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RESEARCH ARTICLE

EFFECT OF HABITAT ON BIRD DISTRIBUTION IN THE CITY OF KORHOGO, NORTHERN COTE D'IVOIRE

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Abstract

In Côte d'ivoire, the place of birds in the city is more at the heart of ornithological research. From August 2020 to July 2021, this study was carried out on the university campus of Korhogo to evaluate the effect of the anthropization gradient on bird distribution. Three different habitats (dwellings, scrub and forests) were sampled using the point abundance index method. The results show that Scrublands and Forest were the most diverse habitats. These two habitats share the highest similarity rate. *Spilopelia senegalensis*, *Ardea ibis*, *Corvinella corvina*, *Corvus albus*, *Ploceus cucullatus* and *Lonchura cucullata* have the highest abundances in Habitations and can be considered synanthropic species. The Forest is home to 20 species that have not been observed in other habitats. The spatial distribution of birds on the campus follows a well-marked anthropization gradient.

Introduction:-

In recent years, the magnitude of catastrophic climate events affecting the Earth are all consequences of climate change (Duvat, 2015; Aoubouazza et al., 2019; Chaix and Slama, 2022). Among the most important causes of global warming and biodiversity loss, urbanization figures prominently. This urbanization causes the alteration of habitat and ecological processes (Sukopp et al., 1996; Alberti, 2005). Increasingly, cities are trying to improve their image and want to be greener and less incompatible with nature, particularly wildlife including birds. Several studies carried out in recent years in some of the most urbanized areas of Côte d'Ivoire have highlighted a significant presence of birds both in quality and quantity (Yaokokoré-Béibro et al., 2015; Zéan et al., 2018; Konan et al., 2021; 2024). Korhogo, the main town in the north of Côte d'Ivoire, has seen increasing interest from ornithologists since 2019.

This interest is materialized by studies carried out on the Koko dam lake (Niamien et al., 2019a and b; 2020) and on the university campus (Konan et al., 2023). The first studies carried out in the city of Korhogo have helped to lift the

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veil on the city's bird diversity. The university campus of Korhogo has already been the subject of a preliminary inventory (Konan et al., 2023). This inventory showed the presence of 110 species of birds that visit or nest on the university campus. These various bird species have different ecological needs and use the study site differently. In addition, the campus landscape is not homogeneous over its entire surface area. It presents the landscape of the majority of Ivorian cities which are made up of a mosaic of habitats. A horizontal stratification of the urban environment then emerges which suggests a gradient of anthropization, with densely built zones, moderately built zones, sparsely built zones and unbuilt zones. Thus, the objective of this study is to determine the effect of the anthropization gradient on the distribution of the bird community of the Korhogo university campus. The data collected at the end of this study will allow us to better understand the use of the university campus by urban avian fauna and to make suggestions and recommendations to improve the living conditions of wild birds in the city.

Materials and Methods:-

Peleforo Gon Coulibaly University of Korhogo (Figure 1) islocated at 9°25'38'' N and 5°37'58'' W, south of the city of Korhogo. The campus landscape is made up of a mosaic of buildings, grassy plots and woodlands. The buildings are organized into two blocks, the first of which groups together the administrative offices, lecture halls and other classrooms. The second block of buildings contains the university residences and the play areas. The grassy area covers a substantial part of the campus territory. It is made up of a regularly mowed and wooded garden on the one hand and a bushy part made of tall grass on the other hand. In addition to the many scattered woody plants, the campus has a botanical garden. This includes a part reforested by *Tectona grandis* and another part made of a forest relict (Figure 1). The city of Korhogo is under the influence of the tropical transitional climate with two seasons, one dry (November – April) and the other rainy (May – October). The average annual rainfall is between 1000 and 1700 mm (Konate and Kampmann, 2010).

