



RESEARCH ARTICLE

EFFECT OF RICE CULTIVATION STAGES ON THE STRUCTURE OF THE BIRD COMMUNITY IN AN URBAN WETLAND IN KORHOGO (CÔTE D'IVOIRE)

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ABSTRACT

Urban rice paddies are agroecosystems that help sustain bird populations amid the loss of natural wetlands. However, the relationships between rice cultivation and changes in the structure of associated bird communities remain insufficiently documented in urban rice-growing systems in Côte d'Ivoire. This study aims to analyze the impact of rice growth stages on bird community structure in an urban wetland. Surveys were conducted from July to December 2023, during the six stages of rice cultivation: pre-ploughing, ploughing, vegetative growth, immature rice, mature rice, and post-harvest. Five observation sessions per stage were conducted to survey birds through slow walks punctuated by 10-minute stops. Diversity and structure were analyzed using ecological indices, the Kruskal-Wallis test, the generalized linear model, principal component analysis, and ascending hierarchical cluster analysis. A total of 2,693 individuals representing 64 species, 33 families, and 15 orders were identified. Species richness ranged from 56 species during the pre-ploughing stage to 10 during the mature rice stage. Overall abundance increased from 264 individuals at the post-harvest stage to 593 individuals at the mature rice stage. The crop stage significantly influenced the structure of the avifauna (GLM: $dof = 5$; $W = 157.82$; $p < 0.0001$). These results highlight the need to maintain habitat heterogeneity and preserve associated wetlands in urban areas in order to support a diverse bird community.

INTRODUCTION

Cereals occupy a preponderant place in global agricultural systems, both in terms of the areas devoted to them and their importance in human nutrition (Leff *et al.*, 2004; Zaamouchi et Mihoubi-Djazzare, 2019). Among cereals, rice is a staple food for more than half of the world's population, primarily in Asia and Africa (Moatti, 2013; Elert, 2014; Gunathilaka, 2019). In sub-Saharan Africa, where rice consumption is rising rapidly, increased production still relies primarily on expanding cultivated areas (Darko *et al.*, 2025). This dynamic contributes to making rice paddies an increasingly important element of tropical agricultural landscapes (Propper *et al.*, 2023). Beyond their role in food production, rice fields constitute temporary wetland agroecosystems capable of performing ecological functions comparable to those of natural wetlands during certain stages of the cropping cycle. They create favorable conditions for various groups of vertebrates. Thus, rice fields provide birds with complementary habitats at a time when natural wetlands are facing increasingly severe and multifaceted pressures (Propper *et al.*, 2023).

The importance of rice paddies as significant wetlands for birds has been widely documented (Lopes *et al.*, 2026a; 2026b). In West Africa, several studies have highlighted the ecological importance of rice fields for birds (Wymenga et Zwartz, 2010; Paulino *et al.*, 2025; Chaves *et al.*, 2026). In Côte d'Ivoire, studies have shown that rice fields support a diverse bird community, the structure and composition of which vary significantly from one cultivation stage to another (Odoukpé *et al.*, 2014a; 2014b; 2020; Odoukpé et Yaokokoré-Bébro, 2015; 2016; Kouadja *et al.*, 2023; Kouadio *et al.*, 2024). However, this relationship remains insufficiently documented in the Ivorian urban context—as in West Africa—where rice fields are part of complexes combining cultivated areas, bodies of water, riparian vegetation, and built-up zones, and accommodating a wide variety of uses. This approach is of particular interest in northern Côte d'Ivoire, and specifically in the city of Korhogo. Indeed, the city's wetlands are the site of significant agricultural activity, primarily market gardening and cereal cultivation. However, to date, no studies on urban birdlife have addressed the interplay between urban wetlands, rice farming, and avian fauna (Niamien *et al.*, 2019).

