INNSPUB

Journal of Biodiversity and Environmental Sciences (JBES)
ISSN: 2220-6663 (Print) 2222-3045 (Online)
Vol. 17, No. 2, p. 80-93, 2020
http://www.innspub.net

RESEARCH PAPER OPEN ACCESS

Spatial distribution of the community of birds of the Koko urban dam and its surroundings (Korhogo, Côte d'Ivoire)

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Article published on August 20, 2020

Key words: Wetland, birds diversity, habitat effect, Korhogo, Côte d'Ivoire.

Abstract

The spatial distribution of the bird community of the Koko urban dam and its surroundings (Korhogo; Côte d'Ivoire), was studied for the first time from February 2016 to January 2017. The inventory method consisted of a slow walk, punctuated by a 15-minute stop, along the banks of the dam in order to test the effect of habitats on the distribution of the bird community. A total of 1,613 birds, divided into 63 species belonging to 32 families and grouped into 14 orders, were inventoried. The Passeriformes order and the Ardeidae family were the best represented. Diversity was highest in the wooded savannah and the prairie. Migratory species were most numerous in the water while resident species were best represented in the prairie and wooded savannah. The distribution of bird species has shown that prairie and tree savannah have been the preferred habitats of this community. Therefore, these refuge habitats must be preserved in light of the anthropogenic pressures experienced by this ecosystem, which could pose a threat to this community.

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Introduction

Human activities exert pressure on natural ecosystems with the consequence of losing biodiversity (Khaffou *et al.*, 2013; Konan *et al.*, 2014). For sustainable and rational ecosystems management, knowledge of communities, habitat specificities, population change and threats must be taken into account (Conservation International, 2001).

Birds have a variety of ecological, pharmacological and conservation interests (Benayas *et al.*, 2017; Platel and Ravel, 2019). Despite these importances, little data is available on their habitats. Habitats are refuges in response to different pressures. Their destruction would lead to downsizing and hence their disappearance (Ahmad and Bhat, 2017; Platel and Ravel, 2019). Therefore, they are essential in the implementation of conservation strategies.

Wetlands are fertile and productive ecosystems (Platel and Ravel, 2019). These environments provide various ecosystem services as well as water on which plant and animal organisms depend for their survival. Man benefits from this in the context of agro-pastoral activities (Odoukpé *et al.*, 2014). These ecosystems are home to variety of habitats with high food resources availability and are therefore home to a high diversity of avifauna (Patole *et al.*, 2009; Ahmad and Bhat, 2017; Platel and Ravel, 2019). Indeed, these wetlands are sites of nutrition, wintering and breeding for many migratory and resident waterbird species, some of which are on the International Union for Conservation of Nature's Red List (El Agbani and Dakki, 2005; Borrow and Demey, 2008; Yaokokoré-Béibro, 2010).

Wetland birds would therefore provide essential information on the health and conservation status of these ecosystems in order to determine their conservation value (Kumar and Gupta, 2009). However, these fragile ecosystems, with high ecological and conservation potential are threatened with disappearance due to anthropogenic activities, with the consequent loss of biodiversity (Williams, 1993; Brooks *et al.*, 2007; Ahmad and Bhat, 2017).

In Côte d'Ivoire, work on avifauna was mainly carried out in forest and urban areas, in the southern part of the country and incidentally in the centre and west (Kouadio *et al.*, 2014; Odoukpé *et al.*, 2014; Konan *et al.*, 2015; Yaokokoré-Béibro *et al.*, 2015 a, b; Zéan *et al.*, 2018). Ornithological studies of wetlands are few and have been concentrated in Grand-Bassam, Yamoussoukro and incidentally in Abidjan (Odoukpé *et al.*, 2014; Konan *et al.*, 2015; Yaokokoré-Béibro *et al.*, 2015 a, b). The north of the country is home to various agro-pastoral dams, which have been the subject of very few studies, relating to global and seasonal variations in avifauna (Niamien *et al.*, 2019 a, b). No studies have focused on spatial variations. To fill this information gap, we conducted this study. It is a contribution to a better knowledge of birds ecology in order to ensure sustainable and rational management. It specifically aims to (i) inventory the birds of the Koko urban dam and (ii) examine how bird communities use their habitats.

Materials and methods

Study Area

The study was conducted in the department of Korhogo (9°34'of Latitude North and 5°37' of Longitude) and more precisely at the Koko urban dam. In this environment, around the wather body, are arranged in a concentric circles order three habitats: the bank, the prairie and the tree savannah (Fig. 1). The water environment consists of the body of water of the dam. Then, follows a strip of land, the bank. This bank can extend due to the removal of water and constitute a mudflat beach. Then there is the prairie, which is a grassy plain. This plain is flooded in the rainy season. Finally, the tree savannah, the last environment, which is a plain with scattered trees and shrubs.

Illegal fishing activities take place on the wather (Fig. 2). In addition, around the dam, agricultural activities take place, particulary market crops (Fig. 3) with the use of fertilizers and pesticides. These inputs are driven into the dam water by runoff during the rainy season. Among these inputs, fertilizers are the basis for the establishment of aquatic plant (Fig. 4).

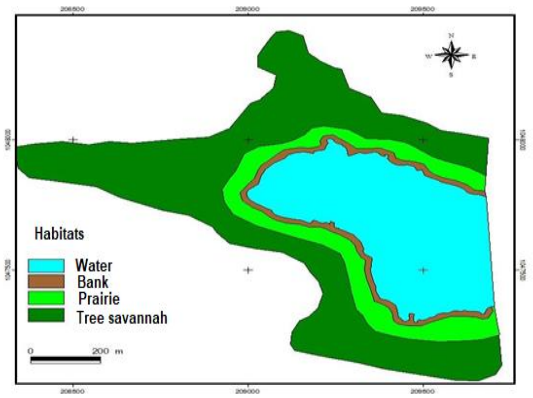

Fig. 1. Habitats of the Koko urban dam ecosystem in Korhogo.