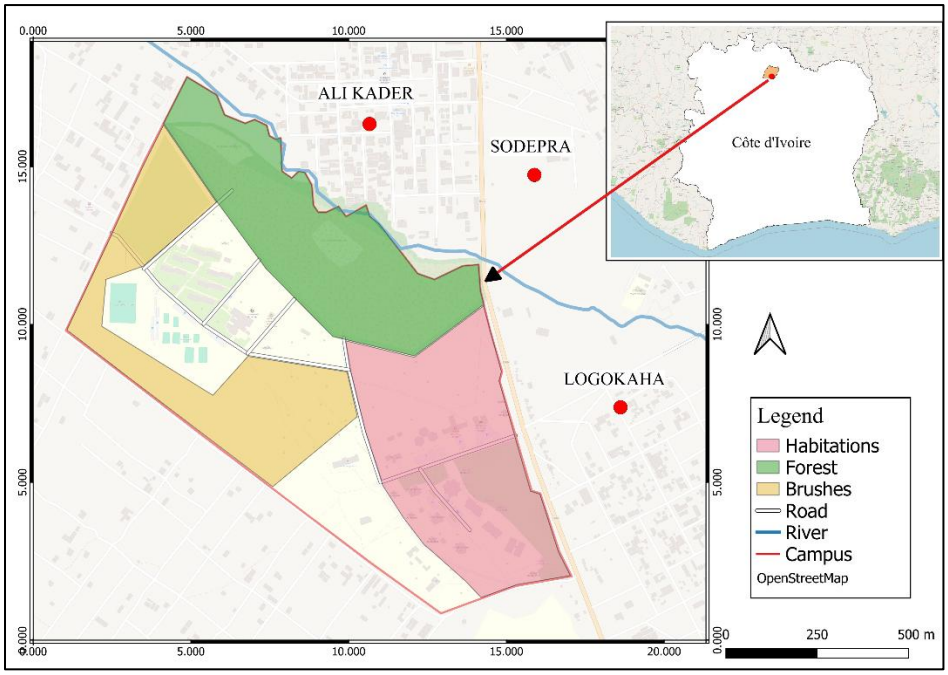

Figure 1 : Map of the Peleforo Gon Coulibaly university campus in Korhogo and the different habitats in the area

The study took place from August 2020 to July 2021. Three different habitats were selected on the campus following a gradient of anthropization. The highly anthropized habitat is represented by university residences, administrative offices and classrooms with their lawns and ornamental plants (Habitations). The moderately anthropized habitat is represented by the scrub areas (Brushes). The least anthropized habitat on the campus is represented by the forest relict (Forest).

Each habitat was sampled once a week for 12 months using the point abundance index method (Blondel et al., 1970) based on the counting points. Three counting points spaced 300 m from each other were installed per habitat. At each point, birds were counted for 20 min using binoculars within a radius of 100 m around the observer (Bibby et al., 2000). Unknown calls and songs were recorded on a dictaphone and subsequently identified using Chappuis' discography (2000). At each weekly observation session, the three habitats were sampled successively and alternately from one session to the next. Inventories took place from 6:30 a.m. to 10:00 a.m.; periods of maximum activity in birds (Thiollay, 1973; Yaokokoré-Béibro, 2001). The data collected made it possible to calculate diversity indices such as the Shannon-Weaver index (H'), equitability (J) and similarity (Si). Significance tests (ANOVA), factorial correspondence analysis and principal component analysis were used to compare habitats based on their avifaunal diversity.

Results:-

The specific richness and abundance of birds differ from one habitat to another. The habitat "Habitations" includes 57 species of birds from 14 orders and 30 families, with 506 birds. The Accipitridae, with five species are the best represented in this habitat. The habitat "Brushes" contains 81 species from 33 families and 14 orders for 450 birds. The Columbidae, with seven species are the most diverse in this habitat. The forest relict, shelters 80 species of birds from 33 families and 14 orders and 527 birds. The Columbidae, with nine species are the most important in this plot. In all three habitats the Shannon indices are high. However, the Brushesis the most diverse with H' = 3.816 and J = 0.868. The Habitations and the forest relict have respectively H' = 3.022 and H' = 3.389; J = 0.747 and J = 0.773 (Table I and Figures 2 to 5).

Table1: List of birds on the Korhogo university campus according to the different habitats sampledfrom August 2020 to July 2021

Biogeo: Biogeographical origins; Habitat: Preferred habitat; IUCN: International Union for Conservation of Nature; R: Resident; M: Intra-African migrant; P: Palearctic migrant; LC: Least concern; HAB: Habitations; BRU: Brushes; FOR: Forest

