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Effects of crop succession on bird communities in an urban wetland in Korhogo (Côte d'Ivoire)

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ABSTRACT

Urban wetlands provide important habitats for birds, but their use for agricultural purposes can influence the bird communities that inhabit them. Furthermore, changes in bird populations during crop succession remain poorly documented in West Africa. Therefore, this study aimed to analyze changes in the composition, diversity, and functional structure of bird populations during a maize-rice succession in a humid urban area of northern Côte d'Ivoire. Birds were monitored from July to December using the point count method, with the first three months dedicated to maize and the last three to rice. The bird community was analyzed using diversity indices, principal component analysis, PERMANOVA, and NMDS. A total of 90 bird species were recorded, with 81 species during the maize phase and 69 species during the rice phase. Species composition varied significantly between the two crops ($F = 10.316$; $R^2 = 0.319$; $p = 0.0001$), as did the structure of the food guilds ($F = 25.578$; $R^2 = 0.538$; $p = 0.0001$). These results show that maize-rice succession is accompanied by a taxonomic and functional reorganization of the birdlife, rather than simply a variation in its abundance. They also indicate the need to maintain a degree of habitat heterogeneity and agricultural practices in urban wetlands to promote biodiversity. Furthermore, multi-year monitoring will allow for a better understanding of the effects of crop succession and seasonality on birds.

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INTRODUCTION

Wetlands are highly important ecosystems for both human societies and the biodiversity they support. They perform numerous ecological functions and, in particular, provide important habitats for a wide range of bird species (Mitsch *et al.*, 2015). However, these ecosystems are subject to increasing pressure from human activities. In West Africa, as in many other parts of the world, rice and maize are essential crops for human consumption and food security (Lopes *et al.*, 2026). Consequently, large areas of land are devoted to cereal cultivation, sometimes at the expense of natural ecosystems such as wetlands. Globally, many wetlands have been drained and converted into agricultural land, industrial areas, or urban spaces (Verhoeven and Setter, 2010). In several regions of the world, wetland drainage has been facilitated by increasingly effective drainage techniques and land-use planning practices.

These transformations profoundly alter the original characteristics of ecosystems, resulting in biodiversity loss and a decline in certain ecological function, while favoring agricultural production (Verhoeven and Setter, 2010).

This agricultural pressure is compounded by that resulting from urbanization. Urban expansion leads to substantial changes in land-use and also contributes to the reduction of wetland areas. In China, for example, studies conducted over a 20-year period, from 1990 to 2010, revealed a loss of 2,880 km² of wetlands as a result of urban expansion (Mao *et al.*, 2018). In landscapes where agriculture and urbanization develop simultaneously, these transformations can profoundly alter the ecological conditions available to wildlife in general and birds in particular. The effects of these land-use changes on an avian community may vary depending on the environmental context and the spatial scale considered. Allen *et al.* (2019) showed that changes in land use can have either positive or negative effects on biodiversity, depending on the scale of analysis. However, when agriculture and

urbanization occur simultaneously, they may contribute to a substantial reduction in avian diversity compared with more rural areas (Chen *et al.*, 2025). These landscape changes are therefore likely to affect not only bird species richness and abundance, but also the composition and structure of avian communities.

In Côte d'Ivoire, urban wetlands present a particular situation. Due to their year-round availability of water, they are used for various agricultural practices, notably involving crop sequences that combine vegetable and cereal crops. These practices help maintain regular agricultural production but also result in successive changes in habitat characteristics throughout the production cycle. Several studies have already contributed to a better understanding of effects of agriculture and urbanization, considered separately, on the structure of bird communities (Odoukpé *et al.*, 2014; Niamien *et al.*, 2024). However, data remain scarce on temporal variations in bird community structure throughout a crop succession in urban wetlands. This knowledge gap represents a major concern for conservation biology, particularly in a context where these wetlands serve both as agricultural production areas and as potential habitats for birds. The different crop phases may be associated with changes in bird community composition, species richness, and abundance.

Therefore, this study aims to analyze variations in bird community structure throughout a maize-rice crop succession in a wetland located in the city of Korhogo, northern Côte d'Ivoire. More specifically, we assessed variations in bird community composition, species richness, and abundance across the different phases of the crop succession.

MATERIALS AND METHODS

Study area

The study was conducted in the wetland of the Lokaha (or Logokaha) river (9°42' N, 5°61' W), located in one of the neighborhoods of Korhogo City (Fig. 1). Korhogo has a Sudanian-type climate characterized by two distinct seasons: a dry season from November to March and a

rainy season from April to October. The vegetation at the study site is heterogeneous and consists mainly of different types of crops cultivated during the dry season. These crops include sweet potato (*Ipomoea batatas* Lam. [Convolvulaceae]), tomato (*Solanum lycopersicum* L. [Solanaceae]), okra (*Abelmoschus*

esculentus L. [Malvaceae]), peanut (*Arachis hypogaea* L. [Fabaceae]), and maize (*Zea mays* L. [Poaceae]). During the rainy season, these crops are replaced by rice (*Oryza sativa* L. [Poaceae]). The study site is also colonized by *Panicum maximum* and *Phragmites australis*.