It therefore remains necessary to determine the extent to which the successive transformations of a rice plot influence the structure of urban bird communities. This study aims to analyze the effect of rice cultivation stages on the structure of the avifauna in an urban wetland. It will involve determining variations in species richness, abundance, and avian community structure across the different stages of rice cultivation.

MATERIALS AND METHODS

Study area: The study was conducted in the city of Korhogo along the river (9°42' N, 5°61' W) located in Logakaha, one of the city's neighborhoods (Figure 1). The city of Korhogo has a Sudanian climate with two seasons: a dry season (November–March) and a rainy season (April–October). The average annual temperature is 27°C, with average annual rainfall ranging between 1,100 mm and 1,600 mm (Boko-Koiadia *et al.*, 2016). The vegetation at the study site is heterogeneous and consists primarily of various crops grown during the dry season, such as 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 site is colonized by *Panicum maximum* and *Phragmites australis*, mainly along the riverbed.

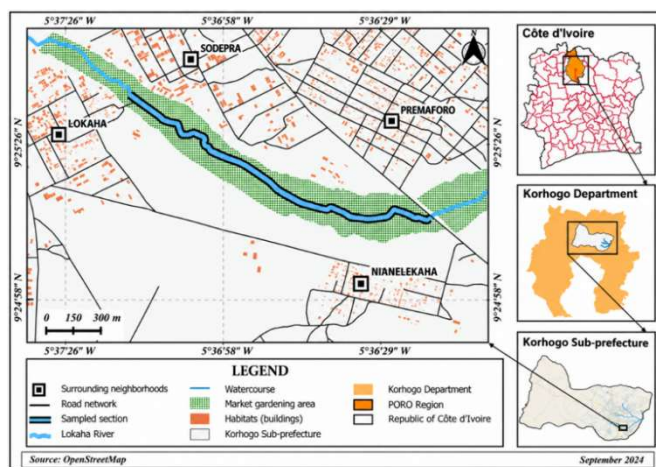


Figure 1: Geographic location of the study site

Bird inventory: This study took place over six months, from July to December 2023. It required regular presence during the six stages of rice cultivation: pre-ploughing, ploughing, vegetative, immature rice, mature rice and post-harvest (Odoukpé *et al.*, 2020). The birds were observed using binoculars from 06:00 to 10:00 and from 15:00 to 18:00, the periods during which they are most active (Yaokokoré-Béibro, 2001). Five survey sessions were conducted at each stage of cultivation. All birds that landed on or foraged within the cultivated areas, from ploughing through to harvest, were recorded. These surveys were carried out in two phases. First, the observer remained stationary for 10 minutes, noting down all bird species. Then, the remaining time was spent walking the accessible areas around the plots to detect species perching on the field margins (Odoukpé et Yaokokoré-Béibro, 2015 ; 2016 ; Odoukpé *et al.*, 2020). The birds were identified using the field guide to the birds of West Africa (Borrow et Demey, 2008) and the discography of African birds (Chappuis, 2000).

Data analysis: For a given species, the maximum count from the five inventory sessions per crop stage was used for the various statistical analyses (Odoukpé *et al.*, 2020). Shannon indice ($H' = -\sum \left(\frac{n_i}{N}\right) \times \ln\left(\frac{n_i}{N}\right)$), evenness indice ($J = \frac{H'}{\ln S}$) and Sorensen similarity indice ($Si = (2 \times \frac{C}{A+B}) \times 100$) were used to assess bird diversity in rice fields at each stage of cultivation (Barbault, 1992 ; Bibby *et al.*, 1998). The frequency of occurrence ($Fo = (Si/St) \times 100$) according to Djakou and Thanon (1988) and the relative frequency of abundance ($Fr = \left(\frac{n_i}{N}\right) \times 100$) according to Thiollay (1986) made it possible to analyze bird diversity. The non-parametric Kruskal-Wallis test was used to compare bird abundances across rice cultivation stages. Principal Component Analysis (PCA) was employed to characterize the distribution of bird species according to these stages. Furthermore, the effect of the cultivation stage on bird distribution was tested using a Generalized Linear Model. All analyses were performed using Past (version 1.0) and Statistica (version 7.1) software at a 5% significance level.