Orders/Families/Species	English name	Biogeo	Habitat	IUCN	HAB	BRU	FOR
Galliformes							
Odontophoridae							
Ptilopachus petrosus (J. F. Gmelin, 1789)	Stone Partridge	R	f.	LC		1	8
Phasianidae							
Pternistis bicalcaratus (Linnaeus, 1766)	Double-spurred Francolin	R	f.	LC		3	2
Campocolinus albogularis (Hartlaub, 1854)	White-throated Francolin	R	f.	LC		1	
Columbiformes							
Columbidae							
Columba guinea Linnaeus, 1758	Speckled Pigeon	R	f.	LC	19	16	4
Streptopelia semitorquata (Ruppell, 1837)	Red-eyed Dove	R	f.	LC	4	3	6
Streptopelia vinacea (Gmelin, 1789)	Vinaceous Dove	R	f.	LC	2	5	2
Spilopelia senegalensis (Linnaeus, 1766)	Laughing Dove	R	f.	LC	30	26	11
Turtur abyssinicus (Sharpe, 1902)	Black-billed Wood Dove	R	f.	LC		4	8
Turtur afer (Linnaeus, 1766)	Blue-spotted Wood Dove	R	f.	LC			4
Turtur tympanistria (Temminck, 1809)	Tambourine Dove	R	F	LC			2
Treron waalia (F. A. A. Meyer, 1793)	Bruce's Green-pigeon	R	f.	LC		4	
Treron calvus (Temminck, 1808)	African Green-pigeon	R	F	LC		3	1
Streptopelia decipiens (Hartlaub&Finsch, 1870)	Mourning Collared Dove	R	f.	LC			1
Caprimulgiformes							
Caprimulgidae							
Caprimulgus inornatus Heuglin, 1869	Plain Nightjar	M/R	f.	LC	1	1	
Caprimulgus longipennis (Shaw, 1796)	Standard-winged Nightjar	M	f.	LC		2	
Caprimulgus europaeus Linnaeus, 1758	European Nightjar	P	f.	LC		1	
Apodiformes							
Apodidae							

Orders/Families/Species	English name	Biogeo	Habitat	IUCN	HAB	BRU	FOR
Cypsiurus parvus (Lichtenstein, 1823)	African Palm-Swift	R	f.	LC	2	2	
Apus affinis (J. E. Gray, 1830)	Little Swift	R	f.	LC		2	
Cuculiformes							
Cuculidae							
Centropus senegalensis (Linnaeus, 1766)	Senegal Coucal	R	f.	LC	4	14	3
Clamator levaillantii (Swainson, 1829)	Levaillant's Cuckoo	M	f.	LC	3	1	3
Chrysococcyx klaas (Stephens, 1815)	Klaas's Cuckoo	R	f.	LC			1
Chrysococcyx caprius (Boddaert, 1783)	Dideric Cuckoo	M/R	f.	LC		2	1
Cercococcyx olivinus Sassi, 1912	Olive Long-tailed Cuckoo	R	F	LC			1
Cuculus gularis Stephens, 1815	African Cuckoo	M	f.	LC	3	1	1
Gruiformes							
Rallidae							
Zapornia flavirostra (Swainson, 1837)	Black Crake	R	E	LC			1
Musophagiformes							
Musophagidae							
Crinifer piscator (Boddaert, 1783)	Western Grey Plantain-eater	R	f.	LC	3	6	7
Tauraco violaceus Isert, 1788	Violet Turaco	R	f.	LC		3	5
Pelecaniformes							
Ardeidae							
Butorides striata (Linnaeus, 1758)	Green-backed Heron	R	E	LC			1
Ardea ibis (Linnaeus, 1758)	Cattle Egret	R/M	E	LC	124		1
Scopidae							
Scopus umbretta Gmelin, 1789	Hamerkop	R	E	LC	1		1
Charadriiformes							
Burhinidae							
Burhinus senegalensis (Swainson, 1837)	Senegal Thick-knee	R	E	LC		1	
Charadriidae							
Vanellus senegallus (Linnaeus, 1766)	Wattled Plover	R/M	E	LC	8	6	3
Accipitriformes							
Accipitridae							
Elanus caeruleus (Desfontaines, 1789)	Black-shouldered Kite	R	f.	LC	2	2	2
Kaupifalco monogrammicus (Temminck, 1824)	Lizard Buzzard	R	f.	LC	2	2	4
Micronisus gabar (Daudin, 1800)	Gabar Goshawk	R	f.	LC	2	1	
Tachyspiza badia (Gmelin, 1788)	Shikra	R/M	F	LC	1	2	4
Milvus migrans (Boddaert, 1783)	Black Kite	M/P	f.	LC	8	9	10
Bucerotiformes							
Bucerotidae							
Lophoceros nasutus (Linnaeus, 1766)	African Grey Hornbill	R	f.	LC	3	7	5
Lophoceros semifasciatus (Shaw, 1812)	Allied Hornbill	R	F	LC	1	2	3
Bycanistes fistulator (Cassin, 1850)	Piping Hornbill	R	F	LC		1	
Coraciiformes							
Coraciidae							
Coracias naevius Daudin, 1800	Purple Roller	R/M	f.	LC	2	4	2
Coracias abyssinicus Hermann, 1783	Abyssinian Roller	M	f.	LC	3	1	
Alcedinidae							
Ispidina picta (Boddaert, 1783)	Pygmy Kingfisher	R/M	f.	LC			2
Halcyon malimbica (Shaw, 1811)	Blue-breasted Kingfisher	R	F	LC			3
Halcyon senegalensis (Linnaeus, 1766)	Woodland Kingfisher	R/M	f.	LC			2
Piciformes							
Lybiidae							

