = 0.58) (Table 2).

Table 2. Shannon and equitability indices by month

Month	Shannon index	Equitability index
January	2,37	0,58
February	2,31	0,61
March	3,23	0,86
April	2,69	0,75
May	2,37	0,74

A total of 17 species were observed at least once every month, with highly fluctuating abundances. These are *Dendrocygna viduata*, *Streptopelia semitorquata*, Centropus senegalensis, *Crinifer piscator*, *Butorides striata*, *Ardeola ralloides*, *Ardea ibis*, *Egretta garzetta*, *Microcarbo africanus*, *Vanellus spinosus*, *Vanellus senegallus*, *Actophilornis africanus*, *Tringa nebularia*, *Milvus migrans*, *Laniarius barbarus*, *Lagonosticta senegala* and *Anthus leucophrys*. Sixteen species were observed in January alone. These are *Ptilopachus petrosus*, *Apus affinis*, *Chrysococcyx klaas*, *Nycticorax nycticorax*, *Ardea purpurea*, *Ardea brachyrhyncha*, *Vanellus lugubris*, *Tringa glareola*, *Lophoceros semifasciatus*, *Merops nubicus*, *Falco cuvierii*, *Terpsiphone rufivnter*, *Atimastillas flavicollis*, *Turdus pelios*, *Ureaginthus bengalus*, *Motacilla flava*. *Poicephalus senegallus* and *Prinia subflava* were only observed in February. Two species, *Clamator levaillanti* and *Tringa ochropus*, were only seen in March. *Cuculus gularis*, *Lamprotornis caudatus* and *Chalcomitra senegalensis* were only recorded in April. *Cisticola marginatus* and *Crex egregia* were only observed in May. In terms of similarity values (Table 3), February and March are the closest months, with a similarity value of 86.36%. Similarity is also relatively high for January and February (73.79%) and January and March (73.27%). On the other hand, similarity is lowest for January and May (48.19%). It is relatively low for February and May (57.14%) and March and May (58.82%).

Table 3. Similarity index values between study months

Months	January	February	March	April	May
January		73,79 %	73,27 %	63,83 %	48,19 %
February	73,79 %		86,36 %	71,60 %	57,14 %
March	73,27 %	86,36 %		68,35 %	58,82 %
April	63,83 %	71,60 %	68,35 %		68,85 %
May	48,19 %	57,14 %	58,82 %	68,85 %	

The dendrogram based on Euclidean distances shows an arrangement of months into three groups. These Euclidean distances are calculated by taking into account the specific richness of birds per month. The first group comprises the month of January. The second group comprises the months of April and May. The last group comprises the months of March and February (Fig. 6).