Fig. 2. Illegal fishing at the Koko urban dam in Korhogo.

Fig. 3. Market gardening around the Koko urban dam in Korhogo.

Fig. 4. Aquatic palnts on the Koko urban dam in Korhogo.

The climate of the town of Korhogo is subject to a Sudanese-type climate, which consists of two seasons: a dry season (from November to March) and a rainy season (from April to October). Flooding at dams occurs from August to October while drying up occurs from November to December (Coulibaly, 2014).

Data collection

The data relating to the avifauna of the Koko urban dam were collected on an annual cycle from February 2016 to January 2017. The inventory method consisted of a slow walk, punctuated by a 15-minute stop, along the banks of the dam (Yaokokoré-Béibro, 2001; Odoukpé *et al.*, 2014; Yaokokoré-Béibro *et al.*, 2015 a, b; Niamien *et al.*, 2019 b). During this walk, all bird species present on and / or around the water in the various dam habitats previously determined (water and aquatic plant, bank, prairie and tree savannah) (Fig. 1) up to 50 meters from the bank have been identified (Konan *et al.*, 2015; Niamien *et al.*, 2019 b). Visits were carried out in good weather and twice a month. Bird inventories were conducted from 7:00 A.m. to 10:00 A.m., which corresponds to a period of high activity (Bibby *et al.*, 1992; Yaokokoré-Béibro *et al.*, 2015 a, b). All birds seen, heard, flown or in each habitat were identified using the West African Bird Identification Guide (Borrow and Demey 2008). In addition, the songs and cries unknown to the birds were recorded with a dictaphone and recognized thanks to the CD-Rom of the songs and cries of the birds of Africa (Chappuis, 2000).

The sequence of orders and families is consistent with the systematic order of Borrow and Demey (2001). The list of observed species gives for each of them the biogeographical status (Borrow and Demey, 2008) and preferential habitats (Benun *et al.*, 1996; Yaokokoré-Béibro, 2001).

Expression of results

Diversity was estimated using Shannon index defined as follows: $H' = -\sum pi \log_2 pi$ with $pi = (ni/N)$, where ni: number of individuals of a species in a sample and N: total number of individuals of all species in the same sample.

The estimation of species regularity in different habitats was made from the computation of equitability index (E): E = H'/H'max where H'max: maximum value of H', H'max = log2Sobs (Sobs: number of species observed). These indices were calculated using Past software (Version 1.0).

Statistical analysis

Before any analysis, the normal distribution of data was verified using the Shapiro-Wilk test. Data were normalized using the X + 1 transformation. The analysis of variances was used to compare the average numbers of bird species in the different habitats. Following this analysis, the Newman-Keuls comparison and classification test was used to classify habitats based on the average numbers of bird species.

The spatial distributions of bird species per habitat were done thanks to the principal component analysis. The Generalized Linear Model (GLM) was used to test the effect of habitat on bird distribution. All statistical tests were performed with Statistica (Version 7.1) and Past (Version 1.0) software.

Results

Global variations

Global specific composition

Surveys of birds (N=1613 individuals) carried out from February 2016 to January 2017 in the different environments of the Koko dam identified 63 species belonging to 32 families and grouped into 14 orders (Table 1).

Table 1. Species observed in the different habitats of the Koko urban dam in Korhogo from February 2016 to January 2017 (R: Resident, P: Palearctic Migratory, M: Intra-African Migratory ; E: Water, f: open environment, F: secondary forest, FF: primary forest, FF / f: primary forest-secondary forest; a: habitat with high number of bird species, b: habitat with moderate number of bird species; c and d: habitats with weak number of bird species).

orders/Families/Species	Habitats					
	Biogeographic status	Preferred habitats	Water	Bank	Prairie	Tree savannah
SULIFORMES						
Phalacrocoracidae						
Microcarbo africanus (Gmelin, 1789)	R	E	16			
PELECANIFORMES						
Scopidae						
Scopus umbretta Gmelin, 1789	R	E	5			
Ardeidae						
Ixobrychus minutus (Linné, 1766)	R/P	E	9			
Ardeola ralloides (Scopoli, 1769)	R/P	E	8			
Bubulcus ibis (Linné, 1758)	R/M	E			28	
Butorides striata (Linné, 1758)	R	E	32			
Egretta garzetta (Linné, 1766)	R/M/P	E	115			
Ardea purpurea Linné, 1766	R/P	E	3			
Ardea cinerea Linné, 1758	R/P	E	1			
ACCIPITRIFORMES						
Accipitridae						
Elanus caeruleus (Desfontaines, 1789)	R	f				2
Milvus migrans (Boddaert, 1783)	R/M	f				11
Accipiter tachiro (Daudin, 1800)	R	F				1
FALCONIFORMES						
Falconidae						
Falco cuvierii A. Smith, 1830	R	f				1
GALLIFORMES						
Phasianidae						
Francolinus bicalcaratus (Linné, 1766)	R	f			3	
GRUIFORMES						
Rallidae						
Porphyrio alleni Thomson, 1842	R/M	E	52			
CHARADRIIFORMES						
Jacanidae						
Actophilornis africanus (Gmelin, 1789)	R	E	59			
Microparra capensis (A. Smith, 1839)	R/M	E	2			
Charadriidae						
Vanellus senegallus (Linné, 1766)	R/M	E			5	