Orders/Families/Species	English name	Biogeo	Habitat	IUCN	HAB	BRU	FOR
Pogoniulus scolopaceus (Bonaparte, 1850)	Speckled Tinkerbird	R	F	LC	2	1	
Pogoniulus chrysoconus (Temminck, 1832)	Yellow-fronted Tinkerbird	R	f.	LC	1	2	2
Pogonornis dubius (Gmelin, 1788)	Bearded Barbet	R	f.	LC	3	6	2
Indicatoridae							
Indicator minor Stephens, 1815	Lesser Honeyguide	R	f.	LC			1
Picidae							
Dendropicos goertae (Statius Muller, 1776)	Grey Woodpecker	R	F	LC		1	2
Falconiformes							
Falconidae							
Falco ardosiaceus Vieillot, 1823	Grey Kestrel	R	f.	LC	1	1	1
Falco biarmicus Temminck, 1825	Lanner Falcon	R	f.	LC	1		
Psittaciformes							
Psittacidae							
Poicephalus fuscicollis (Kuhl, 1820)	Brown-necked Parrot	R	F/f	LC			2
Poicephalus senegalus (Linnaeus, 1766)	Senegal Parrot	R	f.	LC	2	5	3
Psittacula krameri (Scopoli, 1769)	Rose-ringed Parakeet	R	f.	LC		3	3
Passeriformes							
Oriolidae							
Oriolus auratus Vieillot, 1817	African Golden Oriole	M	f.	LC		1	
Platysteiridae							
Platysteira cyanea (Muller, 1776)	Scarlet-spectacled Wattle-eye	R	f.	LC			4
Malaconotidae							
Malaconotus blanchoti Stephens, 1826	Grey-headed Bush-shrike	R	f.	LC		2	2
Dryoscopus gambensis (Lichtenstein, 1823)	Northern Puff-back	R	F	LC			3
Tchagra senegalus (Linnaeus, 1766)	Black-crowned Tchagra	R	f.	LC		2	2
Laniarius leucorhynchus (Hartlaub, 1848)	Sooty Boubou	R	f.	LC			1
Laniarius barbarous (Linnaeus, 1766)	Yellow-crowned Gonolek	R	f.	LC	1	3	2
Dicruridae							
Dicrurus adsimilis (Bechstein, 1794)	Fork-tailed Drongo	R	F	LC			4
Monarchidae							
Terpsiphone rufiventer (Swainson, 1837)	Red-bellied Paradise-flycatcher	R	F	LC			4
Laniidae							
Corvinella corvina (Shaw, 1809)	Yellow-billed Shrike	R	f.	LC	30	9	11
Corvidae							
Ptilostomus afer (Linnaeus, 1766)	Piapiac	R	f.	LC	21	7	7
Corvus albus Statius Muller, 1776	Pied Crow	R	f.	LC	48	18	6
Alaudidae							
Galerida modesta Heuglin, 1864	Sun Lark	R	f.	LC	6	6	
Cisticolidae							
Eremomela pusilla Hartlaub, 1857	Green-backed Eremomela	R	f.	LC	6	6	
Camaroptera brachyura (Vieillot, 1820)	Bleating Bush Warbler	R	f.	LC		2	4
Cisticola erythrops (Hartlaub, 1857)	Red-faced Cisticola	R	f.	LC	2		3
Cisticola cantans (Heuglin, 1869)	Singing Cisticola	R	f.	LC	2	4	
Cisticola lateralis (Fraser, 1843)	Whistling Cisticola	R	f.	LC		1	
Cisticola brachypterus (Sharpe, 1870)	Siffling Cisticola	R	f.	LC	1	2	2
Prinia subflava (J. F. Gmelin, 1789)	Tawny-flanked Prinia	R	f.	LC		1	4
Prinia erythroptera (Jardine, 1849)	Red-winged Warbler	R	f.	LC		2	
Acrocephalidae							
Hippolais polyglotta (Vieillot, 1817)	Melodious Warbler	P	f.	LC	1		
Pycnonotidae							

