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RESEARCH ARTICLE

Comparison of Avian Species Community Assembly in Urban and Coastal Areas around Port Harcourt, Nigeria

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Abstract

As urbanization accelerates and coastal regions face distinct challenges, understanding the implications on avian species community is important. This study investigates the assembly of avian species communities in contrasting habitats within Port Harcourt, Rivers State, focusing on urban and coastal areas. Employing the "Birds of West Africa" field guide and binoculars, avian species were meticulously censured and recorded. The study focused on two distinct habitats: the urban region (GRA Phase 3) and the coastal area (Eagle Island). Abundance patterns and diversity indices were assessed, and soil analysis was conducted to understand physiochemical properties in each habitat. The result shows that urban region (GRA Phase 3) exhibited a Shannon diversity index of 1.75 with an evenness index of 0.59. In contrast, the coastal area (Eagle Island) displayed heightened diversity (Shannon index 2.30) and increased evenness (0.89). A total of 559 birds were identified across both habitats, with 159 birds in the coastal area and 400 in the urban environment. The Spur-winged lapwing (*Vanellus spinosus*) was the most abundant species in the coastal area (Relative abundance= 20.75), while the Intermediate egret (*Egretta intermedia*) dominated the urban landscape (Relative abundance = 55.77). The Ardeidae family was the most abundant in both areas, with GRA Phase 3 having the highest abundance. Soil analysis revealed variations in physiochemical properties, with higher Zinc concentrations observed in Eagle Island compared to GRA Phase 3. Subsequently, THC concentrations followed a similar trend. The study highlights distinct differences between avian communities in urban and coastal habitats, as evidenced by the low Sorenson similarity index value of 0.047. These findings emphasize the importance of habitat-specific factors in shaping avian community dynamics.This comprehensive exploration sheds light on avian community dynamics, offering valuable insights into biodiversity and environmental distinctions between urban and coastal ecosystems in the region. The findings contribute to our understanding of avian species distribution, emphasizing the importance of habitat-specific factors in shaping these communities.

Keywords: Urbanization, Coastal Development, Avian Species Communities, Biodiversity, Habitat-Specific Factors, Conservation, Port Harcourt, Rivers State.

1. Introduction

The rapid urbanization and coastal development in Port Harcourt, Rivers State, have raised concerns about their impacts on avian species communities. The contrasting habitats of urban areas and coastal regions present unique challenges for avian community assembly, including habitat loss, fragmentation, and resource availability. Avian communities play pivotal roles in ecosystem functioning, including pollination, seed dispersal, and pest control. The Earth is undergoing the sixth great mass extinction (Cowie *et al.*, 2022). Numerous driving factors, operating at different trophic levels, directly and indirectly trigger the mass extinction, including habitat loss and destruction, climate change, illegal harvest, environmental pollution and invasion by alien species. Among them, habitat loss and degradation as

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the consequences of human activities play a profound role in influencing global biodiversity (García *et al*. 2018).

Avian communities play a crucial role in maintaining the ecological balance and functioning of ecosystems. When populations of birds of several species are found in a particular environment, it signifies that the environment is healthy and there are also many organisms within that geographical location. They are indicators of environmental health and provide valuable ecosystem services such as seed dispersal, pollination, and pest control. However, urbanization and coastal development have significantly impacted avian species communities, leading to changes in their population dynamics, diversity, and reproductive success. According to Anderson *et al*., 2018, when distinct ecosystems are destroyed, the ecological roles of birds often disappear with them.

Urban areas are characterized by extensive human development, resulting in habitat fragmentation, pollution, and altered resource availability. Coastal areas, on the other hand, are influenced by specific ecological dynamics such as tidal fluctuations, saltwater intrusion, and diverse marine ecosystems (Murthy & Reddy, 2014). Investigating avian species in these contrasting environments provides valuable insights into how birds adapt and respond to human-induced changes and natural coastal processes.

Port Harcourt, located in Rivers State, Nigeria, experiences rapid urbanization and industrialization. The city serves as a major economic hub, attracting increasing human population and infrastructure development. Additionally, its coastal proximity offers unique ecological characteristics, including mangroves, estuaries, and diverse marine habitats. Avian species diversity has decreased due to destruction of natural habitats and human activities which prompts disturbances to the environment especially in Niger Delta regions of Nigeria, Africa (Sylvester *et al.,* 2018). Consequently, studying avian species in this region allows us to understand the effects of urbanization and coastal dynamics on bird communities.