orders/Families/Species	Habitats					
	Biogeographic status	Preferred habitats	Water	Bank	Prairie	Tree savannah
Vanellus spinosus (Linné, 1758)	R	E		33	89	
Scolopacidae						
Tringa ochropus Linné, 1758	P	E	6			
Tringa glareola Linné, 1758	P	E	4			
Actitis hypoleucos (Linné, 1758)	P	E	19			
COLUMBIFORMES						
Columbidae						
Columba guinea Linné, 1758	R	f		18	22	7
Streptopelia decipiens (Hartlaud Finsch, 1870)	R/M	f				9
Streptopelia semitorquata (Ruppell, 1837)	R	FF/f			2	19
Streptopelia senegalensis (Linné, 1766)	R	f			123	47
MUSOPHAGIFORMES						
Musophagidae						
Crinifer piscator (Boddaert, 1783)	R	f				1
CUCULIFORMES						
Cuculidae						
Chrysococcyx klaas (Stephens, 1815)	R	f				2
Chrysococcyx caprius (Boddaert, 1783)	M	f				5
Centropus senegalensis (Linné, 1766)	R	f			4	14
APODIFORMES						
Apodidae						
Cypsiurus parvus (Lichtenstein, 1823)	R	f				
Apus affinis (J. E. Gray, 1830)	R	f				
CORACIIFORMES						
Alcedinidae						
Alcedo cristata Pallas, 1764	R	E	17			
Halcyon senegalensis (Linné, 1766)	R	f				7
Coraciidae						
Coracias naevius Daudin, 1800	R/M	f				3
BUCEROTIFORMES						
Bucerotidae						
Tockus fasciatus (Shaw, 1811)	R	FF/f				4
Lophoceros nasutus Linné, 1766	R	f				16
PASSERIFORMES						
Hirundinidae						
Hirundo lucida Hartlaub, 1858	R	f			24	
Motacillidae						
Anthus leucophrys Vieillot, 1818	R	f			2	
Motacilla flava Linné, 1758	P	f			3	
Pycnonotidae						
Pycnonotus barbatus (Desfontaines, 1789)	R	f				25
Atimastillas flavicollis (Swainson, 1837)	R	f				1
Thescelocichla leucopleura (Cassin, 1855)	R	F				1
Turdidae						
Turdus pelios Bonaparte, 1850	R	f			4	
Muscicapidae						
Cossypha albicapillus (Vieillot, 1818)	R	f				2
Sylviidae						
Sylvia communis Latham, 1787	P	f			2	
Cisticolidae						
Hypergerus atriceps (Lesson, 1831)	R	f				7
Cisticola galactotes (Temminck, 1821)	R	f			77	
Nectariniidae						
Chalcomitra senegalensis (Linné, 1766)	R	f				1
Laniidae						
Corvinella corvina (Shaw, 1809)	R	f				11
Malaconotidae						
Laniarius barbarus (Linné, 1766)	R	FF				13
Tchagra senegalus (Linné, 1766)	R	f				2
Corvidae						
Ptilostomus afer (Linné, 1766)	R	f			13	21
Corvus albus Müller, 1776	R	f		11	11	2
Passeridae						

orders/Families/Species	Biogeographic status	Preferred habitats	Habitats			
			Water	Bank	Prairie	Tree savannah
Passer griseus (Vieillot, 1817)	R	f				12
Ploceidae						
Ploceus cucullatus (Müller, 1776)	R	f			49	151
Malimbus scutatus (Cassin, 1849)	R	f				1
Euplectes franciscanus (Isert, 1789)	R	f			41	
Euplectes afer (J. F. Gmelin, 1789)	R	f			33	
Estrildidae						
Uraeginthus bengalus (Linné, 1766)	R	f				24
Lagonosticta senegala (Linnaeus, 1766)	R	f			9	
Lonchura cucullata (Swainson, 1837)	R	f			120	114
Fringillidae						
Crithagra mozambica (Statius Muller, 1776)	R	f				2
Total			348	62	664	539
Species number (S)			15 c	3 d	21 b	33 a
Shannon index (H')			2,06	1	2,42	2,5
Equitability (J)			0,76	0,91	0,79	0,71

Overall, the order of Passeriformes with 15 families is the most important (46.87%). The orders moderately represented are the Charadriiformes (N = 3 families: 9.37%), Pelecaniformes and Coraciiformes (N = 2 families: 6.25%) while the other orders are weakly represented with only one family (3.12%) (Fig. 5).

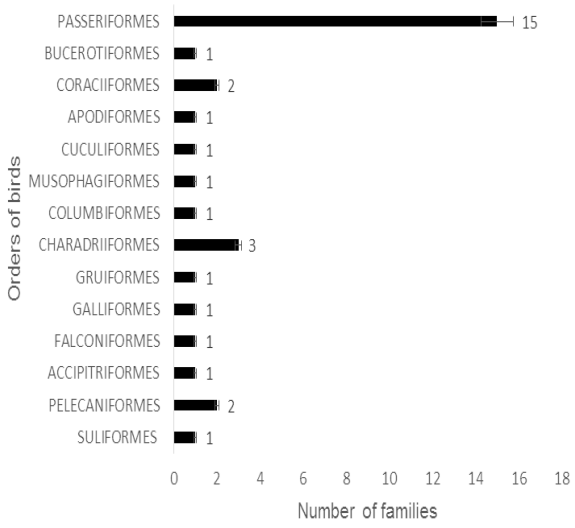

Fig. 5. Global changes in number of bird orders at Koko urban dam and its surroundings in Korhogo from February 2016 to January 2017.

The family of Ardeidae with seven (7) species is the largest (11.11%). It is followed by the families of Estrildidae, Ploceidae, Pycnonotidae, Cuculidae, Columbidae, Scolopacidae and Accipitridae with three (3) or four (4) species (6.35% -4.76%). The rest of the families are poorly represented with one (1) to two (2) species (3.17% -1.58%) (Fig. 6).