Orders/Families/Species	English name	Biogeo	Habitat	IUCN	HAB	BRU	FOR
Atimastillas flavicollis (Swainson, 1837)	Yellow-throated Leaflove	R	F	LC		6	7
Chlorocichla simplex (Hartlaub, 1855)	Simple Greenbul	R	F	LC		2	2
Pycnonotus barbatus (Desfontaines, 1789)	Garden Bulbul	R	f.	LC	12	10	13
Phylloscopidae							
Phylloscopus bonelli (Vieillot, 1819)	Western Bonelli's Warbler	R	F/f	LC	1		
Zosteropidae							
Zosterops senegalensis Bonaparte, 1850	Yellow White-eye	R	F/f	LC	6	2	
Leiothrichidae							
Turdoides plebejus (Cretzschmar, 1828)	Brown Babbler	R	f.	LC		15	24
Sturnidae							
Lamprotornis caudatus (Muller, 1776)	Northern Long-tailed Starling	R	f.	LC	6	9	7
Lamprotornis purpureus (Statius Muller, 1776)	Purple Glossy-starling	R	f.	LC	4		2
Lamprotornis chalcurus Nordmann, 1835	Bronze-tailed Glossy-starling	R	f.	LC	7	21	
Turdidae							
Turdus pelios Bonaparte, 1850	African Thrush	R	f.	LC	3	5	6
Muscicapidae							
Melaenornis edolioides (Swainson, 1837)	Western Black-flycatcher	R	F/f	LC			2
Cossypha niveicapilla (Lafresnaye, 1838)	Snowy-headed Robin-chat	R	F	LC	1		1
Cossypha albicapillus (Vieillot, 1818)	White-crowned Robin-chat	R	f.	LC		1	7
Nectariniidae							
Hedydipna collaris (Vieillot, 1819)	Collared Sunbird	R	F	LC		2	2
Hedydipna platura (Vieillot, 1819)	Pygmy Sunbird	M	F	LC		3	
Cyanomitra verticalis (Latham, 1790)	Green-headed Sunbird	R	F	LC		2	2
Chalcomitra senegalensis (Linnaeus, 1766)	Scarlet-chested Sunbird	R	f.	LC	2		6
Cinnyris chloropygius Jardine, 1842	Olive-bellied Sunbird	R	F	LC		2	
Cinnyris coccinigastrus (Latham, 1802)	Splendid Sunbird	R	f.	LC		2	4
Cinnyris cupreus (Shaw, 1812)	Copper Sunbird	R	f.	LC		3	2
Ploceidae							
Euplectes hordeaceus (Linnaeus, 1758)	Black-winged Red Bishop	R	f.	LC		2	
Euplectes franciscanus (Isert, 1789)	Northern Red Bishop	R	f.	LC	2	9	2
Ploceus nigricollis (Vieillot, 1805)	Black-necked Weaver	R	f.	LC			5
Ploceus heuglini Reichenow, 1886	Heuglin’s Masked-weaver	R	f.	LC		2	
Ploceus cucullatus (Statius Muller, 1776)	Village Weaver	R	f.	LC	31	37	48
Estrildidae							
Lagonosticta rufopicta (Fraser, 1843)	Bar-breasted Firefinch	R	f.	LC			8
Lagonosticta senegala (Linnaeus, 1766)	Red-billed Firefinch	R	V/f	LC		13	15
Uraeginthus bengalus (Linnaeus, 1766)	Red-cheeked Cordon-bleu	R	V/f	LC	7	11	10
Estrilda melpoda (Vieillot, 1817)	Orange-cheeked Waxbill	R	f.	LC	2	10	12
Estrilda troglodytes (Lichtenstein, 1823)	Black-rumped Waxbill	R	f.	LC	1		
Lonchura cucullata (Swainson, 1837)	Bronze Mannikin	R	f.	LC	50	48	150
Passeridae							
Passer griseus (Vieillot, 1817)	Grey-headed Sparrow	R	V/f	LC	6	2	
Gymnoris dentata (Sundevall, 1850)	Bush Petronia	R	f.	LC	3	3	
Motacillidae							
Anthus leucophrys Vieillot, 1818	Plain-backed Pipit	R	f.	LC	4	4	
Macronyx croceus (Vieillot, 1816)	Yellow-throated Longclaw	R	f.	LC	2		
TOTAL					506	450	527