RESULTS

Overall species richness of the rice field bird community: A total of 2,693 individuals belonging to 64 bird species, 33 families, and 15 orders were identified in the rice-growing agroecosystem (Table I). The order Passeriformes is the most significant, comprising 28 species (43.75%) and 1,797 individuals (66.73%). It is followed by the Columbiformes, with six species (9.37%) and 383 individuals (14.22%). The Charadriiformes come next, with four species and 191 individuals (7.09%). The family Columbidae exhibits the highest species richness, with six species (9.37%). The most abundant families are Ploceidae (932 individuals; 34.61%), Columbidae (383 individuals; 14.22%), Sturnidae (336 individuals; 12.90%), Estrildidae (257 individuals; 9.54%), and Charadriidae (166 individuals; 6.16%). The avifauna comprises five dominant species: *Vanellus senegallus* (164 individuals; 6.09%), *Lamprolornis chalcurus* (260 individuals; 9.65%), *Euplectes franciscanus* (455 individuals; 16.90%), *Ploceus cucullatus* (388 individuals; 14.41%), and *Spermestes cucullata* (223 individuals; 8.28%). Together, these five species account for 55.33% of the total abundance (Table I).

Occurrence of bird species observed in rice fields: Five species with very high occurrence rates are classified as "very frequent": *Pternistis bicalcaratus*, *Columba guinea*, *Vanellus senegallus*, *Corvinella corvina*, and *Butorides striata*. These species were observed at virtually all stages of cultivation. Conversely, forty-five species were classified as "accidental" based on their occurrence; these were observed at only one or another of the cultivation stages (Table I).

Variation in bird diversity according to phenological stages
Species richness varied significantly across stages, ranging from 56 species at the pre-ploughing stage to 10 species at the mature rice stage. The ploughing, vegetative, immature rice, and post-harvest stages recorded 21, 25, 15, and 19 species, respectively. The pre-ploughing stage exhibited the highest number of orders (15) and families (32), whereas the mature rice stage recorded the lowest numbers—six and seven, respectively. Abundance ranged from 264 individuals at the post-harvest stage to 593 individuals at the mature rice stage. Diversity indices showed significant variation depending on

Table I. Distribution of bird species according to rice cultivation stages from July to December 2023 in the Lokaha rice fields AB: Abundance; Fr: Frequency; AI: Abundance Index; PS: Ploughing stage; IRS: Immature rice stage; MRS: Mature rice stage; PPS: Pre-ploughing stage; PHS: Post-harvest stage; VS: Vegetative stage; OC: occurrence; GAB: General abundance