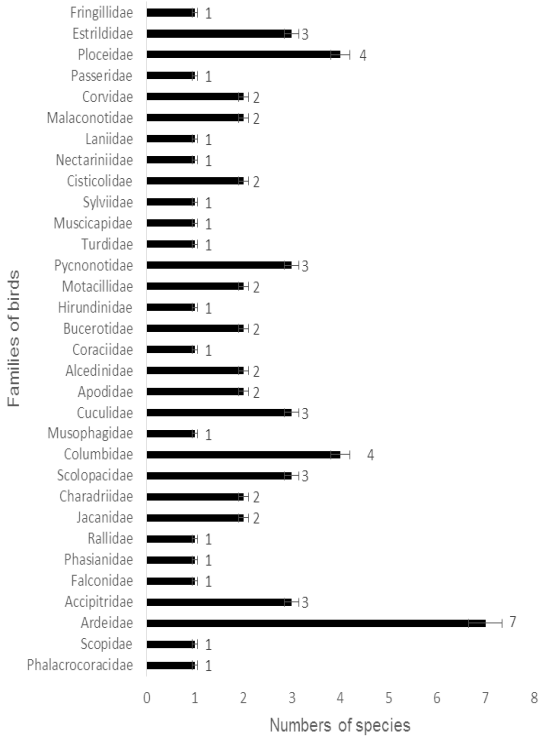

Fig. 6. Global changes in number of bird families at Koko urban dam and its surroundings in Korhogo from February 2016 to January 2017.

Biogeographic status and preferred habitat

Biogeographic status indicates that the population is dominated by resident species with 45 species (71.43%). Palearctic migratory species with five (5) species and intra-African migratory species with one (1) species represent 7.94% and 1.58% of the total population, respectively. The others species are mixed biogeographic status (N = 12 species: 19.05%) (Fig. 7).

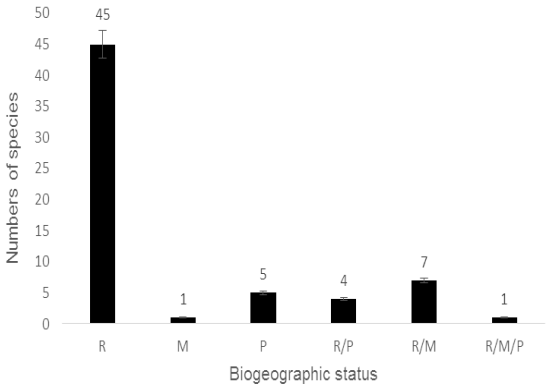

Fig. 7. Biogeographic status of bird species at Koko urban dam and its surroundings in Korhogo from February 2016 to January 2017 (R: resident; M: intra-African migratory; P: palearctic migratory).

Based on prefered habitats, open habitat species are dominat (N = 40 species: 63.49%). Waterbirds are secondarily represented (N = 18 species: 28.57%) while other species in primary and secondary forests are weakly present (N = 5 species: 7.94%) (Fig. 8).

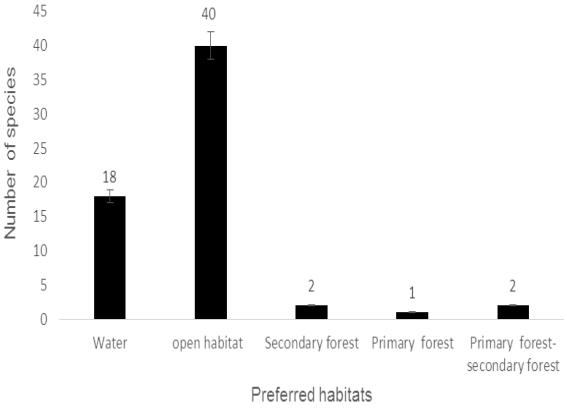

Fig. 8. Distribution of bird species at the Koko urban dam and its surroundings in Korhogo according to preferred habitats from February 2016 to January 2017.

Spatial variations

Spatial composition of supra-specific taxa

Out of a total of 14 orders, the tree savannah with eight orders (8) has the largest number of orders (57.14%). Grassland and water come in second position with six (6) (42.85%) and five (5) (35.71%) orders respectively while the bank hosting the lowest number of orders (N = 3 orders: 21.42%) (Fig. 9).

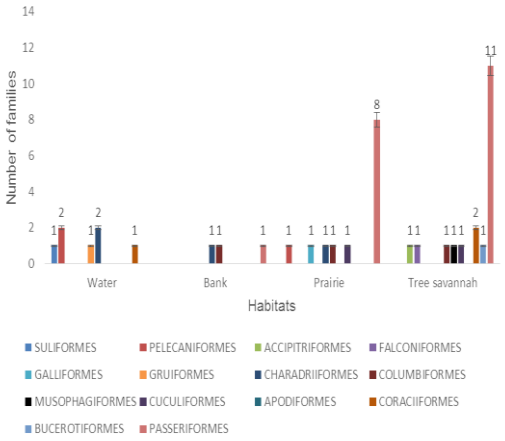

Fig. 9. Spatial distribution of bird orders at Koko urban dam and its surroundings in Korhogo from February 2016 to January 2017.

The specific orders of water habitat are Suliformes and Gruiformes. Within the prairie, only the order of Galliformes is characteristic of this habitat while the orders of Accipitriformes, Falconiforms, Musophagiformes and Bucerotiformes are particular to the tree savannah. No order is specific to the bank (Fig. 9).