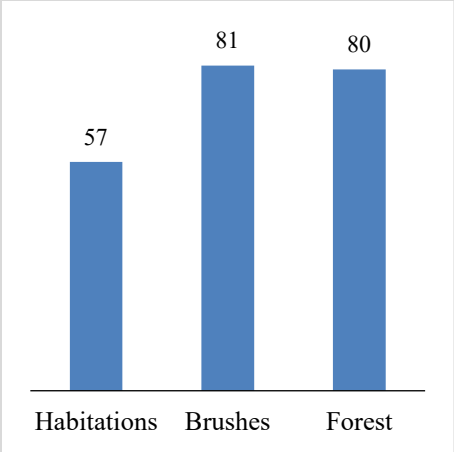

Figure 2: Species richness of the different habitats sampled on the campus

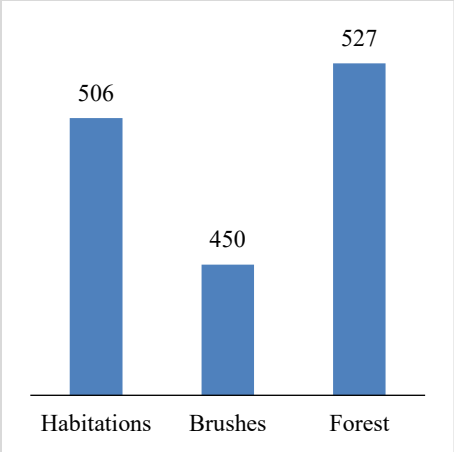

Figure 3: Relative abundance of different habitats sampled on campus

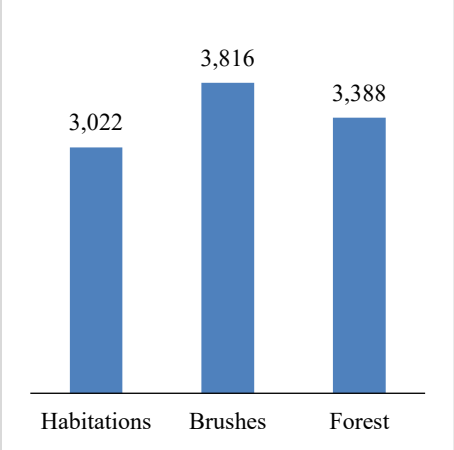

Figure 4: Comparison of the different sampled habitats based on the equitability index

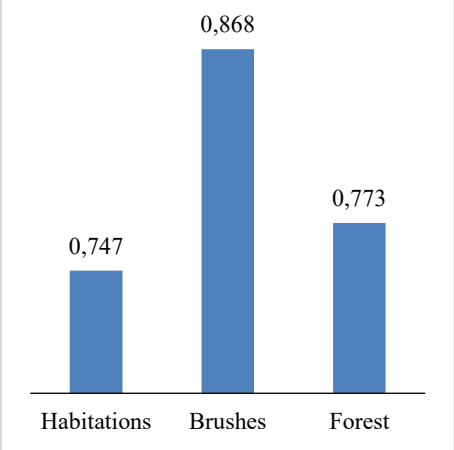

Figure 5: Comparison of different habitats sampled according to the Shannon-Wiener index

The order Galliformes was not observed in the Habitations. Apodiformes and Caprimulgiformes are absent from the forest. The Gruiformes was only observed in the forest. The Pelecaniformes are absent from the Brushes. Two families were observed only in the Habitations (Acrocephalidae and Phylloscopidae); two other families (Burhinidae and Oriolidae) were observed only in the Brushes; six families were encountered only in the Forest (Rallidae, Alcedinidae, Indicatoridae, Platysteiridae, Dicruridae and Monarchidae). Ardeidae and Scopidae were not observed in the Brushes. Caprimulgidae, Apodidae, Alaudidae, Zosteropidae, Passeridae and Motacillidae were not observed in the Forest. Odontophoridae, Phasianidae, Picidae, Platysteiridae and Leiothrichidae were not observed in the Habitations.

The specific compositions of the bird community vary according to the different habitats. In the Habitations, six species have the highest abundance. These are *Spilopelia senegalensis* (30 individuals), *Ardea ibis* (124 individuals), *Corvinella corvina* (30 individuals), *Corvus albus* (48 individuals), *Ploceus cucullatus* (31 individuals) and *Lonchura cucullata* (50 individuals). This habitat records five species (*Falco biarmicus*, *Hippolais polyglotta*, *Phylloscopus bonelli*, *Estrilda troglodytes* and *Macronyx croceus*) that were not observed in the other two habitats. In the Brushes, 14 species that were absent from other habitats were observed. These are *Campocolinus albogularis*,

Treron waalia, *Caprimulgus longipennis*, *Caprimulgus europaeus*, *Apus affinis*, *Burhinus senegalensis*, *Bycanistes fistulator*, *Oriolus auratus*, *Cisticola lateralis*, *Prinia erythroptera*, *Hedydipna platura*, *Cinnyris chloropygius*, *Euplectes hordeaceus* and *Ploceus heuglini*. The most abundant species in the Brushes are *Spilopelia senegalensis* (26 individuals), *Corvus albus* (18 individuals), *Lamprotornis chalcurus* (21 individuals), *Ploceus cucullatus* (37 individuals) and *Lonchura cucullata* (48 individuals). In the third habitat, the Forest, the five most abundant species are *Pycnonotus barbatus* (13 individuals), *Turdoides plebejus* (24 individuals), *Ploceus cucullatus* (48 individuals), *Lagonosticta senegala* (15 individuals) and *Lonchura cucullata* (150 individuals).