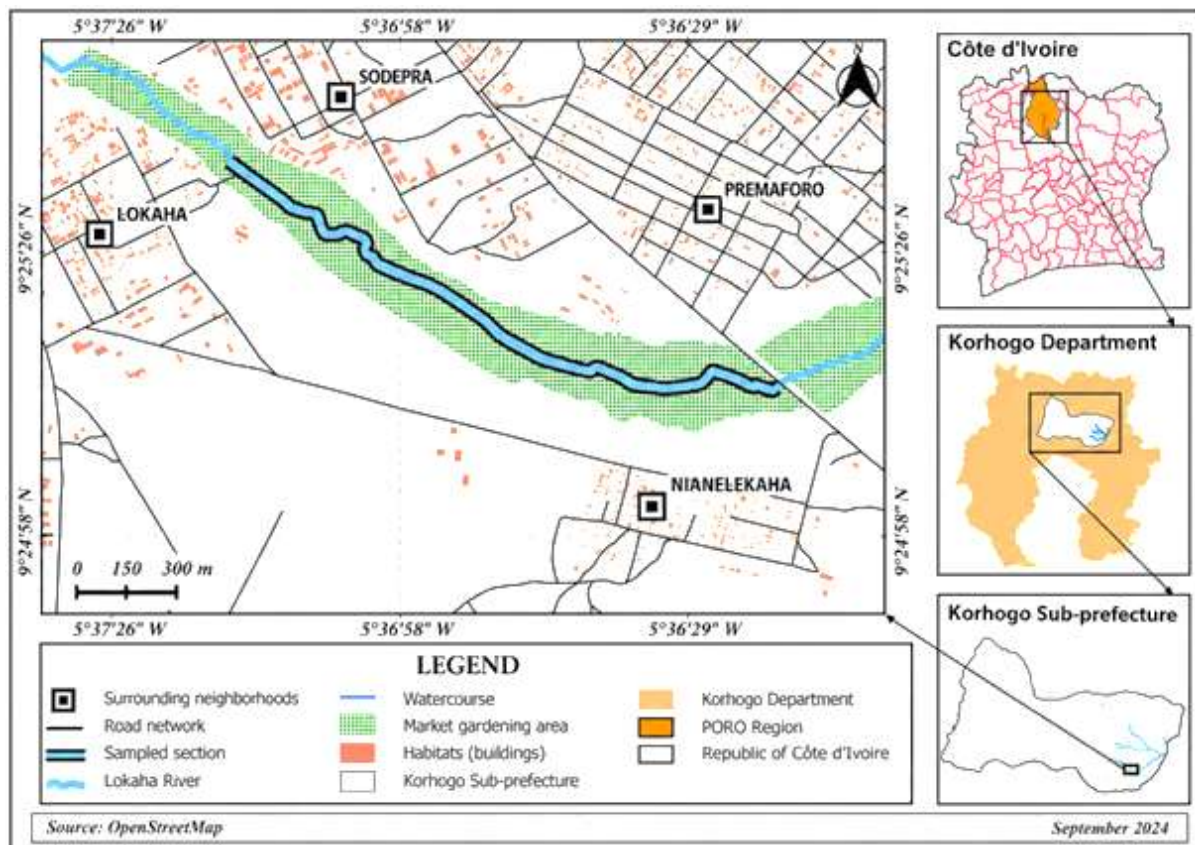


Fig. 1. Geographic location of the study area

Bird survey method

The bird survey was conducted from July to December 2023, with the first three months of monitoring corresponding to the maize cultivation phase and the following three months to the rice cultivation phase. Birds were surveyed using the point count method, based on the point abundance index developed by Blondel *et al.* (1970) and modified by Bibby *et al.* (2000). During each crop cycle, six observation points were established within the cultivated plots. These points were surveyed in the morning from 06:00 to 10:00 and in the afternoon from 15:00 to 18:00 (Yaokokoré-Béibro, 2001). During each survey session, each of the six points was sampled for 15 minutes (Bibby *et al.*,

2000). The cultivated plots were surveyed four times per month, with one visit per week. Only birds observed interacting with the fields perching in them, or flying repeatedly over the plots were included in the study.

Data analysis

Overall species richness and species richness for each crop type were determined. The contribution of each species to the bird community was assessed by calculating its relative abundance frequency ($Fr = (n_i/N) \times 100$), where n_i is the number of individuals of species i and N is the total abundance of the community. This frequency was used to determine the abundance index of each species following

Thiollay (1986). Four categories were defined: dominant species (D), when $Fr \geq 5\%$; regular species (Re), when $1\% \leq Fr < 5\%$; rare species (Ra), when $0,2\% \leq Fr < 1\%$; and accidental species (Ac), when $Fr < 0,2\%$. The abundance index was used to identify the most abundant species and to assess how their abundance varied among crop types. Diversity indices were also calculated for each crop type, including the Shannon-Wiener diversity index ($H' = -\sum (ni/N) \times \ln (ni/N)$) and Pielou's evenness index ($J = H'/\ln(S)$), where S represents species richness.

Each bird species was classified according to its biogeographical status, preferred habitat, and feeding guild. Biogeographical status was assigned following Borrow and Demey (2001) and included three categories: resident (R), for species occurring year-round in the study area and known to breed there; intra-African migrant (M), for species undertaking seasonal movements within Africa, particularly from the Sahelian region; and Palearctic migrant (P), for species migrating between the Palearctic region and Africa. Preferred habitat was assigned according to the habitat associations described by Yaokokoré-Béibro (2001). Species were classified as water-birds (E), open-habitat species (f) or forest species (F), according to their predominant habitat requirements. Feeding guilds were assigned based on the main food resources and foraging habits documented for each species in the ornithological literature.

Principal Component Analyses (PCAs) were used to visualize and examine the distribution of bird species and feeding guilds across months and crop phases. PERMANOVA was used to compare bird abundance among crop phases and feeding guilds.

RESULTS

Bird community structure and composition

Regarding biogeographical status, the bird community was dominated by resident species, with 73 species (81,11%). Four species were intra-African migrants (4,44%), while ten species (11,11%) had a mixed status, being classified as both resident and intra-African migrant, or as resident and palearctic migrant.

Regarding preferred habitat, open -habitat bird species were predominant, with 68 species (75,55%). They were followed by forest species, with 11 species (12,22%), and waterbird species, with nine species (10,00%).

A total of 90 bird species were recorded during the two crop phases. During the maize phase, 81 species were recorded, and 69 species were recorded during the rice phase. In term of total bird abundance, 857 individuals were recorded during the maize phase, compared with 1,784 individuals during the rice phase (Table 1).

Diversity indices also varied between crop phases. The Shannon diversity index was higher during the maize phase ($H' = 3.41$) than during the rice phase ($H' = 3.00$). Similarly, Pielou's evenness index decreased from 0.78 during the maize phase to 0.71 during the rice phase.

Species composition showed a turnover between the two crop phases. Of the 90 species recorded overall, 60 (66,67%) were shared between the two phases, whereas 21 (23,33%) species were recorded exclusively during the maize phase and nine (10,00%) species exclusively during the rice phase.

Variation in feeding guilds across crop phases

The functional structure of the bird community comprised six feeding guilds: carnivores, insectivores, granivores, frugivores, nectarivores, and omnivores. In terms of species richness, insectivores were the most represented guild, with 26 species overall, including 22 species recorded during maize phase and 16 during the rice phase. In terms of abundance, the number of insectivorous individuals increased from 95 during the maize phase to 213 during the rice phase. This increase was largely driven by aerial insectivores, whose abundance increased from 18 individuals during the maize phase to 72 during the rice phase. This increase was mainly attributable to *Cypsiurus parvus*, whose abundance increased from 15 individuals to 72 individuals when transitioning from the maize to rice phase. In contrast, granivores were the dominant feeding guild in terms of abundance during both the maize and rice phases.