SPECIES	GAB	OC (%)	PPS			PS			VS			IRS			MRS			PHS		
			AB	Fr	AI	AB	Fr	AI	AB	Fr	AI	AB	Fr	AI	AB	Fr	AI	AB	Fr	AI
Galliformes																				
Odontophoridae																				
<i>Ptilopachus petrosus</i> (J. F. Gmelin, 1789)	3	3,70	3	0,52	Ra	-			-			-			-			-		
Phasianidae																				
<i>Pternistis bicalcaratus</i> (Linné, 1766)	30	88,89	8	1,39	R	1	0,26	R	16	3,59	R	8	1,86	R	4	0,67	Ra	4	1,51	R
Anseriformes																				
Anatidae																				
<i>Dendrocygna viduata</i> (Linné, 1766)	3	7,40	2	0,35	Ra	-			-			-			-			-		
Columbiformes																				
Columbidae																				
<i>Columba guinea</i> Linné, 1758	53	81,48	24	4,16	R	22	5,74	D	28	6,28	D	-			-			50	18,94	D
<i>Streptopelia semitorquata</i> (Ruppell, 1837)	87	74,07	29	5,02	D	53	13,84	D	25	5,6	D	-			-			11	4,16	R
<i>Streptopelia vinacea</i> (Gmelin, 1789)	5	18,52	1	0,17	Ac	-			-			-			-			5	1,89	R
<i>Spilopelia senegalensis</i> (Linné, 1766)	29	77,78	82	14,21	D	12	3,13	R	6	1,34	R	-			-			29	10,98	D
<i>Turtur abyssinicus</i> (Sharpe, 1902)	1	7,40	1	0,17	Ac	-			-			-			-			-		
<i>Streptopelia decipiens</i> (Hartlaub & Finsch, 1870)	2	14,81	-			1	0,26	Ra	2	0,45	Ra	-			2	0,34	Ra	-		
Apodiformes																				
Apodidae																				
<i>Cypsiurus parvus</i> (Lichtenstein, 1823)	15	11,11	15	2,6	R	-			-			-			-			-		
<i>Apus affinis</i> (J. E. Gray, 1830)	3	3,70	3	0,52	Ra	-			-			-			-			-		
Cuculiformes																				
Cuculidae																				
<i>Centropus senegalensis</i> (Linné, 1766)	12	74,07	10	1,73	R	1	0,26	Ra	2	0,45	Ra	1	0,23	Ra	1	0,17	Ac	10	3,79	R
<i>Clamator levaillantii</i> (Swainson, 1829)	4	11,11	25	4,33	R	-			-			-			-			-		
<i>Cuculus gularis</i> Stephens, 1815	2	3,70	2	0,35	Ra	-			-			-			-			-		
Gruiformes																				
Rallidae																				
<i>Crecopsis egregia</i> (W. Peters, 1854)	5	29,63	2	0,35	Ra	3	0,78	Ra	2	0,45	Ra	-			-			1	0,38	Ra
<i>Zapornia flavirostra</i> (Swainson, 1837)	21	70,37	18	3,12	R	9	2,35	R	10	2,24	R	2	0,46	Ra	-			2	0,76	Ra
Musophagiformes																				
Musophagidae																				
<i>Crinifer piscator</i> (Boddaert, 1783)	15	0,64	15	2,6	R	-			-			-			-			-		
Pelecaniformes																				
Ardeidae																				
<i>Botaurus minutus</i> (Linné, 1766)	2	7,40	-			1	0,26	Ra	1	0,22	Ra	-			-			-		
<i>Butorides striata</i> (Linné, 1758)	35	96,30	15	2,6	R	7	1,82	R	17	3,81	Ra	7	1,63	R	1	0,17	Ac	6	2,27	R
<i>Ardea ibis</i> (Linné, 1758)	32	37,04	-			-			-			-			-			32	12,12	D