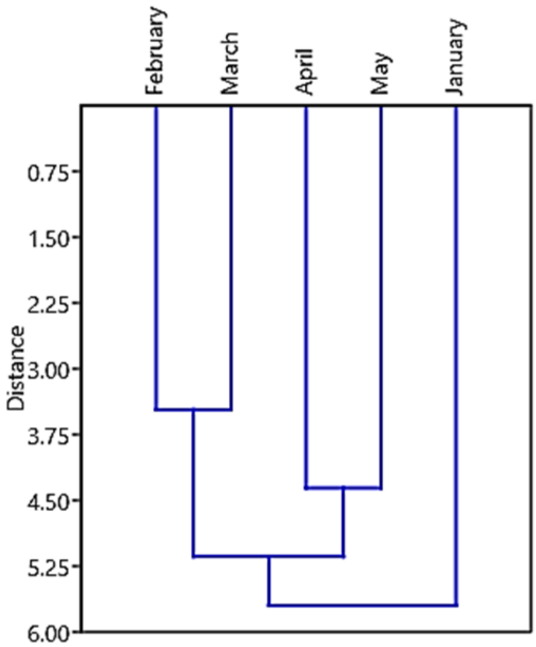

Fig. 6. Dendrogram showing the grouping of months based on their similarity

Similarly, correspondence factor analysis allows us to group the months along the x-axis into two groups based on their respective bird communities. January and February are correlated with the negative side of the axis. These months are associated with *Nettapus auritus*, *Ardeola ralloides*, *Acrocephalus schoenobanaeus*, *Halcyon leucocephala*, *Euplectes franciscanus*, *Rostratula benghalensis*. March, April and May form the second group and are positively correlated with the axis. These three months are most closely associated with *Pycnonotus barbatus*, *Turtur abyssinicus*, *Kaupifalco monogrammicus*, *Elanus caeruleus*, *Halcyon malimbica*, *Crinifer piscator*, *Zapornia flavirostra*, *Anthus leucophrys* (Fig. 7).

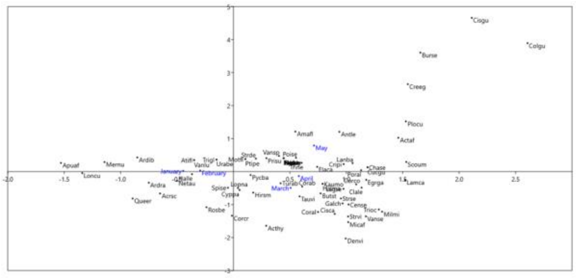

Fig. 7. Distribution of birds by month on the Fodonition dam lake

Spatial variations in avifauna at Nindjo dam

At open water level, 28 bird species were inventoried. Aquatic vegetation is dominated by resident species, with 21 out of 48 species. The shoreline is home to 31 species. Of these, 18 are resident. The grassland has a total of 37 species, 23 of which are resident, eight intra-African migrants and two Palearctic migrants. In the cultivated environment, 17 species were identified, including nine residents (52.84%), four intra-African migrants (23.52%), one palearctic migrant (5.88%) and three species of mixed origin (17.64%). The tree savannah is the most diverse environment, with 54 species dominated by resident species (Fig. 5). The Generalized Linear Model confirms that the habitat type observed in the wetland significantly influences the distribution of bird species at the Fodonition Nindjo dam (GLM: ddl=5; W=32.03; $p<0.0001$).

The diversity indices for the different habitat types in the lake range from 2.73 to 3.60. The highest diversity is observed in the wooded savannah (3.60). The lowest diversity is found in the open water (2.73) and the cultivated environment (2.66). Equitability indices ranged from 0.98 to 0.94. The equitability index is very high for all habitats. The maximum value is observed in the cultivated environment (0.98) and the minimum in aquatic vegetation and grassland (0.94).

Table 4. Sorensen's similarity indices for pairs of different habitats identified on Fodonition's Nindjo dam lake from January to March 2022

	Open water	Aquatic vegetation	Bank	Meadow	Cultivated area	Wooded savannah
Open water		62,50%	42,85%	16,32%	15,18%	6,66%
Aquatic vegetation			51,85%	32,78%	31%	25%
Bank				50,90%	56,41%	36,36%
Meadow					56,52%	65,75%
Cultivated area						42,10%
Wooded savannah						

The Sorensen similarity indices (Si) of the environments range from 6.67% to 65.75%. The highest similarity is observed for the savannah-grassland habitats (Si = 65.75%). The lowest similarity value is obtained for savannah-tree-freshwater habitats (Si =6.66%) (Table 4).

Comparison of bird abundances by habitat using the Generalized Linear Model shows no significant difference ($p > 0.05$).