Urban areas often exhibit higher levels of habitat fragmentation due to infrastructure development, resulting in reduced nesting sites and foraging opportunities for avian species. Pollution from industrial activities and vehicular emissions can also affect bird populations, leading to changes in species composition and abundance. In contrast, coastal areas provide distinct feeding opportunities for avian species, such as intertidal zones rich in marine organisms. However, they are also susceptible to habitat loss through erosion and sea-level rise.

Furthermore, avian communities in urban areas may face competition from non-native species that thrive in human-altered environments. In coastal areas, birds may be influenced by tidal patterns, salinity levels, and the availability of specific food sources. These environmental factors can shape avian community structure, diversity, and composition, highlighting the importance of studying avian species in both urban and coastal areas. Understanding these changes is essential for effective conservation and management strategies. Therefore, this study aims to compare the avian species community assembly between urban (GRA Phase 3) and coastal (Eagle Island) areas in Port Harcourt, with a specific focus on assessing and understanding the avian species abundance, diversity, similarities and properties of the soil and water in urban and coastal area.

2. Materials and Methods

The coastal area used in this research is located behind Rivers State University at Eagle Island in the Niger Delta with coordinates of latitude 4°47'N and longitude 6°58'E (Figure 1). This specific area had undergone deforestation and was later filled with sand due to mining activities, which lasted for three years before being abandoned. Subsequently, the site became a transportation hub, with speed boats ferrying passengers across the river to a nearby community. The site is also made up of different organisms like fiddler crabs, periwinkle, fingerlings and birds. The study area experiences rainfall throughout the year, with an average annual precipitation of 3,567.4 mm. The temperature ranges from 28 to 34°C monthly. The adjacent river is an estuary, and the soil in the area varies from sandy to muddy (swampy) and displays a range of colors from white to dark brown. Some portions of the sand have a reddish hue due to the presence of iron II. The soil pH ranges from 6 to 7 (Numbere, 2020a). The Eagle Island has different sites of plastic pollution including commercial activities. The study plot is located approximately 91 meters away from the main river course. During high tide, water enters the sand-filled area while during low tide, the water goes back leaving behind leaf litter, seeds, and seedlings of mangrove.

The second study area which is the urban area is located in GRA Phase 3, Port Harcourt, with GPS coordinates of N 04°49.181' and E 006°59.443'

(Figure 2). This study area is an undisturbed bird breeding site predominantly covered with vegetation, including various trees and grasses, providing a suitable habitat for different species of birds, which can be observed nesting in the trees. The study site is situated in close proximity to the main road, where hotels, schools, and residential houses are located.