On campus, 20 of the species observed frequent the Forest exclusively. These include: *Turtur afer*, *Turtur tympanistria*, *Streptopelia decipiens*, *Chrysococcyx klaas*, *Cercococcyx olivinus*, *Ispidina picta*, *Poicephalus fuscicollis*, *Dryoscopus gambiensis*, *Melaenornis edolioides*, *Zapornia flavirostra*, *Butorides striata*, *Halcyon malimbica*, *Halcyon senegalensis*, *Indicator minor*, *Platysteira cyanea*, *Laniarius leucorhynchus*, *Dicrurus adsimilis*, *Terpsiphone rufiventer*, *Ploceus nigricollis* and *Lagonosticta rufopicta.*

A total of 33 bird species observed on the campus frequent all three habitats. Figure 6 shows the affinity of these species to the habitats surveyed. Thus, *Corvus albus*, *Corvinella corvina*, *Ardea ibis*, *Columba guinea*, *Spilopelia senegalensis* and *Vanellus senegallus* are more attached to the Habitations. The forestis the domain of *Lonchura cucullata*. The scrubs are more associated with *Coracias naevius*, *Pogonornis dubius*, *Streptopelia vinacea*, *Centropus senegalensis* and *Euplectes franciscanus*.

The Kruskal-Wallis analysis carried out at the 5% threshold indicates that on the basis of their respective communities, thereis a significant difference between the Habitations and Scrub environments ($p < 0.05$) on the one hand and between Habitations and Forest ($p < 0.05$) on the other hand. Furthermore, there is no significant difference between the Scrub and Forest environments ($p = 0.953$).

The similarity between the different habitats was calculated. Overall, the similarity is almost identical between the Habitations and Scrubland environments (Si = 66.67%) on the one hand and the Scrubland and Forest environments (Si = 67.08%) on the other hand. The similarity is lower between the Habitations and Forest environments (Si = 56.93%). The dendrogram (Figure 7) confirms the similarity values and indicates that the Scrubland and Forest environments form a group by being separated by a lower Euclidean distance. These two environments are separated by a higher distance from the Habitations environment.

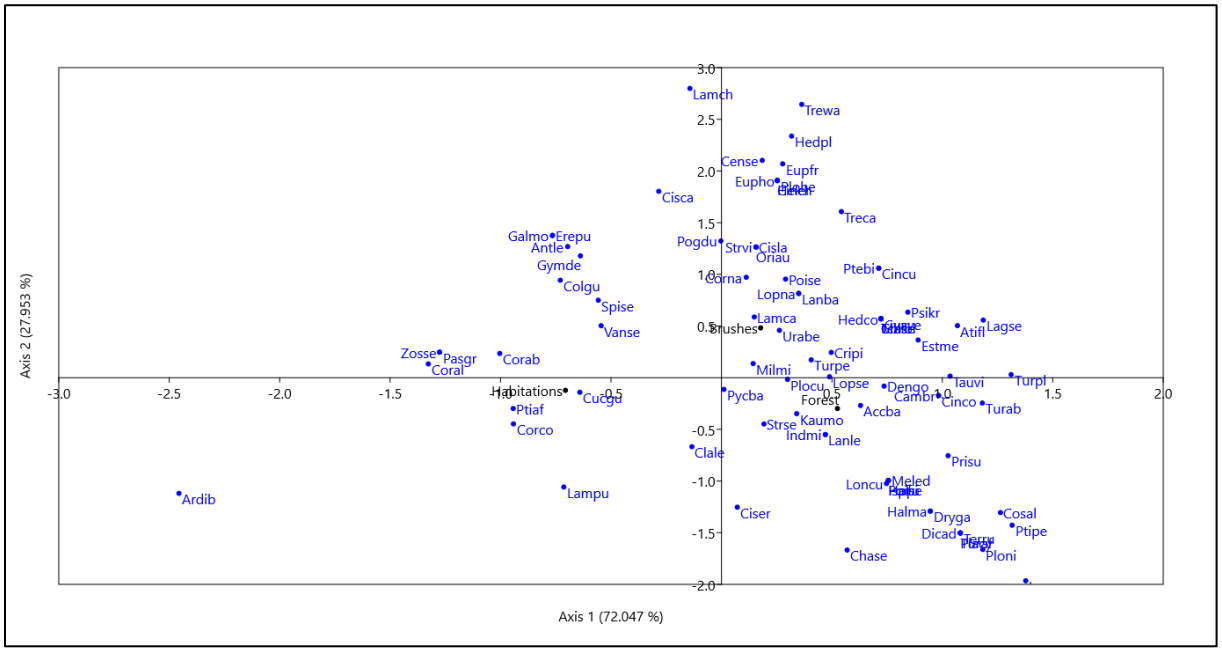

Figure 6: Distribution of species common to the three habitats according to their abundance