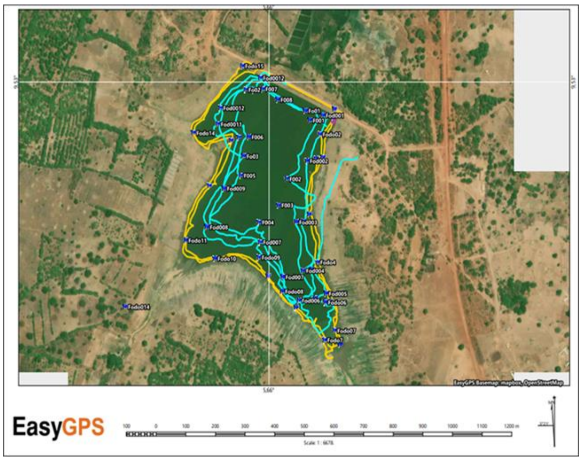

Fig. 8. Mapping of water recession at Fodonition's Nindjo dam from January to May 2022

The effect of receding water on birdlife

Water recession is the result of drought, the irrigation of rice paddies and fish ponds in the lowlands, and the irrigation of above-ground crops using motor-driven pumps. Fig. 8. shows the estimated water recession observed during the study period, obtained from weekly GPS readings. Based on this mapping, the measured water recession is estimated at over 150 metres. Evaluation of water recession on bird diversity using Spearman's correlation test reveals that species richness ($r = -0.81$; $p < 0.05$) and abundances ($r = -0.87$; $p < 0.001$) are negatively correlated with water recession. Furthermore, the Generalized Linear Model shows that the distribution of bird species (GLM: ddl= 2; W= 315.3; $p<0.0001$) and bird abundances (GLM: ddl= 2; W= 7.9; $p<0.05$) are a function of water recession.

DISCUSSION

Avifauna inventories of the Fodonition Nindjo dam wetland from January to May 2022 identified 73 species. This period corresponds to the dry season (January, February, March) and the start of the rainy season (April, May). During the dry months, the lake's water level drops significantly. In addition to the effect of evaporation, large quantities of water are drawn from the lake using motor-driven pumps and by opening the dam gates to water the surrounding crops (market gardening, rice growing, fish farming). As the dam dries up, the way in which the banks of the dam are used for market gardening has an impact on local biodiversity. As the water recedes, farmers gradually transform the emerged land into new crop squares, so as to be as close as possible to the water. To achieve this, they unfortunately destroy habitats such as phragmites, rushes and tall grasses that provide shelter for waterbirds, some of which breed there (Rasolonjatovo *et al.*, 2024). All these factors would have a significant impact on birds, whose species richness and abundance dropped significantly from January to May. Indeed, on lakes in the town of Yamoussoukro less subject to the influence of drainage and cultivation practices, variations in bird populations were less significant (Konan and Yaokokoré-Béibro, 2015). Similarly, this significant drop in diversity in the avifauna of the site studied is contrary to the findings made in the internationally important wetland of Grand-Bassam, where the structure of the avifauna is certainly influenced by the seasons, but from one season to another the specific richness and abundance remain relatively stable (Odoukpé *et al.*, 2023).

The Nindjo dam lake in Fodonition is one of the very first rural wetlands of artificial origin to be the subject of an ornithological inventory in the north of the country, after that of the Sologo dam (Ehouman *et al.*, 2023). In comparison with these two environments, in terms of overall species richness, 120 bird species have been observed on the Sologo dam lake. This can be justified by the longer study period of seven months, compared with the present study site. However, it should be noted that the same number of waterbirds was observed at both sites (26 species). On the other hand, in the center of the country, the number of waterbird species observed on the lakes is greater and represents around double that observed in the north of the country, i.e. 47 species (Konan and Yaokokoré-Béibro, 2015). On the other hand, in the rice-growing wetlands of central Côte d'Ivoire, the proportion of waterbirds is much the same (32 species) (Kouadja *et al.*, 2023) as in the dams of northern Côte d'Ivoire. These differences could be explained by the fact that the waterbird community in the Poro region (northern Côte d'Ivoire) is essentially made up of resident species, and less suitable for migratory waterbirds. Compared with the bird fauna of the Kisangani wetlands in the Democratic Republic of Congo (Bapeamoni *et al.*, 2007), which is rich in 71 species, the diversity of birds in the Fodonition dam lake is very low at this time of year. In addition to the fact that the area is less suitable for migratory species, this low level of richness can be explained by the significant pressure exerted by man on the environment, in a context of drought and increasing scarcity of water resources. All the more so as in the same northern region of Côte d'Ivoire, but in a protected environment such as the Comoé National Park (CNP), 47 waterbird species have been inventoried (Zago *et al.*, 2024). However, this result needs to be put into perspective, given that the study in the CNP lasted two years, compared with only five months for the present study.