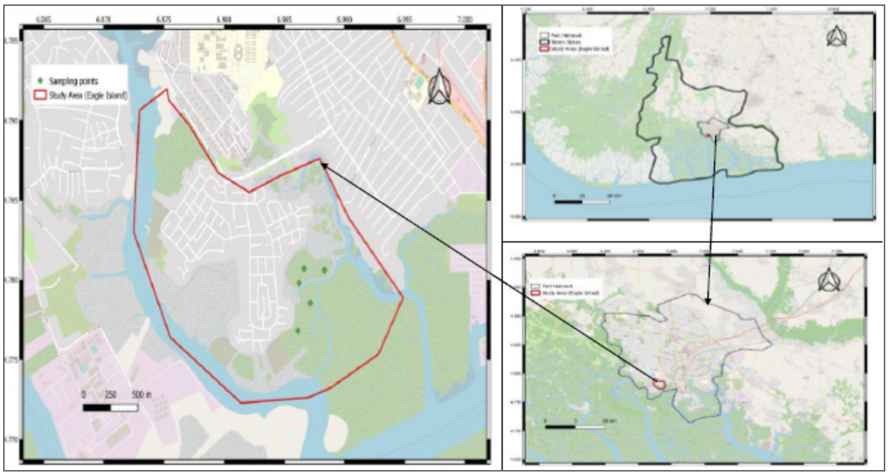

Figure 1. *Map of study area at Eagle Island, Rivers State Nigeria.*

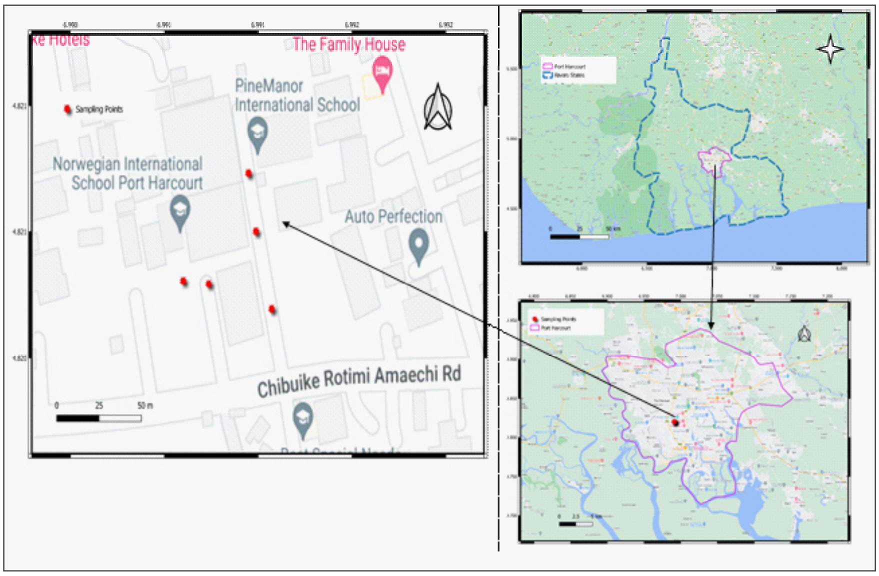

Figure 2. *Map of study area at the bird breeding site, Rivers State, Nigeria.*

The avian species of the study site were surveyed to determine the patterns of avian species diversity across various plots in the area. The bird surveys were conducted between August – October 2023. The timing of field visits was between 08:00 to 10:00 am in the morning when birds were more active and 02:00 pm to 05:00 pm in the evening when the birds are back to roost. A systematic census of avian species was undertaken, documenting observations on a designed data sheet. During the surveys, the avian species on the study sites were identified and each individual species sighted, were counted and recorded in a data sheet. Different sites were regularly surveyed during the study period and birds were observed in each site with the help of binoculars. The binoculars were used to view the birds from far distances to have a clearer view for colors, tails, beaks and other structures essential for bird identification. Photographs were also taken for further identification. Field guides were utilized to aid in the accurate identification of birds, considering factors such as color, beak characteristics, and other distinctive features. The use of a data sheet, camera, binoculars, and protective gear contributed to a methodical and well-documented research process.

The Shannon diversity index was calculated to assess the species diversity of avian communities at each sampling site. This index takes into account both species richness (number of different species) and species evenness (relative abundance of each species).

The relative abundance was measured using the formula below:

$$\frac{\text{Species abundance}}{\text{Total abundance}} \times 100$$

The Shannon Wiener diversity index was used to measure the avian species diversity. It is expressed as:

$$H = - \sum_{pi}^{s} \times \ln(pi)$$

Where :

- H is Shannon Diversity Index
- Pi is Proportion of avian species in the community
- ln is natural log
  Species evenness was evaluated using Evenness Index (E) which is expressed as:

E=H/Hmax,

Where:

- E= Evenness Index
- H =Shannon-Wiener diversity index
- Hmax = LnS (natural logarithm of the total number of species).

The Sorenson Similarity index (SSI) was used to compare the avian species of the two communities. It is expressed as:

$$SSI= \frac{C}{(S1+S2)/2}$$

Where:

- SSI is Sorenson Similarity Index
- C is Number of species held in common
- S1 and S2 is the number of species in each community

Water and soil samples were collected from Eagle Island (coastal area) and GRA Phase 3 (Urban area) using containers and polyethylene bags respectively from designated points within each area. The collected samples were labelled accordingly and taken to the laboratory to ensure the integrity of the materials. Laboratory analysis focused on testing for heavy metals and total hydrocarbon content in both water and soil samples.