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Scopidae																			
<i>Scopus umbretta</i> Gmelin, 1789	15	55,56	1	0,17	Ac	2	0,52	Ra	1	0,22	Ra	2	0,46	Ra	-			12	4,54
Charadriiformes																			
Charadriidae																			
<i>Vanellus spinosus</i> (Linné, 1758)	1	7,40	-			1	0,26	Ra	1	0,22	Ra	-			-			-	
<i>Vanellus senegallus</i> (Linné, 1766)	169	96,30	25	4,33	R	36	9,4	D	69	15,47	D	5	1,16	R	-			29	10,98
Rostratulidae																			
<i>Rostratula benghalensis</i> (Linné, 1758)	15	37,04	3	0,52	Ra	-			2	0,45	Ra	-			3	0,5	Ra	11	4,16
Jacanidae																			
<i>Actophilornis africanus</i> (J. F. Gmelin, 1789)	6	7,40	1	0,17	Ac	2	0,52	Ra	3	0,67	Ra	-			-			-	
Accipitriformes																			
Accipitridae																			
<i>Elanus caeruleus</i> (Desfontaines, 1789)	2	7,40	2	0,35	Ra	-			-			-			-			1	0,38
<i>Kaupifalco monogrammicus</i> (Temminck, 1824)	2	14,81	2	0,35	Ra	-			-			-			-			-	
<i>Tachyspiza badia</i> (Gmelin, 1788)	1	3,70	1	0,17	Ac	-			-			-			-			-	
Bucerotiformes																			
Bucerotidae																			
<i>Lophoceros nasutus</i> (Linné, 1766)	2	3,70	2	0,35	Ra	-			-			-			-			-	
<i>Lophoceros semifasciatus</i> (Hartlaub, 1855)	8	11,11	8	1,39	R	-			-			-			-			-	
Coraciiformes																			
Alcedinidae																			
<i>Corythornis cristatus</i> (Pallas, 1764)	3	14,81	3	0,52	Ra	-			-			-			-			-	
<i>Halcyon malimbica</i> (Shaw, 1811)	2	22,22	2	0,35	Ra	-			1	0,22	Ra	-			-			-	
<i>Halcyon senegalensis</i> (Linné, 1766)	1	11,11	1	0,17	Ac	1	0,26	Ra	-			-			-			-	
Piciformes																			
Lybiidae																			
<i>Pogonornis dubius</i> (Gmelin, 1788)	2	3,70	2	0,35	Ra	-			-			-			-			-	
Psittaciformes																			
Psittacidae																			
<i>Poicephalus senegalus</i> (Linné, 1766)	3	11,11	3	0,52	Ra	-			-			-			-			-	
<i>Psittacula krameri</i> (Scopoli, 1769)	8	14,81	8	1,39	R	-			-			-			-			-	
Passeriformes																			
Platysteiridae																			
<i>Platysteira cyanea</i> (Muller, 1776)	4	7,40	4	0,69	Ra	-			-			-			-			-	
Malaconotidae																			
<i>Laniarius barbarus</i> (Linné, 1766)	2	11,11	2	0,35	Ra	-			-			-			-			-	
Monarchidae																			
<i>Terpsiphone rufiventer</i> (Swainson, 1837)	5	7,40	5	0,87	Ra	-			-			-			-			-	