In the water habitat, the most important orders are the Pelecaniformes and the Gruiformes with two families each (14.28%). On the bank, three orders of equal importance in number of families (N = 1 family: 7.14%) are observed. These are the ordres of the Charadriiformes, Colombiformes and Passeriformes. At the prairie and tree savannah level, the order of Passeriformes dominates with eight (8) families (57.14%) and 11 families (78.57%) respectively (Fig. 9). The Generalized Linear Model confirms this observation by revealing that the distribution of bird orders has varied with habitat (GLM: dof = 3; W = 37.96; p <0.0001).

Out of a total of 32 families, the largest number of families (N = 19 families) is observed in the tree savannah (59.37%). An average number of families is recorded in the prairie (N = 13 families: 40.62%) while low numbers are noted respectively in water (N = 7 families: 21.87%) and on bank (N = 3 families: 21.87%) (Fig. 10).

The specific families of water are the families of Phalacrocoracidae, Scopidae, Jacanidae and Rallidae. In the prairie, these are the families of Phasianidae, Hirundinidae, Motacillidae, Turdidae and Sylvidae. In the tree savannah, these are the families of Accipitridae, Falconididae, Musophagidae, Bucerotidae, Pycnonotidae, Muscicapididae, Nectaridae, Lanidae and Malaconotidae. No family is specific to the bank (Fig. 10).

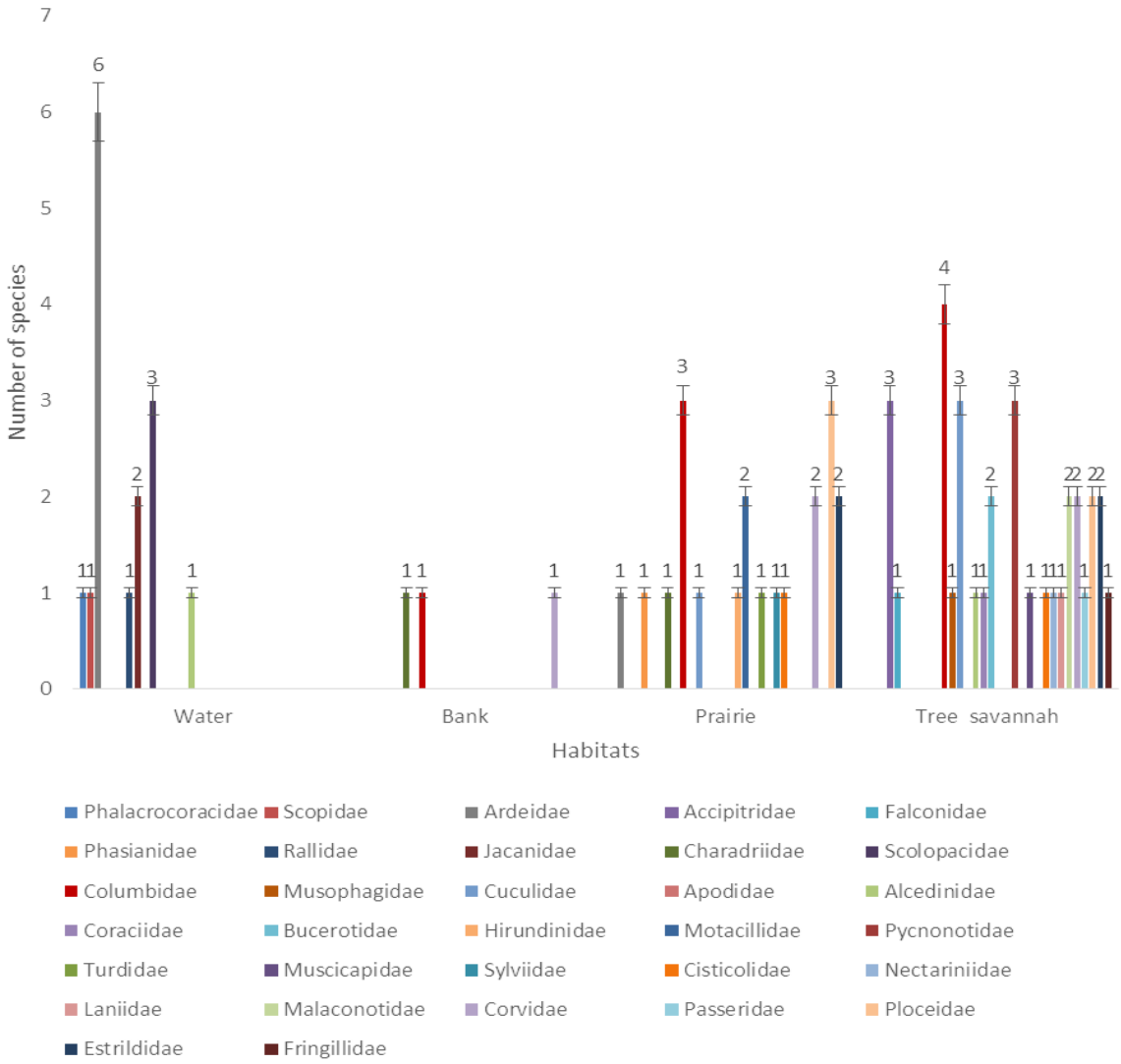

Fig. 10. Spatial distribution of bird families at Koko urban dam and its surroundings in Korhogo from February 2016 to January 2017.

In tree savannah habitat, the dominant family is the Columbidae family with four species (6.35%). The families of Accipitridae, Cuculidae, Pycnonotidae, Bucerotidae, Corvidae, Motacillidae, Ploceidae and Estrildidae are of second importance with a number of species varying between three and two species (4.76%-3.17%) while the rest of the families are poorly represented with one species each (1.58%) (Fig. 10). The distribution of bird families is habitat dependent (GLM: ddl=3; W=24.02; p 0.0001).