2.1 Laboratory Analysis

A Spectrophotometer was used in determining the total hydrocarbon with a calorimeter (i.e., HACH DR, 890). 2g of the crushed soil sample was added into a glass beaker with 20ml of hexane and then stirred. Afterwards, the mixture was filtered through a glass funnel with wool, silica gel and anhydrous sodium sulphate. 10 ml of organic extract was added to a 10ml sample curvet, it was put into the calorimeter. The detection limit for THC is 0.01mg/1(APHA, 1995).

Heavy metals were extracted following the procedures of Aigberua and Tarawou (2018).0.25g of the soil sample was air dried and then weighed into a Teflon inset of a microwave digestion vessel, 2ml of concentrated (90%) nitric acid was introduced into the soil sample. The metals were extracted using a microwave accelerated reaction system (MARS Xpress, CEM Corporation, Mathews, North Carolina). The detection limit for the two metals analysed in mg/l i.e., Cadmium and Lead were 0.001 and 0.002 respectively (Aigberua and Numbere, 2019).

2.2 Statistical Analysis

An analysis of variance (ANOVA) was conducted since there were multiple samples per block to test whether there was any significant difference in the concentration of hydrocarbon and heavy metals in water, soil, plant and animal samples collected within study plots. Logarithmic transformation of the data was performed to meet assumptions of normality and homoscedasticity (Logan, 2010). Similarly, a post-hoc Tukey's HSD test was done to investigate pair wise mean differences between groups. All analyses were performed in R statistical environment, 3.0.1 (R Core Team, 2013).

3. Results

The ANOVA result indicates that there is significant difference in the abundance of avian species between Eagle Island and GRA Phase 3 ($F_{1, 50} = 2.90$, $P<0.05$, Table 1, Figure 3). A total of 559 birds were counted (Table 1). There are thirteen (13) different bird species in the population (Table 1, Figure 3). The result shows that GRA Phase 3 has a higher abundance (n = 400) than Eagle Island (n = 159).

The avian species observed are African thrush (*Turdus pelios*), Black heron (*Egretta ardesiaca*), Common Kestrel (*Falcon tinnunculus*), Great egret (*Egretta alba*), Grey heron (*Ardea cinerea*), Intermediate egret (*Egretta intermedia*), Long-tailed Cormorant (*Microcarbo africanus*), Piapiac (*Ptilostomus afer*), Pied Crow (*Corvus albus*), Spur-winged lapwing (*Vanellus spinosus*), Western reef heron (*Egretta gularis*), and Yellow-billed kite (*Milvus aegyptius*). The spur-winged lapwing (*Vanellus spinosus*) is the most abundant avian specie in Eagle Island while the Intermediate egret (*Egretta intermedia*) is the most abundant avian specie in GRA Phase 3 (Table 1, Figure 3).

Table 1. *Avian Species Abundance in Eagle Island and GRA Phase3 in Rivers State, Nigeria.*

S/N	Common name	Scientific name	Eagle Island	GRA Phase 3
1.	African thrush	*Turdus pelios*	5	1
2.	Black heron	*Egretta ardesiaca*	14	18
3.	Common bulbul	*Pycnonotus barbatus*	9	15
4.	Common Kestrel	*Falcon tinnunculus*	1	31
5.	Great egret	*Egretta alba*	4	1
6.	Grey heron	*Ardea cinerea*	6	1
7.	Intermediate egret	*Egretta intermedia*	13	223
8	Long-tailed Cormorant	*Microcarbo africanus*	24	55
9.	Piapiac	*Ptilostomus afer*	1	27
10.	Pied Crow	*Corvus albus*	19	4
11.	Spur-winged lapwing	*Vanellus spinosus*	33	1
12.	Western reef heron	*Egretta gularis*	24	22
13.	Yellow-billed kite	*Milvus aegyptius*	6	1
	Total		**159**	**400**