Table 1. Bird species recorded during the maize-rice crop succession in the urban wetland

Orders/Families/Species	Biogeo	Habitat	Guild	Maize			Rice		
				AB	Fr	AI	AB	Fr	AI
Galliformes									
Odontophoridae									
<i>Ptilopachus petrosus</i> (J. F. Gmelin, 1789)	R	f.	Omnivore	3	0,35	Ra	-		
Phasianidae									
<i>Pternistis bicalcaratus</i> (Linné, 1766)	R	f.	Omnivore	10	1,17	Re	6	0,34	Ra
Anseriformes									
Anatidae									
<i>Dendrocygna viduata</i> (Linné, 1766)	R/M	E	Omnivore	2	0,23	Ra	-		
Columbiformes									
Columbidae									
<i>Columba guinea</i> Linné, 1758	R	f.	Granivore	55	6,42	D	36	2,02	Re
<i>Streptopelia semitorquata</i> (Ruppell, 1837)	R	f.	Granivore	33	3,85	Re	32	1,79	Re
<i>Streptopelia vinacea</i> (Gmelin, 1789)	R	f.	Granivore	3	0,35	Ra	4	0,22	Ra
<i>Spilopelia senegalensis</i> (Linné, 1766)	R	f.	Granivore	15	1,75	Re	19	1,07	Re
<i>Turtur abyssinicus</i> (Sharpe, 1902)	R	f.	Granivore	3	0,35	Ra	4	0,22	Ra
<i>Treron waalia</i> (F. A. A. Meyer, 1793)	R	f.	Frugivore	3	0,35	Ra	3	0,17	Ac
<i>Streptopelia decipiens</i> (Hartlaub & Finsch, 1870)	R	f.	Granivore	55	6,42	D	9	0,5	Ra
Apodiformes									
Apodidae									
<i>Cypsiurus parvus</i> (Lichtenstein, 1823)	R	f.	Insectivore	15	1,75	Re	72	4,04	Re
<i>Apus affinis</i> (J. E. Gray, 1830)	R	f.	Insectivore	3	0,35	Ra	-		
Cuculiformes									
Cuculidae									
<i>Centropus senegalensis</i> (Linné, 1766)	R	f.	Carnivore	11	1,28	Re	14	0,78	Ra
<i>Centropus monachus</i> Ruppell, 1837	R	f.	Carnivore	2	0,23	Ra	1	0,06	Ac
<i>Clamator levaillantii</i> (Swainson, 1829)	M	f.	Insectivore	2	0,23	Ra	2	0,11	Ac
<i>Chrysococcyx klaas</i> (Stephens, 1815)	R	f.	Insectivore	-			2	0,11	Ac
<i>Chrysococcyx caprius</i> (Boddaert, 1783)	M/R	f.	Insectivore	1	0,12	Ac	-		
<i>Cuculus solitarius</i> Stephens, 1815	R/M	F	Insectivore	1	0,12	Ac	1	0,06	Ac
<i>Cuculus clamosus</i> Latham, 1802	M/R	F	Insectivore	1	0,12	Ac	1	0,06	Ac
<i>Cuculus gularis</i> Stephens, 1815	M	f.	Insectivore	2	0,23	Ra	-		
Gruiformes									
Rallidae									
<i>Crecopsis egregia</i> (W. Peters, 1854)	M/R	f.	Omnivore	2	0,23	Ra	1	0,06	Ac
<i>Amaurornis flavirostra</i> (Swainson, 1837)	R	E	Omnivore	20	2,33	Re	15	0,84	Ra
Musophagiformes									
Musophagidae									
<i>Crinifer piscator</i> (Boddaert, 1783)	R	f.	Frugivore	18	2,1	Re	13	0,73	Ra
<i>Tauraco violaceus</i> (Isert, 1788)	R	f.	Frugivore	-			6	0,34	Ra
Pelecaniformes									
Ardeidae									
<i>Botaurus minutus</i> (Linné, 1766)	R/P	E	Carnivore	1	0,12	Ac	-		
<i>Butorides striata</i> (Linné, 1758)	R	E	Carnivore	17	1,98	Re	6	0,34	Ra
<i>Ardea ibis</i> (Linné, 1758)	R/M	E	Insectivore	-			80	4,48	Re
Scopidae									
<i>Scopus umbretta</i> Gmelin, 1789	R	E	Carnivore	4	0,47	Ra	7	0,39	Ra
Charadriiformes									
Charadriidae									
<i>Vanellus senegallus</i> (Linné, 1766)	R/M	E	Insectivore	38	4,43	Re	34	1,91	Re
Rostratulidae									
<i>Rostratula benghalensis</i> (Linné, 1758)	R/M	E	Omnivore	3	0,35	Ra	13	0,73	Ra
Jacanidae									
<i>Actophilornis africanus</i> (J. F. Gmelin, 1789)	R	E	Omnivore	3	0,35	Ra	-		
Accipitriformes									
Accipitridae									
<i>Elanus caeruleus</i> (Desfontaines, 1789)	R	f.	Carnivore	2	0,23	Ra	2	0,11	Ac
<i>Kaupifalco monogrammicus</i> (Temminck, 1824)	R	f.	Carnivore	7	0,82	Ra	9	0,5	Ra
<i>Tachyspiza badia</i> (Gmelin, 1788)	R/M	F	Carnivore	2	0,23	Ra	-		
<i>Milvus migrans</i> (Boddaert, 1783)	M/P	f.	Carnivore	1	0,12	Ac	5	0,28	Ra