In the water habitat, the Ardeidae family with six species is the best represented (9.52%). The families of second importance are the families of Scolopacidae (N = 3 species: 4.76%) and Jacanidae (N = 2 species: 3.17%). The remainning families are the least represented with one species each (1.58%). At the bank, three families of equal importance with each one species are recorded (1.58%). These are the families of Charadriidae, Columbidae and Corvidae. In the prairie, three families dominate with two species.

These are the families of Columbidae (4.76%) and Ploceidae (4.76%). The families moderately represented with two species are the families of Motacillidae, Corvidae and Estrildidae (3.17%), the other families are low importance with each one species (1.58%). In the tree savannah habitat, the dominant family is the Columbidae with four species (6.35%). The families of Accipitridae, Cuculidae, Pycnonotidae, Bucerotidae, Corvidae, Motacillidae, Ploceidae and Estrildidae are the second importance with a number of species varying between three and two species (4.76% -3.17%) while the rest of the families are poorly represented with one species (1.58%) (Fig. 10). Habitat influences the distribution of bird families (GLM: dof = 3; W = 24.02; p <0.0001).

Spatial structure

Based on biogeographic status, migratory species are the most numerous in the water (N = 11 species: 17.46%) compared to resident species (N = 4 species: 6.34%). In the other environments (bank, prairie and tree savannah), the resident species dominate on the bank (N = 3 species: 4.76%), the prairie (N = 17 species: 26.96%) and the tree savannah (N = 27 species: 42.83%) (Fig. 11).

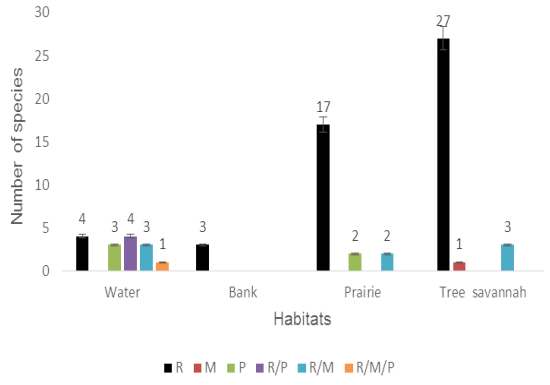

Fig. 11. Spatial distribution of biogeographic status of bird species at Koko urban dam and its surroundings in Korhogo from February 2016 to January 2017.

Global spatial variations of bird species

Comparison of the average number of bird species per habitat using an analysis of variances shows a very highly significant difference (ddl = 3; F = 117.02; p <0.0001). Following this analysis, the Newman-Keuls comparison and classification test revealed that the largest number of bird species is observed in tree savannah. Average numbers are observed in prairie while small numbers of species are recorded in water and bank (Table 1).

Comparison of the number of bird species between habitats by association using an analysis of variances (Table 2), shows that with the exception of the water-prairie association which is significant (p <0. 05), the other associations water-bank, water-tree savannah and bank-prairie are highly significant (p <0.001). In other words, the number of bird species varies significantly from habitat to habitat.

Table 2. Comparison of bird species by habitat of the Koko urban dam in Korhogo from February 2016 to January.

	Water	Bank	Prairie	Tree savannah
Water		p < 0,001	p < 0,05	p < 0,001
Bank			p < 0,001	p < 0,001
Prairie				p < 0,001
Tree savannah				

Variations in bird abundances

A total of 1,613 individuals are counted in the different habitats of the Koko dam ecosystem. In this total, the highest abundances are observed in the prairie (N = 664 individuals: 41.16%) and the tree savannah (N = 539 individuals: 33.25%) respectively. Average abundances are recorded in water (N = 348 individuals: 21.75%) while low numbers are noted on the bank (N = 62 individuals: 3.84%) (Table 1).

Diversity and equitability index

Shannon's diversity index (H') by habitat, reveal that the strongest indices are observed in the tree savannah (H' = 2.5) and the prairie (H '= 2.42) respectively. Average indice is recorded in water (H '= 2.06) and the lowest index is noted on the bank (H' = 1) (Table 1).

The equitability index is highest on the bank (J=0.91) and low on the rest of the other habitats (J=0.71-0.79) (Table 1).

Spatial distribution of bird species

The study of the spatial characterization of bird species in relation to the environments of the Koko dam and its surroundings, by the means of principal component analysis, permitted to distinguish three large groups of environments, which can be divided into two preferred habitats : water and open environment (prairie and tree savannah) (Fig. 12).