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Laniidae																			
<i>Corvinella corvina</i> (Shaw, 1809)	17	81,48	15	2,6	R	5	1,3	R	13	2,91	R	5	1,16	R	-		9	3,41	R
Corvidae																			
<i>Ptilostomus afer</i> (Linné, 1766)	40	7,40	-			-			-			-			-		37	14,01	D
<i>Corvus albus</i> Statius Muller, 1776	82	51,85	18	3,12	R	19	4,96		54	12,1	D	-			-		10	3,79	R
Cisticolidae																			
<i>Camaroptera brachyura</i> (Vieillot, 1820)	2	7,40	2	0,35	Ra	-			-			-			-		-		
<i>Cisticola erythrops</i> (Hartlaub, 1857)	10	22,22	5	0,87	Ra	-			-			10	2,32	R	-		-		
<i>Cisticola guinea</i> Lynes, 1930	4	7,40	9	1,56	R	-			-			-			-		-		
Hirundinidae																			
<i>Hirundo lucida</i> Hartlaub, 1858	1	3,70	1	0,17	Ac	-			-			-			-		-		
Pycnonotidae																			
<i>Atimastillas flavicollis</i> (Swainson, 1837)	4	7,40	4	0,69	Ra	-			-			-			-		-		
<i>Pycnonotus barbatus</i> (Desfontaines, 1789)	12	14,81	12	2,1	R	-			-			-			-		-		
Leiothrichidae																			
<i>Turdoides reinwardtii</i> (Swainson, 1831)	3	3,70	3	0,52	Ra	-			-			-			-		-		
<i>Turdoides plebejus</i> (Cretzschmar, 1828)	11	44,44	11	1,9	R	6	1,57	R	6	1,34	R	1	0,23	Ra	-		-		
Sturnidae																			
<i>Lamprotornis caudatus</i> (Muller, 1776)	60	33,33	13	2,25	R	-			60	13,45	D	-			-		3	1,14	R
<i>Lamprotornis chalcurus</i> Nordmann, 1835	379	33,33	-			160	41,77	D	100	22,42	D	-			-		-		
Turdidae																			
<i>Turdus pelios</i> Bonaparte, 1850	2	18,52	2	0,35	Ra	-			-			-			-		2	0,76	Ra
Nectariniidae																			
<i>Cinnyris coccinigastrus</i> (Latham, 1802)	1	7,40	1	0,17	Ac	-			-			-			-		-		
Ploceidae																			
<i>Quelea erythrops</i> (Hartlaub, 1848)	9	3,70	-			-			-			7	1,63	R	2	0,34	Ra	-	
<i>Euplectes afer</i> (J. F. Gmelin, 1789)	43	11,11	-			-			-			28	6,51	D	50	8,43	D	-	
<i>Euplectes franciscanus</i> (Isert, 1789)	450	74,07	4	0,69	Ra	-			1	0,22	Ra	200	46,51	D	250	42,16	D	-	
<i>Ploceus heuglini</i> Reichenow, 1886	2	3,70	2	0,35	Ra	-			-			-			-		-		
<i>Ploceus cucullatus</i> (Statius Muller, 1776)	300	62,96	58	10,05	D	38	9,92	D	2	0,45	Ra	40	9,3	D	250	42,16	D	-	
Estrildidae																			
<i>Lagonosticta senegala</i> (Linné, 1766)	10	7,40	10	1,73	R	-			-			-			-		-		
<i>Uraeginthus bengalus</i> (Linné, 1766)	4	14,81	4	0,69	Ra	-			-			-			-		-		
<i>Estrilda melpoda</i> (Vieillot, 1817)	9	29,63	3	0,52	Ra	3	0,78	Ra	9	2,02	R	5	1,16	R	-		-		
<i>Spermestes cucullata</i> (Swainson, 1837)	149	59,26	69	11,96	D	-			15	3,36	R	109	25,34	D	30	5,05	D	-	
Viduidae																			
<i>Vidua chalybeata</i> (Muller, 1776)	1	3,70	1	0,17	Ac	-			-			-			-		-		

the crop stage; the Shannon index, for instance, ranged from 3.28 at the pre-ploughing stage to 1.21 at the mature rice stage. Evenness ranged from 0.85 at the post-harvest stage to 0.52 at the mature rice stage. Thus, the pre-ploughing stage appears to be the most diverse, while the mature rice stage is the least diverse.

Species abundance according to rice cultivation stages:

Across the various phenological stages, 13 species were the most abundant during at least one stage: *Streptopelia semitorquata*, *Spilopelia senegalensis*, *Ploceus cucullatus*, *Spermestes cucullata*, *Columba guinea*, *Vanellus senegallus*, *Lamprotornis chalcurus*, *L. caudatus*, *Corvus albus*, *Ptilostomus afer*, *Euplectes franciscanus*, *Ardea ibis*, and *E. afer*. Specifically, *P. cucullatus*, *S. cucullata*, *E. franciscanus*, and *E. afer* reach their peak abundance during the immature and mature rice stages, while being virtually absent during the other stages. Conversely, the other species are significantly present during the remaining phases, yet are virtually absent during the immature and mature rice stages. Indeed, principal component analysis (Figure 2), based on Hellinger-transformed species abundances, revealed a structuring of the community according to rice cultivation stages. Together, the first two axes explain 75.9% of the total inertia, with 55.1% accounted for by axis 1 and 20.8% by axis 2. Axis 1 separates the immature and mature rice stages, located on the negative side of the axis, from the pre-ploughing, ploughing, vegetative, and post-harvest stages, which are positioned on the positive side. Furthermore, Axis 2 clearly separates the pre-ploughing and post-harvest stages from the ploughing and vegetative stages. Only four species are associated with the negative side of Axis 1, and thus with the immature and mature rice stages. These are *Euplectes franciscanus*, *Euplectes afer*, *Ploceus cucullus* and *Spermestes cucullata*. The species *Lamprotornis chalcurus* and *Streptopelia semitorquata* are associated with the ploughing and vegetative stages, whereas *Ptilostomus afer*, *Spilopelia senegalensis*, *Ardea ibis*, and *Centropus senegalensis* are associated with the pre-ploughing stage.