Bucerotiformes										
Bucerotidae										
<i>Lophoceros nasutus</i> (Linné, 1766)	R	f.	Omnivore	2	0,23	Ra	25	1,4	Re	
<i>Lophoceros semifasciatus</i> (Hartlaub, 1855)	R	F	Omnivore	8	0,93	Ra	18	1,01	Re	
Coraciiformes										
Alcedinidae										
<i>Corythornis cristatus</i> (Pallas, 1764)	R	f.	Carnivore	2	0,23	Ra	1	0,06	Ac	
<i>Halcyon leucocephala</i> (Statius Muller, 1776)	M	f.	Carnivore	-			1	0,06	Ac	
<i>Halcyon chelicuti</i> (Stanley, 1814)	R	f.	Carnivore	3	0,35	Ra	-			
<i>Halcyon malimbica</i> (Shaw, 1811)	R	F	Carnivore	2	0,23	Ra	4	0,22	Ra	
<i>Halcyon senegalensis</i> (Linné, 1766)	R/M	f.	Carnivore	1	0,12	Ac	1	0,06	Ac	
Piciformes										
Lybiidae										
<i>Pogonornis dubius</i> (Gmelin, 1788)	R	f.	Omnivore	2	0,23	Ra	1	0,06	Ac	
Psittaciformes										
Psittacidae										
<i>Poicephalus senegalus</i> (Linné, 1766)	R	f.	Granivore	14	1,63	Re	6	0,34	Ra	
<i>Psittacula krameri</i> (Scopoli, 1769)	R	f.	Granivore	15	1,75	Re	9	0,5	Ra	
Passeriformes										
Oriolidae										
<i>Oriolus auratus</i> Vieillot, 1817	M	f.	Frugivore	1	0,12	Ac	2	0,11	Ac	
Platysteiridae										
<i>Platysteira cyanea</i> (Muller, 1776)	R	f.	Insectivore	4	0,47	Ra	1	0,06	Ac	
Malaconotidae										
<i>Malaconotus blanchoti</i> Stephens, 1826	R	f.	Carnivore	1	0,12	Ac	-			
<i>Dryoscopus gambensis</i> (Lichtenstein, 1823)	R	F	Insectivore	1	0,12	Ac	-			
<i>Laniarius barbarus</i> (Linné, 1766)	R	f.	Carnivore	4	0,47	Ra	5	0,28	Ra	
Dicuridae										
<i>Dicrurus adsimilis</i> (Bechstein, 1794)	R	F	Carnivore	1	0,12	Ac	3	0,17	Ac	
Monarchidae										
<i>Terpsiphone viridis</i> (Muller, 1776)	R	F	Insectivore	-			2	0,11	Ac	
<i>Terpsiphone rufivente</i> Swainson, 1837	R	F	Insectivore	5	0,58	Ra	4	0,22	Ra	
Laniidae										
<i>Corvinella corvina</i> (Shaw, 1809)	R	f.	Carnivore	22	2,57	Re	16	0,9	Ra	
Corvidae										
<i>Ptilostomus afer</i> (Linné, 1766)	R	f.	Omnivore	1	0,12	Ac	43	2,41	Re	
<i>Corvus albus</i> Statius Muller, 1776	R	f.	Omnivore	49	5,72	D	22	1,23	Re	
Cisticolidae										
<i>Camaroptera brachyura</i> (Vieillot, 1820)	R	f.	Insectivore	3	0,35	Ra	-			
<i>Cisticola erythrops</i> (Hartlaub, 1857)	R	f.	Insectivore	5	0,58	Ra	5	0,28	Ra	
<i>Cisticola cantans</i> (Heuglin, 1869)	R	f.	Insectivore	2	0,23	Ra	-			
<i>Cisticola lateralis</i> (Fraser, 1843)	R	f.	Insectivore	1	0,12	Ac	-			
<i>Cisticola aberrans</i> (Smith, 1843)	R	f.	Insectivore	2	0,23	Ra	-			
<i>Cisticola natalensis</i> (Smith, 1843)	R	f.	Insectivore	1	0,12	Ac	2	0,11	Ac	
<i>Cisticola guinea</i> Lynes, 1930	R	f.	Insectivore	4	0,47	Ra	2	0,11	Ac	
<i>Cisticola brachypterus</i> (Sharpe, 1870)	R	f.	Insectivore	1	0,12	Ac	1	0,06	Ac	
<i>Cisticola eximius</i> (Heuglin, 1869)	R	f.	Insectivore	1	0,12	Ac	1	0,06	Ac	
Hirundinidae										
<i>Hirundo rustica</i> Linné, 1758	P	f.	Insectivore	1	0,12	Ac	-			
<i>Hirundo lucida</i> Hartlaub, 1858	R	f.	Insectivore	1	0,12	Ac	-			
Pycnonotidae										
<i>Atimastillas flavicollis</i> (Swainson, 1837)	R	F	Frugivore	4	0,47	Ra	-			
<i>Pycnonotus barbatus</i> (Desfontaines, 1789)	R	f.	Frugivore	28	3,27	Re	35	1,96	Re	
Leiothrichidae										
<i>Turdoides reinwardtii</i> (Swainson, 1831)	R	f.	Omnivore	2	0,23	Ra	14	0,78	Ra	
<i>Turdoides plebejus</i> (Cretzschmar, 1828)	R	f.	Omnivore	10	1,17	Re	21	1,18	Re	
Sturnidae										
<i>Lamprotornis caudatus</i> (Muller, 1776)	R	f.	Omnivore	11	1,28	Re	15	0,84	Ra	
<i>Lamprotornis purpureus</i> (Statius Muller, 1776)	R	f.	Omnivore	2	0,23	Ra	-			
<i>Lamprotornis chalcurus</i> Nordmann, 1835	R	f.	Omnivore	64	7,47	D	50	2,8	Re	
Turdidae										
<i>Turdus pelios</i> Bonaparte, 1850	R	f.	Omnivore	3	0,35	Ra	2	0,11	Ac	
Muscicapidae										

<i>Cossypha niveicapilla</i> (Lafresnaye, 1838)	R	F	Omnivore	1	0,12	Ac	-		
<i>Cossypha albicapillus</i> (Vieillot, 1818)	R	f.	Omnivore	1	0,12	Ac	-		
Nectariniidae									
<i>Cinnnyris coccinigastrus</i> (Latham, 1802)	R	f.	Nectarivore	1	0,12	Ac	21	1,18	Re
Ploceidae									
<i>Euplectes afer</i> (J. F. Gmelin, 1789)	R	f.	Granivore	-			40	2,24	Re
<i>Euplectes hordeaceus</i> (Linné, 1758)	R	f.	Granivore	-			65	3,64	Re
<i>Euplectes franciscanus</i> (Isert, 1789)	R	f.	Granivore	6	0,7	Ra	106	5,94	D
<i>Euplectes macroura</i> (Gmelin, 1789)	R	f.	Granivore	-			13	0,73	Ra
<i>Ploceus heuglini</i> Reichenow, 1886	R	f.	Granivore	2	0,23	Ra	45	2,52	Re
<i>Ploceus cucullatus</i> (Statius Muller, 1776)	R	f.	Granivore	129	15,1	D	363	20,3	D
Estrildidae									
<i>Lagonosticta senegala</i> (Linné, 1766)	R	f.	Granivore	6	0,7	Ra	8	0,45	Ra
<i>Uraeginthus bengalus</i> (Linné, 1766)	R	f.	Granivore	8	0,93	Ra	8	0,45	Ra
<i>Estrilda melpoda</i> (Vieillot, 1817)	R	f.	Granivore	2	0,23	Ra	3	0,17	Ac
<i>Spermestes cucullata</i> (Swainson, 1837)	R	f.	Granivore	77	8,98	D	398	22,3	D
Viduidae									
<i>Vidua chalybeata</i> (Muller, 1776)	R	f.	Granivore	2	0,23	Ra	2	0,11	Ac
Motacillidae									
<i>Anthus leucophrys</i> Vieillot, 1818	R	f.	Insectivore	-			3	0,17	Ac

AB: Abundance; Fr: Relative abundance frequency; AI: Abundance index; Biogeo: Biogeographical origin; Habitat: Preferred habitat; Guild: Feeding guild; R: Resident species; M: intra-African migrants species; P: Palearctic migrants species; f: Open habitats; E: Wetlands; F: Forest habitats; D: Dominant species; Re: Regular species; Ra: Rare species; Ac: Accidental species.