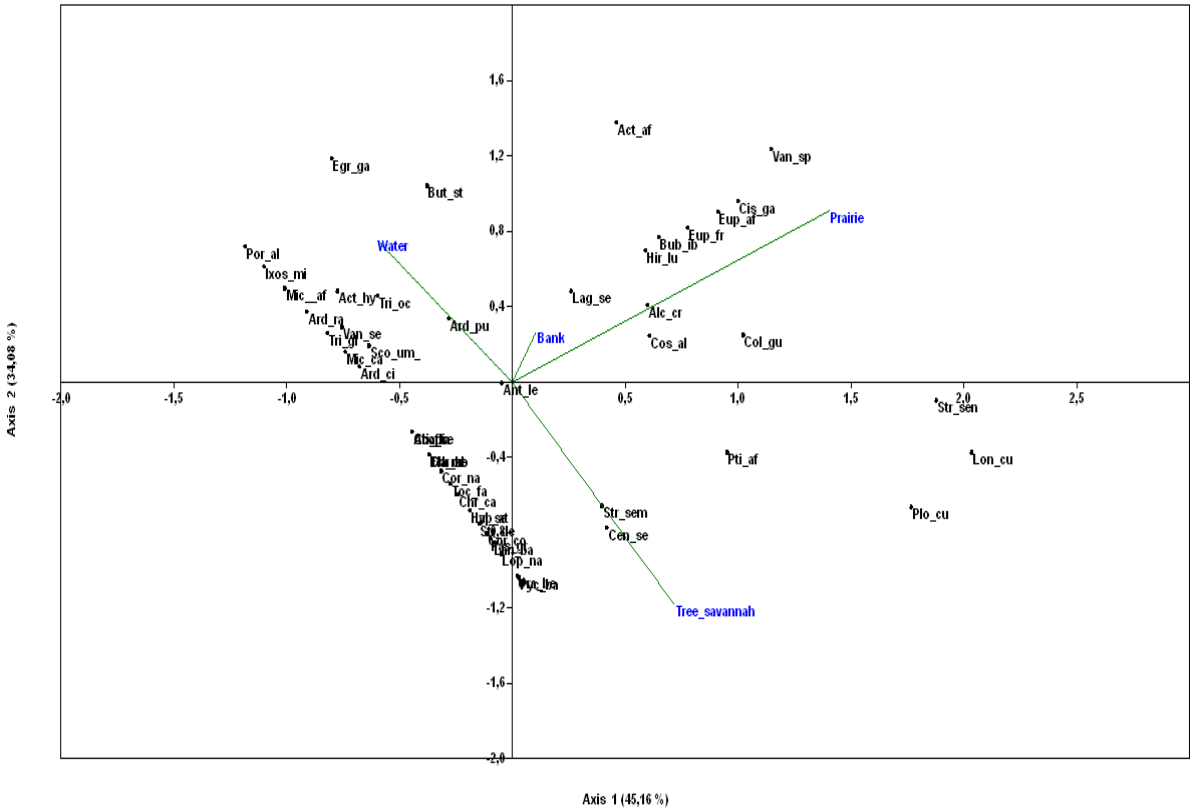

Fig. 12. Spatial characterization of bird species at Koko urban dam and its surroundings in Korhogo from February 2016 to January 2017.

(Mic af : *Microcarbo africanus* ; Sco um : *Scopus umbretta* ; Ixos mi : *Ixobrychus minutus* ; Ard ra : *Ardeola ralloides* ; Bub ib : *Bubulcus ibis* ; But st : *Butorides striata* ; Egr ga : *Egretta garzetta* ; Ard pu : *Ardea purpurea* ; Ard ci : *Ardea cinerea*; Ela ca : *Elanus caeruleus* ; Acc ta : *Accipiter tachiro* ; Por al : *Porphyrio alleni* ; Act af : *Actophilornis africanus* ; Mic ca : *Microparra capensis* ; Van se : *Vanellus senegallus* ; Van sp : *Vanellus spinosus* ; Tri oc : *Tringa ochropus* ; Tri gl : *Tringa glareola* ; Act hy : *Actitis hypoleucos* ; Col gu : *Columba guinea* ; Str de : *Streptopelia decipiens* ; Str sen : *Streptopelia senegalensis* ; Str sem : *Streptopelia semitorquata* ; Cri pi : *Crinifer piscator* ; Chr kl : *Chrysococcyx klaas* ; Chr ca : *Chrysococcyx caprius* ; Cen se : *Centropus senegalensis* ; Alc cr : *Alcedo cristata* ; Hal se : *Halcyon senegalensis* ; Cor na : *Coracias naevius* ; Toc fa : *Tockus fasciatus* ; Lop na : *Lophoceros nasutus* ; Hir lu : *Hirundo lucida* ; Ant le : *Anthus leucophrys* ; Pyc ba : *Motacilla flava* ; Ati fl : *Atimastillas flavicollis* ; Cos al : *Cossypha albicapillus* ; Hyp at : *Hypergerus atriceps* ; Cis ga : *Cisticola galactotes* ; Cha se : *Chalcomitra senegalensis* ; Cor co : *Corvinella corvina* ; Lan ba : *Laniarius barbarus* ; Tch se : *Tchagra senegalus* ; Pti af : *Ptilostomus afer* ; Pas gr : *Passer griseus* ; Plo cu : *Ploceus cucullatus* ; Eup fr : *Euplectes franciscanus* ; Eup af : *Euplectes franciscanus* ; Ura be : *Uraeginthus bengalus* ; Lag se : *Lagonosticta senegala* ; Lon cu : *Lonchura cucullata*; Cri mo : *Crithagra mozambica*)

Water habitat, negatively correlated to the first axis (45.15% contribution) and positively to the second axis (34.08% contribution) is characterized by bird species *Egretta garzetta*, *Butorides striata, Porphyrio alleni, Ixobrychus minutus*, *Microcarbo africanus*, *Actitis hypoleucos*, *Tringa ochropus*, *Ardeola ralloides*,

Vanellus senegallus, *Tringa glareola*, *Scopus umbretta*, *Microparra capensis*, *Ardea cinerea* and *Ardea purpurea*. The second habitat, the bank and prairie, are positively correlated with the first and second axis. The species associated with this habitat are *Actophilornis africanus*, *Vanellus spinosus*, *Cisticola galactotes*, *Euplectes afer*, *Euplectes franciscanus*, *Bubulcus ibis*, *Hirundo lucida*, *Lagonosticta senegala*, *Alcedo cristata*, *Cossypha albicapillus* and *Columba guinea*. The last habitat, the tree savannah positively correlated to axis 1 and negatively to the second axis shelters the species *Streptopelia senegalensis*, *Centropus senegalensis*, *Ptilostomus afer*, *Streptopelia semitorquata*, *Lonchura cucullata* and *Ploceus cucullatus* (Fig. 12). The Generalized Linear Model confirms these observations by revealing that the habitat influenced the distribution of bird species (GLM: ddl = 3; W = 120.17; p <0.0001).