Concerning the entire community of birds observed on the Fodonition dam lake, the 73 species observed are lower than the 188 species inventoried on the urban and peri-urban lakes of Yamoussoukro (Konan *et al.*, 2015), as well as the 120 species observed on the Sologo dam lake (Ehouman *et al.*, 2023) but, higher than the 63 species observed on the Koko dam in the city of Korhogo (Niamien *et al.*, 2019). In fact, the strong difference observed between the two rural wetlands is more related to the duration of the inventory, since the study on Lake Sologo was carried out over a full year. Furthermore, the low anthropization of our study site compared to the urban dam of Koko (12 months of inventory) on the one hand and the heterogeneity of habitats offered by the Nindjo dam of Fodonition (water, aquatic vegetation, bank, grassland, mango and cashew orchards and market garden crops) could explain this difference (Yaokokoré-Béibro *et al.*, 2015b; Ahmad and Bhat, 2017; Hervé *et al.*, 2020).

In terms of threats, the retreat of water due to drought has resulted in the appearance of mudflat beaches, a preferred feeding area for limnicolous bird species. However, these feeding grounds are exploited by market gardeners. This anthropic pressure would result in the departure of mud specialist birds, with the corollary loss of biodiversity (Ahmad and Bhat, 2017; Hervé *et al.*, 2020). Illegal fishing could pose a long-term threat to waterbird populations. Some of the site's waterbirds are fish-eaters. Overexploitation could lead to a reduction in fish stocks, resulting in the relocation of these birds to other sites. This would increase their vulnerability (Ahmad and Bhat, 2017; Hervé *et al.*, 2020).

CONCLUSION

A study of the distribution of avifauna at the Nindjo de Fodonition dam in Korhogo revealed 73 species. The order Passeriformes and the families Ardeidae and Columbidae were the best represented. Within the population, resident species and those of open environments were in the majority. The highest diversity was observed in the wooded savannah, while the lowest diversities were recorded in the riverbank, water and cultivated areas. Qualitative spatial variations showed that the order Charadriiformes was best represented in water and aquatic vegetation, while in other environments the order Passeriformes was best represented. In terms of families, the Ardeidae family was in the majority in water, aquatic vegetation and banks, while in other environments the Columbidea family was predominant. Three threats were identified: water recession, agriculture and illegal fishing. Assessment of the effect of receding water on diversity resulted in significant reductions in species richness and abundance. To give this bird community a chance of survival, this potential breeding site should be protected from the influence of anthropogenic activities that result in the loss of biodiversity.

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REFERENCES

Ahmad MA, Bhat IA. 2017. Bird abundance of a flood plain wetland of Kashmir Himalayas. International Journal of Zoology Studies **2**(1), 10–13.

Bánki O, Roskov Y, Vandepitte L, DeWalt RE, Remsen D, Schalk P, Orrell T, Keping M, Miller J, Aalbu R, Adlard R, Adriaenssens E, Aedo C, Aescht E, Akkari N, Alonso-Zarazaga MA, Alvarez B, Alvarez F, Anderson G. 2021. Catalogue of Life Checklist (Annual Checklist 2021). Catalogue of Life. https://doi.org/10.48580/d4sb

Bapeamoni A, Amundala D, Bakondangama B, Danadu M, Kadange N, Kaswera K, Upoki A. 2007. Les oiseaux d'eau et de milieux humides de la région de Kisangani (RDC): diversité et abondance spécifiques. Ostrich **78**(2), 501–504. https://doi.org/10.2989/OSTRICH.2007.78.2.61.175

Barbault R. 1992. Ecologie des peuplements: structure, dynamique et évolution. Masson, Paris, France, 267 p.