Granivores accounted for 49.6% of all individuals recorded during the maize phase, compared with 65.6% during the rice phase. This increase was mainly associated with the high abundance of *Ploceus cucullatus*, whose abundance increased from 129 to 363 individuals, and *Spermestes cucullata*, which increased from 77 to 398 individuals when transitioning from the maize to the rice phase. *Euplectes franciscanus* also showed a marked increase in abundance, from six individuals during the maize phase to 106 during the rice phase.

The omnivorous guild also constituted an important component of the bird community. In terms of species richness, omnivores were the second most diverse guild, with 20 species recorded overall, all of which were present during the maize phase, compared with only 14 species during the rice phase. They were also the second most abundant guild, with 199 individuals recorded during the maize phase and 246 during the rice phase. However, their relative contribution to total abundance declined from 23.2% to 13.8%, largely due to the marked increase in granivore abundance during the rice phase. Frugivores showed relatively stable abundance

between the two crop phases, with five species recorded during each phase and 54 and 59 individuals recorded during the maize and rice phases, respectively. A similar pattern was observed for carnivores, with 18 species recorded overall, including 17 during the maize phase and 14 during the rice phase. In terms of abundance, 83 individuals were recorded during the maize phase, compared with 75 during the rice phase.

Dominant species across the different crop phases

The dominant species differed between the two crop phases. During the maize phase, six species were classified as dominant ($Fr \geq 5\%$), belonging to the granivorous and omnivorous feeding guilds. The most abundant species were *Ploceus cucullatus* (129 individuals), *Spermestes cucullata* (77 individuals), *Lamprotornis chalcurus* (64 individuals), *Columba guinea* (55 individuals), *Streptopelia decipiens* (55 individuals), and *Corvus albus* (49 individuals). During the rice phase, only three species met the dominance threshold ($Fr \geq 5\%$): *Spermestes cucullata* (398 individuals), *Ploceus cucullatus* (363 individuals), and *Euplectes franciscanus* (106

individuals). In addition to these dominant species, three other species were among the most abundant during the rice phase: *Ardea ibis* (80 individuals), *Cypsiurus parvus* (72 individuals), and *Euplectes hordeaceus* (65 individuals).

Distribution of bird species across crop phases

The principal component analysis (PCA), performed on Hellinger-transformed data, revealed a temporal organization of the bird community throughout the crop succession (Fig. 2).

The first two axes jointly explained 66.49% of the total variance, with 44.64% explained by Axis 1 and 21.85% by Axis 2. Axis 1 clearly separated the three months associated with the rice phase (October, November, and December), located on the positive side of the axis, from

the three months associated with the maize phase (July, August, and September), located on the negative side. The species *Corvus albus* and *Lamprotornis chalcurus* were associated with August and September, whereas *Ploceus cucullatus*, *P. heuglini*, *Euplectes hordeaceus*, *E. franciscanus*, and *E. afer* showed strong associations with the months corresponding to the rice phase. Axis 2 provided an additional dimension of community structuring. Along this axis, July was clearly differentiated from the other months of the maize phase by its markedly higher position, whereas October occupied a relatively low position compared with the other months of the rice phase. This pattern suggests temporal variation in bird community composition within each crop phase. Overall, the PCA revealed a reorganization of the bird community associated with the transition from maize to rice cultivation.

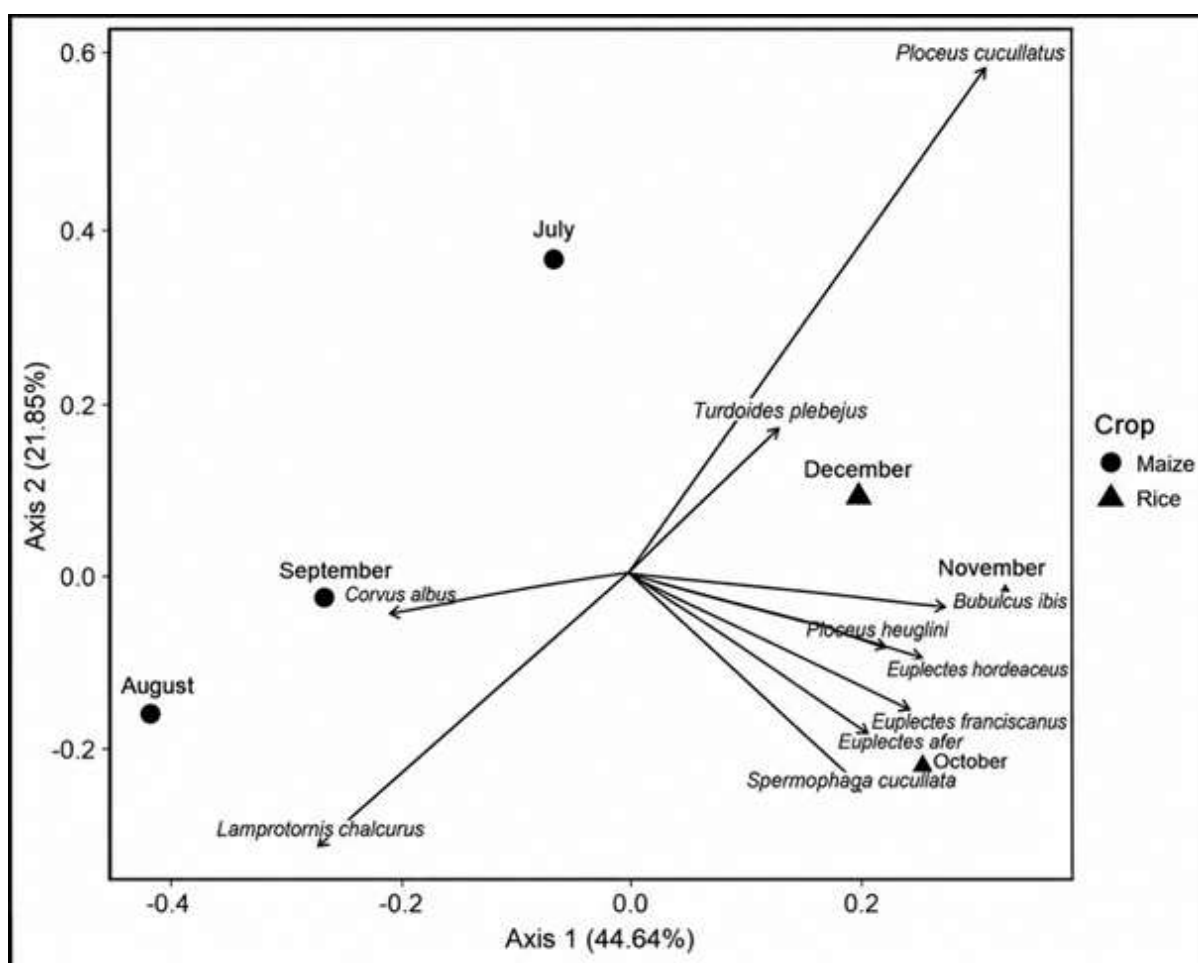


Fig. 2. Monthly variation in the most contributing bird species during the crop phases