Discussion

The inventory of the qualitative composition of the avifauna of the Koko urban dam and its surroundings identified 63 bird species. This number is less than the 138 species, 218 species and 165 species inventoried in the Grand-Bassam wetland (Yaokokoré-Béibro, 2010; Odoukpé *et al*., 2014; Yaokokoré-Béibro *et al*., 2015 b) as well as the122 species observed on the urban lakes of Yamoussoukro (Konan *et al*., 2015). This specific richness is close to the 73 species of birds determined in the swampy area of Djibi in Abidjan (Yaokokoré-Béibro *et al*., 2015 a) but is greater than the 29 species identified in the Kashmir wetland in India (Ahmad and Bhat, 2017).

This difference may be related to the extent of the other study areas, their diversity and abundance of food resources, as well as the heterogeneity of habitats offered by these ecosystems (Patole *et al*., 2009; Yaokokoré-Béibro *et al*., 2015 a, b). Furthermore, disturbances resulting from intense anthropogenic activities on the water (illegal fishing) and around the dam (market gardening) could explain this low specific richness (Khaffou *et al*., 2013; Konan *et al*., 2014; Ahmad and Bhat, 2017).

The order of Passeriformes was best represented in the same way as the studies carried out on urban lakes of Yamoussoukro (Konan *et al*., 2015) and in the swampy area of Djibi in Abidjan (Yaokokoré-Béibro *et al*., 2015 a). However, studies have shown that Non-Passeriformes were the largest group in Grand-Bassam wetland in Côte d'Ivoire (Yaokokoré-Béibro *et al*., 2010; Odoukpé *et al*., 2014; Yaokokoré Béibro *et al*., 2015 b) and in Kashmir wetland in India (Ahmad and Bhat, 2017). The fact that the Passeriformes were the most important could be linked to the Koko dam ecosystem with different habitats (water, bank, prairie and tree savannah). This heterogeneity and food availability would contribute to the establishment of Passeriformes (Patole *et al*., 2009; Konan *et al*., 2015; Yaokokoré-Béibro *et al*., 2015 a, b; Platel and Ravel, 2019).

The Ardeidae family was the richest in species. This result is similar to the work carried out in Côte d'Ivoire in Grand-Bassam wetland, in the swampy area of Djibi in Abidjan and on the urban lakes of Yamoussoukro (Yaokokoré-Béibro *et al*., 2010; Konan *et al*., 2015; Yaokokoré-Béibro *et al*., 2015 b). This could be explained by the variations in the water level of this ecosystem in relation to seasons. In fact, during the rainy season, the rising water level of the dam has the effect of flooding, the bank and prairie with the installation of aquatic plant. As a result, two habitats are distinguished, water and tree savannah. This fact would therefore be favorable for the installation of waterbirds including the Ardeidae family. Indeed, this ecosystem is beneficial to great herons, for whom water would constitute their fishing territory and the trees of the tree savannah their nesting sites. In addition, in the dry season, the removal and lowering of water levels will lead to the appearance of mudflat beaches exploited by other waterbirds, shorebirds (Konan *et al*., 2015).

Spatial variations in specific richness revealed that the greatest number of birds was observed in the tree savannah. This specialization for tree savannah (open environment) could be linked to the fact that this environment is the preferred habitat for bird species

in this ecosystem, due to the availability of food resources. In addition, these trees or shrubs would serve as perches, dormitories and protection against predators. Finally, this environment would be used as a refuge in response to anthropogenic disturbances (Konan *et al.*, 2015; Yaokokoré-Béibro *et al.*, 2015 a, b; Nasasagare *et al.*, 2017; Castaño-Villa *et al.*, 2019).

In terms of their biogeographical status, the observed population structure, dominated by resident species, is similar to that of studies carried out in the swampy area of Djibi (Yaokokoré-Béibro *et al.*, 2015 a) and in the Grand-Bassam wetland (Yaokokoré-Béibro *et al.*, 2010; Odoukpé *et al.*, 2014 ; Yaokokoré-Béibro *et al.*, 2015 b) . This observation may be due to the fact that this ecosystem would provide food and safety, ideal conditions for the installation and maintenance of resident species (Niamien *et al.*, 2019 b).

Numerical abundances and species distribution were more pronounced in different habitats, the most representative of which are water and the open environment (prairie and tree savannah). The specialization of individuals for these environments would be related to their bioecological activities and their security (specific habitat, nutrition or breeding place, refuge) (Konan *et al.*, 2015; Yaokokoré-Béibro *et al.*, 2015 a, b; Nasasagare *et al.*, 2017; Niamien *et al.*, 2019 a, b).

Conclusions

The study of the spatial distribution of the avifauna of the Koko urban dam and its surroundings in Korhogo, has identified 1,613 birds, divided into 63 species and grouped into 32 families and 14 orders. Overall, the Passeriformes order and the Ardeidae family were the best represented. Resident species and open habitat species were the most important. In the water, the Pelecaniforme and Charadriiforme orders were the most abundant, while in the prairie and tree savannah, the Passeriformes were the best represented. At the family level, the Ardeidae were the most important in water while the Columbidae were the best represented respectively in the prairie and in tree savannah. Diversity was highest in the open environments that are the prairie and tree savannah.

The distribution of birds was based on two main types of habitat: water and open environment (prairie and tree savannah). This urban site is subject to various anthropogenic pressures related to the practice of market gardening with the use of pesticides and fertilizers upstream around the dam. These inputs could pose a risk to the survival of this waterbirds community. Indeed, these inputs are driven by rainwater into the water, with the repercussion of pollution and intoxication. This would pose possible threats to the reproduction of waterbird species.

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