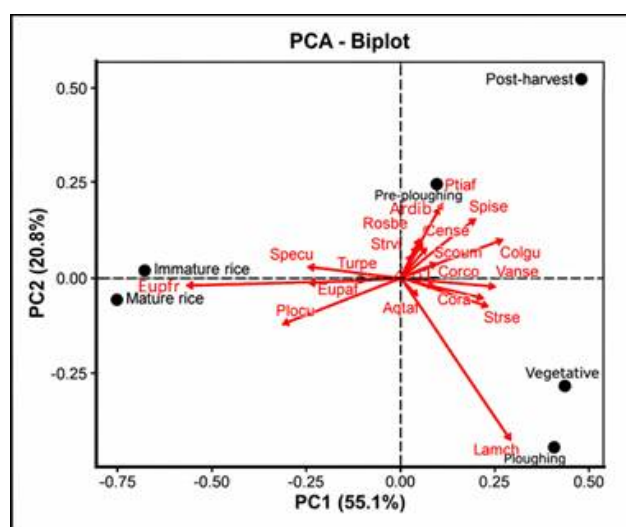


Figure 2: Distribution of bird species according to the different stages of rice cultivation from July to December 2023.

Analysis of the similarity between bird communities across different stages of rice cultivation: Similarity indices (S_i) for the rice cultivation stages, based on species richness, range from 18.18% to 82.61%. The highest similarity index (82.61%) was found between the ploughing stage and the vegetative stage. The lowest similarities were observed between the pre-

ploughing and mature rice stages ($S_i = 21.21\%$) and between the ploughing and mature rice stages ($S_i = 18.18\%$). The Kruskal-Wallis test reveals a highly significant difference in bird abundance between the pre-ploughing stage and the other rice cultivation stages ($p < 0.0001$). Furthermore, a significant difference was observed between the ploughing/mature rice pair and the vegetative/mature rice pair ($p < 0.05$). Conversely, the other pairwise comparisons were not significant ($p > 0.05$). The Generalized Linear Model confirms this observation, indicating that rice cultivation stages significantly influence the distribution of bird species in the Lokaha rice fields (GLM: $df=5$; $W=157.82$; $p < 0.0001$). Hierarchical agglomerative clustering, performed using Hellinger-transformed bird abundance data based on Euclidean distance and Ward.D2's method, identified three groups of cultivation stages. This grouping was based on the similarity of avifaunal composition (Figure 3). The first group consists of the immature and mature rice stages, which exhibit the highest similarity and the lowest Euclidean distance (distance = 0.540). The second group comprises the ploughing and vegetative stages (distance = 0.589), while the third group includes the pre-ploughing and post-harvest stages, which show a greater distance (0.969).

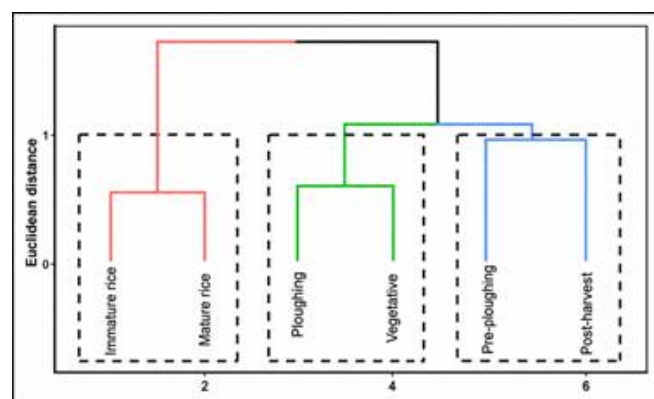


Figure 3: Dendrogram showing the clustering of cultivation stages based on their similarity