Differentiation in bird community composition among crop phases

A multivariate analysis based on Bray–Curtis dissimilarities revealed a significant difference in bird community composition between the maize and rice phases. PERMANOVA showed a highly significant effect of crop phase on avian community composition ($F = 10.316$, $R^2 = 0.319$, $p = 0.0001$), with crop phase accounting for 31.9% of the variation in community composition. The NMDS based on Bray–Curtis dissimilarities provided a two-dimensional representation of community structure, with a stress value of 0.164 (Fig. 3). Samples from

the maize phase were primarily distributed on the left side of the ordination, whereas those from the rice phase were mainly located on the right side. A temporal pattern was also apparent, with samples from July, August, and September, corresponding to the maize phase, clustering mainly on the left, while samples from October, November, and December, corresponding to the rice phase, were primarily distributed on the right. Overall, the ordination pattern was consistent with the PERMANOVA results and indicated a shift in bird community composition following the transition from maize to rice cultivation.

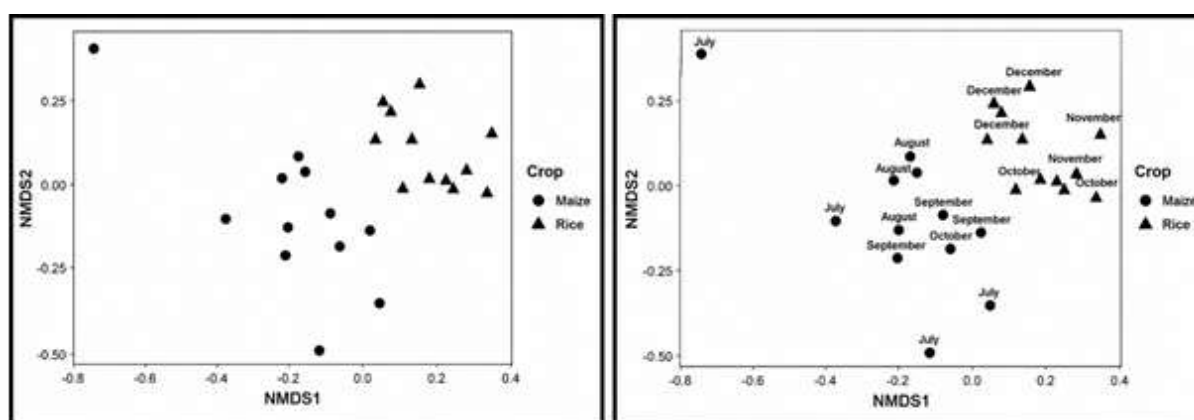


Fig. 3. NMDS ordination of the bird community based on Bray–Curtis dissimilarities, showing the distribution of samples by crop phase and month

Table 2. Main bird species contributing to dissimilarity between maize- and rice-phase communities according to SIMPER analysis

Species	Maize	Rice	Contribution (%)	Cumulative contribution (%)	p
<i>Spermestes cucullata</i>	33.1	138.5	19.1	19.1	<0.001
<i>Ploceus cucullatus</i>	32.5	125.7	17.8	36.9	<0.001
<i>Euplectes franciscanus</i>	2.42	43.42	7.7	44.6	<0.001
<i>Euplectes hordeaceus</i>	0	28.5	5.2	49.8	<0.001
<i>Ardea ibis</i>	0	19.83	3.8	53.6	<0.001
<i>Lamprotornis chalcurus</i>	15.8	12.58	3.3	56.9	1.000
<i>Cypsiurus parvus</i>	4.17	16.83	3.1	60	0.003
<i>Columba guinea</i>	12.2	14.17	2.8	62.8	1.000
<i>Vanellus senegallus</i>	16.2	20.33	2.6	65.4	1.000
<i>Euplectes afer</i>	0	10.33	2	67.4	<0.001
<i>Ptilostomus afer</i>	0.08	10.33	2	69.4	<0.001
<i>Corvus albus</i>	14	10.67	1.9	71.3	1.000
<i>Streptopelia semitorquata</i>	19.8	21.58	1.8	73.1	1.000
<i>Pycnonotus barbatus</i>	13.6	17.17	1.7	74.8	1.000
<i>Ploceus heuglini</i>	0.17	7.83	1.5	76.2	<0.001

Species contributions to community differentiation between crop phases

The SIMPER analysis (similarity percentages) identified the bird species contributing most to the

observed dissimilarity between the maize and rice phases (Table 2). Five species jointly accounted for 53.6% of the cumulative dissimilarity: *Spermestes cucullata* (19.1%), *Ploceus cucullatus* (17.8%),

Euplectes franciscanus (7.7%), *Euplectes hordeaceus* (5.2%), and *Ardea ibis* (3.8%). These species had higher mean abundances in the rice-phase samples. Several other species also contributed to the differentiation between crop phases, including *Cypsiurus parvus*, *Euplectes afer*, *Ptilostomus afer*, *Ploceus heuglini*, *Turdoides plebejus*, and *Lophoceros nasutus*, all of which showed higher mean abundances in the rice-phase samples.

Conversely, species such as *Lamprotornis chalcurus*, *Columba guinea*, and *Vanellus senegallus* contributed to the observed dissimilarity despite having relatively similar mean abundances between the two crop phases.