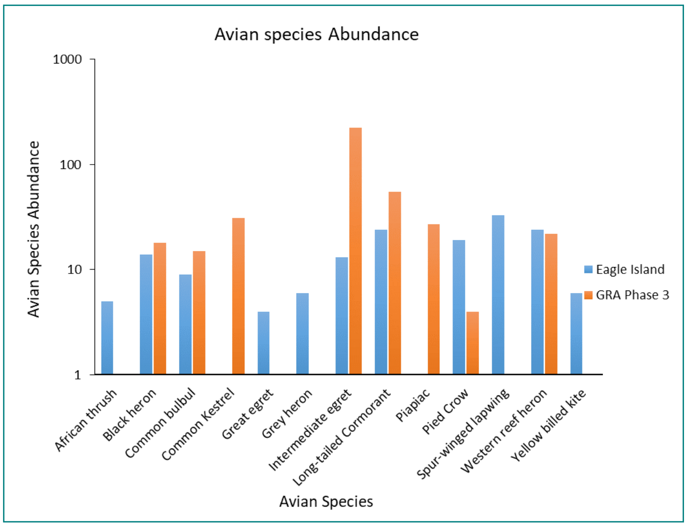

Figure 3. *Avian Species Abundance in Eagle Island and GRA Phase3 in Rivers State, Nigeria.*

The 13 avian species identified were composed of 6 orders and 8 families. The orders recorded were Accipitriformes, Charadriiformes, Falconiformes, Passeriformes, Pelecaniformes, Suliformes. The families recorded were Accipitridae, Ardeidae, Charadriidae, Corvidae, Falconidae, Phalacrocoracidae, Pycnonocidae, and Turdidae.

Table 2 and Figures 4 and 5 show that the order Pelecaniformes with 1 family (Ardeidae) has the highest number of species (n = 326) in both Eagle Island and GRA Phase 3. It is more abundant in GRA Phase 3 with (n = 265) than in Eagle Island (n = 65). The Passeriformes comes next with 3 families (Turdidae, Corvidae and Pycnonotidae) in both Eagle Island (n = 34) and GRA phase 3 (n = 81).

Table 2. *Abundance of families and order of Avian Species in Eagle Island and GRA Phase 3.*

Order	Family	Eagle Island	GRA Phase 3	Total
Accipitriformes	Accipitridae	6	1	7
Charadriiformes	Charadriidae	33	1	34
Passeriformes	Turdidae	5	1	6
	Pycnonotidae	9	15	24
	Corvidae	20	31	51
Pelecaniformes	Ardeidae	61	265	326
Suliformes	Phalacrocoracidae	24	55	79
Falconiformes	Falconidae	1	31	32
Total		**159**	**400**	**559**

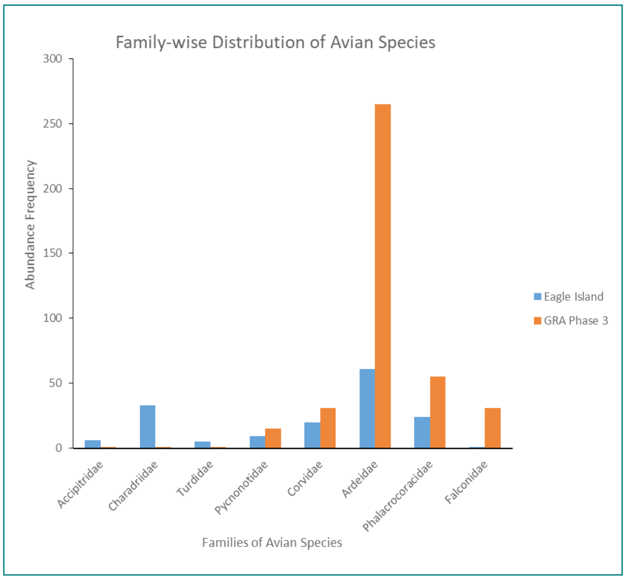

Figure 4. *Avian species arrangement by taxonomic order in Eagle Island and GRA Phase 3.*