Bibby C, Martin J, Marsden S. 1998. Bird survey in expedition field techniques. Royal Geographical Society, London, England, 137 p.

Bibby CJ, Burgess ND, Hill DA. 1992. Bird Census Techniques. Cambridge University Press, Cambridge, 257 p.

Boko Koiadia AN, Cissé G, Koné B, Dedy S. 2016. Variabilité climatique et changements dans l'environnement à Korhogo en Côte d'Ivoire : mythes ou réalité ? European Scientific Journal **12**(5), 158–176. https://doi.org/10.19044/esj.2016.v12n5p158

Borrow N, Demey R. 2001. Birds of western Africa. Christopher Helm, London, England, 832 p.

Borrow N, Demey R. 2008. Guide des oiseaux de l'Afrique de l'Ouest. Delachaux et Niestlé, Paris, France, 511p.

Chappuis C. 2000. Oiseaux d'Afrique. 15 CDs. Société d'étude Ornithologique, Paris, France.

Dajoz R. 1985. Précis d'Ecologie. Dnod, Paris, 489p.

Ehouman BF, Niamien CJM, Konan EM. 2023. Premières données sur la communauté des oiseaux du lac de barrage de Sologo, Département de Korhogo, Côte d'Ivoire. European Scientific Journal **19**(27), 18–35. https://doi.org/10.19044/esj.2023.v19n27p18

Fromageot A. 2007. Colonisation maraîchère des rives des petits barrages: une nouvelle géographie. In: L'Eau en Partage: les petits barrages de Côte d'ivoire, Cecchi P (Ed). Edition IRD, Paris, 229–243.

Hervé D, Randriambanona H, Ravonjimalal HR, Ramanankierana H, Rasoanaivo HS, Boahanta R, Carrière SM. 2020. Perceptions des fragments forestiers par les habitants des forêts tropicales humides malgaches. Bois et forêts des tropiques **345**, 43–62. https://doi.org/10.19182/bft2020.345.a31929

Kanga HK, Kaudjhis JP. 2016. La sécheresse dans le « quart Nord-Est » de la Côte d'Ivoire : de la réalité climatique à la perception paysanne. European Scientific Journal **12**(29), 214–231. https://doi.org/10.19044/esj.2016.v12n29p214

Konan EM, Niamien CJM, Guétondé VF, Approu SO, Yaokokoré-Béibro KH. 2023. Données préliminaires sur les oiseaux du campus universitaire Peleforo Gon Coulibaly de Korhogo, dans le septentrion de la Côte d'Ivoire. European Scientific Journal **19**(24), 161–184. https://doi.org/10.19044/esj.2023.v19n24p161

Konan EM, Yaokokoré-Béibro KH, Odoukpé KSG. 2015. Richesse spécifique et abondance des oiseaux des dix lacs urbains de la ville de Yamoussoukro, dans le centre de la Côte d'Ivoire. International Journal of Innovation and Applied Studies **10**(1), 217–225.

Konan EM, Yaokokoré-Béibro KH. 2015. Variation temporelle du peuplement aviaire des écosystèmes lacustres de la ville de Yamoussoukro, centre de la Côte d'Ivoire. International Journal of Biological and Chemical Sciences **9**(6), 2566–2581. https://doi.org/10.4314/ijbcs.v9i6.5

Kouadja KES, Odoukpé KSG, Konan EM, Yaokokoré-Béibro KH. 2023. Composition and abundance of rice field birds in the District of Yamoussoukro (central Côte d'Ivoire). Journal of Applied Biosciences **186**, 19571–19587. https://doi.org/10.35759/JABs.186.4

Kouassi KD, Diaby M, Soro Y, N'Da K. 2020. Faune ichtyologique du lac de barrage Solomougou (Korhogo, Côte d'Ivoire). International Journal of Biological and Chemical Sciences **14**(7), 2528–2537. https://doi.org/10.4314/ijbcs.v14i7.13

Le Guen T. 2002. Les barrages du Nord de la Côte d'Ivoire: développement socio-économique et état sanitaire des populations. Thèse de doctorat, Université de Bretagne Occidentale, Brest, France, 467p.