Indicator species of the crop phases

Indicator species analysis (IndVal) identified 15 species showing significant associations with one of the two crop phases. Three species were significantly associated with the maize phase, whereas 12 were indicative of the rice phase. For maize, *Halcyon senegalensis*, *Corythornis cristatus*, and *Platysteira cyanea* had IndVal values of 0.801, 0.797, and 0.767, respectively, with corresponding significance levels of $p = 0.0134$, $p = 0.0074$, and $p = 0.0194$. For rice, the strongest associations were observed for *Turdoides reinwardtii* (IndVal = 0.970; $p = 0.0001$), *Euplectes hordeaceus* (IndVal = 0.957; $p = 0.0001$), *Lophoceros nasutus* (IndVal = 0.935; $p = 0.0002$), and *Ardea ibis* (IndVal = 0.913; $p = 0.0002$). Other species also showed significant associations with the rice phase, including *Cinnyris coccinigastrus* (IndVal = 0.886; $p = 0.0001$), *Turdoides plebejus* (IndVal = 0.859; $p = 0.0029$), *Scopus umbretta* (IndVal = 0.825; $p = 0.0142$), *Tauraco violaceus* (IndVal = 0.764; $p = 0.0057$), *Euplectes afer* (IndVal = 0.704; $p = 0.0133$), *Euplectes macroura* (IndVal = 0.707; $p = 0.0142$), *Ptilostomus afer* (IndVal = 0.704; $p = 0.0162$), and *Milvus migrans* (IndVal = 0.691; $p = 0.0148$). Overall, the rice phase was characterized by a greater number of indicator species and, for several species, substantially higher indicator values, suggesting stronger species–crop associations during the rice phase.

Differentiation in the functional structure of the bird community across crop phases

PERMANOVA based on feeding-guild composition revealed a significant difference in the functional structure of the bird community between the maize and rice phases ($F = 25.578$, $R^2 = 0.5376$, $p = 0.0001$). Crop phase explained 53.76% of the variation in feeding-guild structure. The transition from maize to rice cultivation was therefore associated with a substantial shift in the relative representation of feeding guilds, driven primarily by granivores, insectivores, and nectarivores. Mean abundance was significantly higher during the rice phase than during the maize phase for granivores (424.25 vs. 123 individuals; $p = 0.001$), insectivores (63.67 vs. 30.75; $p = 0.012$), and nectarivores (5.42 vs. 0.33; $p = 0.003$).

In contrast, no significant differences were detected between crop phases for frugivores ($p = 0.149$), omnivores ($p = 0.151$), or carnivores ($p = 1.000$).

Fig. 4 shows an overall increase in the abundance of most feeding guilds during the rice phase, although the magnitude of the increase varied among guilds. The increase was particularly pronounced for granivores and insectivores. Although nectarivores were considerably less abundant, their distributions differed clearly between the two crop phases. Frugivore and omnivore abundances were also higher during the rice phase, but their distributions showed substantial overlap between phases. Carnivores, in contrast, displayed relatively similar abundance distributions across the two crop phases.

Distribution of bird feeding guilds across months and crop phases

The PCA based on monthly abundances of the six feeding guilds showed that the first two axes jointly explained 87.30% of the total variance, with 58.57% explained by Axis 1 and 28.73% by Axis 2 (Fig. 5). The distribution of months in the factorial space showed a clear differentiation primarily along Axis 1. Months corresponding to the maize phase were predominantly associated with the negative side of

this axis, whereas those corresponding to the rice phase were positioned on the positive side. The transition from September to October, corresponding to the shift from maize to rice cultivation, was associated with a marked displacement along Axis 1, from -1.145 to $+1.145$. Axis 1 was mainly structured by the insectivorous (27.04%), frugivorous (23.29%),

and granivorous (19.43%) guilds, which together accounted for 69.76% of the axis contribution. Axis 2 accounted for 28.73% of the total variance and was primarily structured by the nectarivores (31.36%), carnivorous (31.31%), and omnivorous (27.97%) guilds, which together accounted for 90.64% of the overall contribution to this axis.