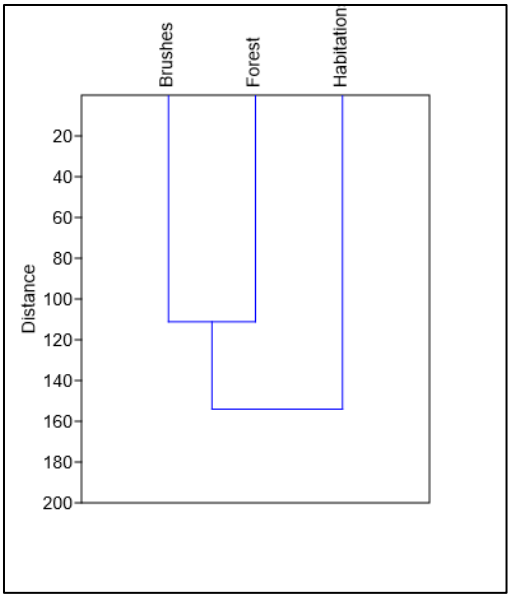

Figure 7: Dendrogram showing the association of habitats according to their similarity

Discussion:-

The general avifauna of the Korhogo university campus has already been presented in a first publication (Konan et al., 2023). This study presents the spatial distribution of these species within the university campus. By analyzing the results obtained, it is noted that scrubland and forest are the most diverse habitats, with an advantage for scrubland which has the highest diversity index. The structure of the vegetation in the scrub could explain this. Indeed, the scrub habitat is a mosaic of trees and shrubs, various herbaceous plants of varying sizes including several grasses. This vegetation structure would favor various species of birds with food guilds and habitat choices as diverse as they are varied.

Unlike the scrubland, the forest has a higher tree density, with taller trees than in the scrubland. The level of diversity of the forest's avifauna is enhanced by the presence of a wetland as well as experimental crop areas. Due to their structure and heterogeneity, these two habitats would be areas where birds flock to the campus. Indeed, food sources favor the presence of birds in urban environments. This has also been observed for several other studies in urban environments (Zéan et al., 2018; Yaokokoré-Béibro et al., 2016; Niamien et al., 2019a; 2020; Konan et al., 2021). The degree of disturbance and disruption of the environment, in addition to the density of buildings, could explain the low attractiveness of the Habitations for birds compared to the other two habitats. Indeed, the permanent presence of students as well as the method of maintaining large spaces, by keeping the grass short, would be one of the reasons for the low specific richness observed in this habitat.

To this must be added the homogeneous nature of this habitat characterized by a density of buildings and green spaces that are certainly wooded but regularly mowed. The homogeneity of the habitat was pointed out by Hamel (2019) as one of the causes of the low specific richness in the heavily built-up areas of the city of Ksar Shabi in eastern Algeria. Furthermore, Lougbegnon and Codjia (2011) demonstrated during their study on the avifauna of the city of Cotonou that the determining element in the distribution of birds was mainly the presence of vegetation and the degree of homogeneity of the urban environment. The present study made it possible to highlight bird species indicative of the different sampled habitats characteristic of a clear anthropogenic gradient. This distribution of birds following the anthropogenic gradient is manifested by a number of habitat-specific species that is increasingly high when moving from the built environment to the forest. Arboreal species that are more sensitive to disturbance are specific to the forest habitat, while birds associated with open wooded environments are found only in scrubland. The built environment is preferred by synanthropic birds that have adapted to human presence by taking advantage of available food sources. This is the case of *Ardea ibis*, *Corvinella corvina* and *Vanellus senegallus* which have specialized in the consumption of insects from landscaped gardens on the one hand, *Columba guinea* and *Spilopelia senegalensis* which feed on the ground and finally *Corvus albus* which takes advantage of food remains in dumps. These six species although present in the other two habitats are much more abundant in the built environment. It is also one of the effects of urbanization which increases the density and abundance of anthropophilic birds able to

take advantage of the increased availability of food and artificial nesting sites such as buildings, telephone and electricity transmission pylons as well as public lighting elements (Kontsiotis et al., 2019). Thus, Chace and Walsh (2006) point out that urbanization is beneficial for a small number of birds that have become synanthropic but constitutes a threat to a large number of other bird species.

Although they present differences, statistically, scrub and forest are not significantly different. On the other hand, these two habitats are statistically moving away from the Habitations environment. This shows the negative impact of the concreting of urban environments on bird diversity. This reinforces the observation that the presence of more or less heterogeneous natural vegetation is beneficial to faunal diversity (Dale, 2018).

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