Le Guen T. 2004. Le développement agricole et pastoral du Nord de la Côte d'Ivoire : problèmes de coexistence. Les Cahiers d'Outre-Mer **226–227**, 259–288. https://doi.org/10.4000/com.563

Niamien CJM, Konan EM, Kouadja KES, Yaokokoré-Béibro KH, N'Goran KE. 2020. Spatial distribution of the community of birds of the Koko urban dam and its surroundings (Korhogo, Côte d'Ivoire). Journal of Biodiversity and Environmental Sciences **17**(2), 80–93. https://doi.org/10.4000/etudesrurales.8207

Niamien CJM, Konan EM, Odoukpé KSG, Yaokokoré-Béibro KH, N'goran KE. 2019. Premières données sur les variations saisonnières de la communauté d'oiseaux du barrage urbain de Koko (Korhogo, Côte d'Ivoire). Journal of Animal & Plant Sciences **41**(2), 6926–6939. https://doi.org/10.35759/JAnmPlSci.v41-2.6

Odoukpé KSG, Yaokokoré-Béibro HK, Kouadio PK, Konan ME. 2014. Dynamique du peuplement des Oiseaux d'une riziculture et ses environs dans la zone humide d'importance internationale de Grand-Bassam. Journal of Applied Biosciences **79**, 6909–6925. https://doi.org/10.4314/jab.v79i0.6

Odoukpé SGK, Gueye FM, Koné SY, Yaokokoré-Béibro HK. 2023. Diversité, structure du peuplement et distribution des oiseaux d'eau de la zone humide de Grand-Bassam (Sud-Est, Côte d'Ivoire). International Journal of Biological and Chemical Sciences **17**(4), 1430–1442. https://dx.doi.org/10.4314/ijbcs.v17i4.12

Rasolonjatovo D, Benjara A, Razafiherison R, Fabrice S, Razafimanjato G, Réné de Roland L-A. 2024. Facteurs déterminants l'abondance du Grèbe malgache *Tachybaptus pelzelnii* dans les lacs volcaniques de l'Aire Protégée Bemanevika, Hautes Terres du Nord de Madagascar. Afrique SCIENCE **24**(2), 92–107.

Thiollay JM. 1971. L'avifaune de la région de Lamto (Moyenne Côte d'Ivoire). Annales de l'Université d'Abidjan **4**, 1–132.

UICN. 2024. IUCN Red List of Threatened Species. Version 2014.2. www.iucnredlist.org. Consulté le 15 décembre 2024.

Yaokokoré-Béibro HK, Koné SY, Odoukpé SGK, Gueye FM. 2015a. Avifaune d'un milieu marécageux urbain dans la commune de Cocody (Abidjan, Côte d'Ivoire). International Journal of Innovation and Scientific Research **18**(1), 99–108.

Yaokokoré-Béibro KH, Gueye FM, Koné YS, Odoukpé SGK. 2015b. Biodiversité urbaine des Oiseaux dans la Zone humide d'Importance Internationale de Grand-Bassam (Sud-Est de la Côte d'Ivoire). International Journal of Innovation and Applied Studies **11**(2), 339–349.

Yaokokoré-Béibro KH. 2001. Avifaune des forêts classées de l'Est de la Côte d'Ivoire: données sur l'écologie des espèces et effet de la déforestation sur les peuplements. Cas des forêts classées de la Béki et de la Bossématié (Abengourou). Thèse de Doctorat, Université de Cocody, Abidjan, 245p.

Zago HM, Kouadio KP, Koué-Bi TM, Yaokokoré-Beibro KH. 2024. Diversité et Abondance Relative des Oiseaux d'Eau du Parc National de la Comoé, Côte d'Ivoire. European Scientific Journal **20**(3), 116–133. https://doi.org/10.19044/esj.2024.v20n3p116