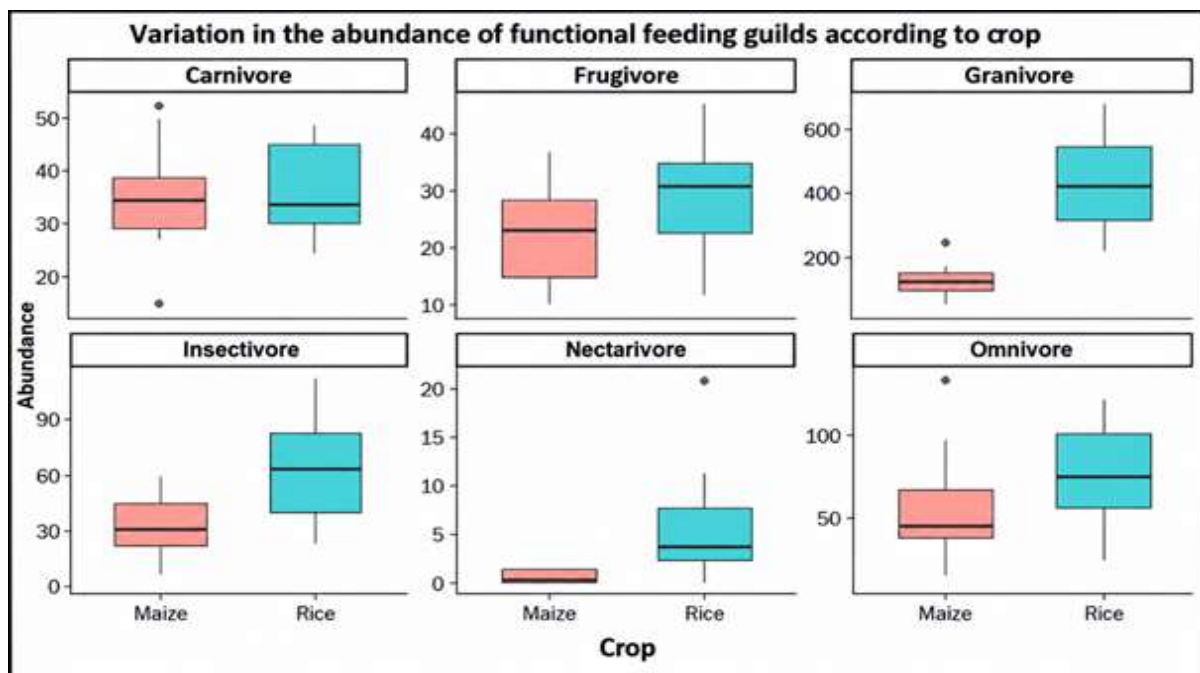


Fig. 4. Variation in the abundance of bird feeding guilds across crop phases

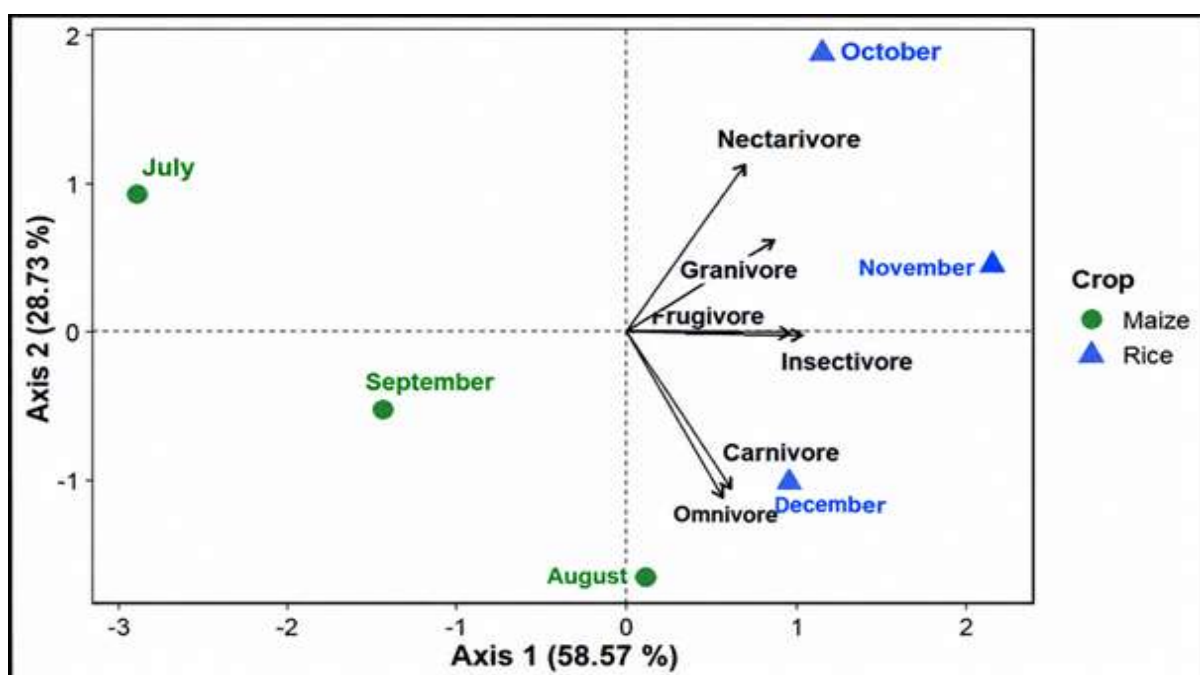


Fig. 5. Monthly variation in the functional structure of bird feeding guilds across crop phases

DISCUSSION

The results showed that the maize–rice crop succession was associated with a shift in the structure of the bird community in the urban wetland. Despite higher species richness during the maize phase, total abundance was more than twice as high during the rice phase, while diversity indices decreased. This decoupling between species richness and abundance suggests that the transition from maize to rice cultivation resulted in a concentration of bird individuals among a smaller number of species. Such restructuring of the bird community is consistent with the ecological consequences of habitat homogenization in agricultural landscapes. Changes in agricultural practices tend to favor certain generalist species or species strongly adapted to the resources available under particular conditions, potentially disadvantaging less adapted species (Donald *et al.*, 2001; Benton *et al.*, 2003).

Furthermore, 60 species were shared between the two crop phases, whereas 21 species were recorded exclusively during the maize phase and nine exclusively during the rice phase. The relatively high similarity between the two crop phases indicates the persistence of a common core of bird species. This suggests that the two crop types do not constitute completely distinct habitats, but rather modify habitat conditions in different ways. At the same time, the occurrence of species restricted to each phase indicates that the respective crop environments modify local conditions sufficiently to promote different bird assemblages. The importance of habitat composition and its temporal dynamics is well recognized in agroecosystems, where bird responses to environmental changes depend on both agricultural practices and the temporal changes they induce (Tscharntke *et al.*, 2005; Allen *et al.*, 2019). The rice phase was characterized by a marked increase in granivore abundance, particularly *Spermestes cucullata*, *Ploceus cucullatus*, and *Euplectes franciscanus*. This pattern is consistent with findings from rice-growing areas in Côte d'Ivoire (Odoukpé *et al.*, 2020). However, the high concentration of granivorous birds in rice fields may represent an

important economic concern, as some species can cause substantial crop losses (de Mey *et al.*, 2012).

The increase in insectivore abundance during the rice phase also deserves particular attention from an ecosystem-service perspective. Insectivorous birds can contribute to the natural regulation of arthropod pests in agricultural systems (Sekercioglu, 2006; Whelan *et al.*, 2008).

This role has been documented in West African rice-growing systems, where birds and bats consume substantial numbers of insects and may consequently contribute to pest regulation. Thus, the simultaneous increase in granivorous and insectivorous birds may reflect a trade-off between the potential crop-damage effects of granivores and the ecosystem services provided by insectivores, particularly during the rice phase.

The changes observed in bird community structure across the crop phases also highlight the importance of temporal heterogeneity in agricultural landscapes. Temporal variation in agroecosystem structure can contribute to the maintenance of bird communities by providing changing habitat conditions and resource availability over time (Benton *et al.*, 2003; Tscharntke *et al.*, 2005). In an urban wetland where crops succeed one another throughout the year, maintaining crop succession in combination with the intrinsic environmental characteristics of the wetland may help sustain higher species diversity and a more balanced functional structure. Such an approach may be particularly relevant in tropical agroecosystems, where agricultural intensification and rapid urbanization represent increasing pressures on biodiversity (Marcacci *et al.*, 2021; Chen *et al.*, 2025).

CONCLUSION

This study demonstrated a clear restructuring of the bird community following the transition from maize to rice cultivation in the Lokaha urban wetland in Korhogo, northern Côte d'Ivoire. The maize phase supported higher species richness (81 species), while the rice phase was characterized by a much higher bird abundance (1,784 individuals compared with 857

during the maize phase). The change in crop type was also associated with a significant shift in avian species composition ($F = 10.316$, $R^2 = 0.319$, $p < 0.05$), consistent with the separation of samples observed in the NMDS ordination. At the functional level, crop succession resulted in a highly significant reorganization of feeding-guild structure ($F = 25.578$, $R^2 = 0.5376$, $p = 0.0001$), characterized by marked increases in granivores, insectivores, and nectarivores birds during the rice phase. The study also highlights the contrasting roles of birds within the agroecosystem: granivorous species may act as crop pests; however insectivorous species may provide valuable pest-control services. Finally, the maize–rice succession modified not only bird abundance but also the taxonomic composition and functional structure of the avian community. These findings highlight the importance of maintaining urban wetlands as multifunctional spaces that reconcile agricultural production with urban biodiversity conservation. Long-term monitoring incorporating vegetation structure, water availability, and agricultural practices would be necessary to identify the mechanisms underlying the observed temporal changes and to assess the consistency of these patterns across years.

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