DISCUSSION

The overall species richness of the urban rice-farming agroecosystem studied here demonstrates that such habitats can play a significant role in urban bird conservation. Indeed, flooded rice fields act as ecotones and serve as important wildlife habitats, particularly in urban and suburban areas (Bambaradeniya *et al.*, 2004). However, this species richness is lower than the 121 species (Odoukpé *et al.*, 2014a) and 100 species (Odoukpé and Yaokokoré-Béibro, 2015) recorded in the rice fields of the Grand-Bassam wetland. These differences are likely attributable to two factors: the shorter duration of our study (six months) compared to the 24-month duration of the other studies, and the study area's location in the city center. Unlike rural or peri-urban areas, the city center can act as a significant ecological barrier for many species; connectivity is higher in vegetated rural and peri-urban zones but very low in dense urban cores (Yu *et al.*, 2024; Merckens *et al.*, 2026). According to the ACAH, the very short distance between immature and mature rice indicates that these two phases support fairly similar communities. This aligns with observations made in the Grand-Bassam wetland of international importance, where the grain-filling and maturation stages of the rice crop attracted the highest numbers of birds (Odoukpé *et al.*, 2014b). These substantial numbers were driven by a small group of gregarious, seed-eating birds

whose populations fluctuated significantly during these phases. The clustering of the ploughing and vegetative stages reflects continuity in bird community composition between soil preparation and the initial development of the rice plants; indeed, species that foraged in the turned soil likely continued to find food resources during the early stages of seedling development. This is consistent with findings from peri-urban rice fields in central Côte d'Ivoire (Odoukpé *et al.*, 2020), which showed that the vegetative phase was the richest in terms of species diversity.

In this study, the pre-tillage phase was by far the most diverse. This could be explained by the strong presence of invertivores during the early stages of rice growth (Lopes *et al.*, 2026a). Furthermore, the association between pre-tillage and post-harvest stages might reflect a convergence in habitat structure. Indeed, practices such as soil preparation, harvesting, residue management, and field flooding can significantly alter habitat use, benefiting only specific species. For instance, Wymenga and Zwarts (2010) demonstrated that the value of rice fields for birds depended heavily on their hydrological status, with higher densities of wetland-associated birds observed when plots remained moist or flooded. Ultimately, the results indicate that the cultivation stage is a key determinant of rice field avifauna composition. However, explaining species distribution also requires considering other factors—such as hydrology, vegetation structure, available food resources, and landscape context—the latter being a crucial dimension in urban wetland areas. This has been demonstrated in rice fields in Grand-Bassam (Odoukpé and Yaokokoré-Béibro, 2015; 2016) and Yamoussoukro (Odoukpé *et al.*, 2020) in Côte d'Ivoire, as well as in eastern Uganda (Nachuha, 2009) and Burundi (Nasasagare *et al.*, 2014). Maintaining a diversity of cultivation stages, combined with the conservation of wetland habitats, could help sustain a diverse urban bird community. Nevertheless, the limitations of these human-altered environments compared to natural wetlands have been extensively documented.

CONCLUSION

This study highlighted the importance of rice-based agroecosystems for bird conservation in urban environments. The data collected provided insight into how rice cultivation stages influence bird community dynamics. The highest species diversity was observed during the pre-tilling stage, whereas the lowest diversity was recorded during the mature rice stage; however, the latter stage recorded the highest number of individual birds. Bird species distribution varied according to the different phases of rice cultivation. The orders Passeriformes and Columbiformes were the best represented across all stages. The family Columbidae was most prevalent during the pre-tilling, tilling, vegetative, and post-harvest stages, while the family Ploceidae was most abundant during the immature and mature rice stages. These findings demonstrate that rice cultivation, as currently practiced, exerts pressure on local bird populations as the crop progresses through its phenological stages.

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