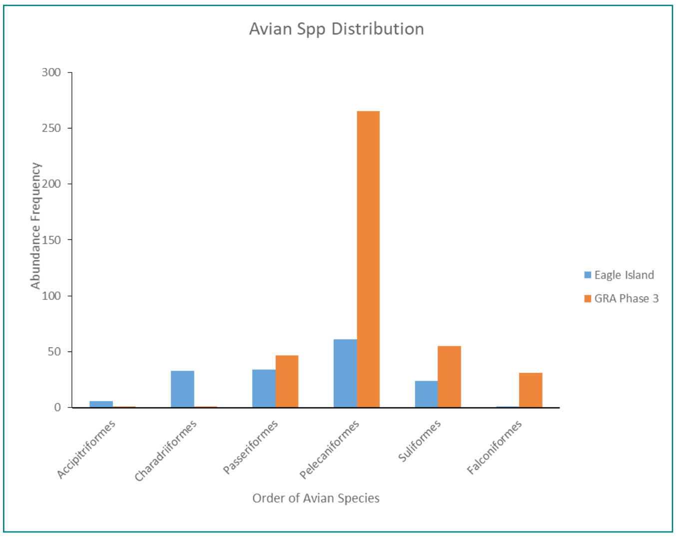

Figure 5. *Avian species distribution across taxonomic order in Eagle Island and GRA Phase 3.*

The relative abundance of avian species in Eagle Island and GRA Phase 3 are shown in Tables 3 and 4 respectively.

Table 3. *Relative abundance of avian species in Eagle Island.*

S/N	Species	Scientific name	Total	Relative Abundance
1.	African thrush	*Turdus pelios*	5	3.14
2.	Black heron	*Egretta ardesiaca*	14	8.81
3.	Common bulbul	*Pycnonotus barbatus*	9	5.66
4.	Common Kestrel	*Falcon tinnunculus*	1	0.63
5.	Great egret	*Egretta alba*	4	2.52
6.	Grey heron	*Ardea cinerea*	6	3.77
7.	Intermediate egret	*Egretta intermedia*	13	8.18
8.	Long tailed cormorant	*Microcarbo africanus*	24	15.09
9.	Piapiac	*Ptilostomus afer*	1	0.63
10.	Pied Crow	*Corvus albus*	19	11.95
11.	Spur-winged lapwing	*Vanellus spinosus*	33	20.75
12.	Western reef heron	*Egretta gularis*	24	15.09
13.	Yellow-billed kite	*Milvus aegyptius*	6	3.77
	Total		**159**	**100**

Table 4. *Relative abundance of avian species in GRA Phase 3.*

S/N	Species	Scientific name	Total	Relative Abundance
1.	African thrush	*Turdus pelios*	1	0.25
2.	Black heron	*Egretta ardesiaca*	18	4.5
3.	Common bulbul	*Pycnonotus barbatus*	15	3.75
4.	Common Kestrel	*Falcon tinnunculus*	31	7.75
5.	Great egret	*Egretta alba*	1	0.25
6.	Grey heron	*Ardea cinerea*	1	0.25
7.	Intermediate egret	*Ardea intermedia*	223	55.75
8.	Long tailed Cormorant	*Microcarba africanus*	55	13.75
9.	Piapiac	*Ptilostomus afer*	27	6.75
10.	Pied Crow	*Corvus albus*	4	1
11.	Spur-winged lapwing	*Vanellus spinosus*	1	0.25
12.	Western reef heron	*Egretta gularis*	22	5.5
13.	Yellow-billed kite	*Milvus aegyptius*	1	0.25
	Total		**400**	**100**

Using the Shannon-Wiener index, the diversity of the avian species in Eagle Island and GRA Phase 3 are 2.30 and 1.52 respectively. The diversity is higher in the coastal area (Eagle Island). The species evenness in Eagle Island and GRA Phase 3 are 0.89 respectively 0.59 (Table 5).

Table 5. *Diversity Indices of avian species in Eagle Island and GRA Phase 3*

Diversity Index	Eagle Island	GRA Phase 3
Shannon diversity index	2.300	1.519
Evenness	0.897	0.592

The result of the Sorenson similarity index is 0.047 which indicates dissimilarity between the two sites as the SSI is not equal to 1.

The ANOVA result indicates that there is no significant difference in the THC and heavy metal concentration between different treatments ($F_{2, 52}$ = 2.36, P=0.11, Table 6). In river water Zinc had the highest concentration (2.20±0.001ml/kg), followed by THC (1.17±0.001ml/kg), Lead (0.05±0.001ml/kg) and cadmium had the least concentration (0.05±0.001ml/kg). While in sandfill water Zinc also dominated with a concentration of (3.30±0.56ml/kg), followed by THC (2.42±0.03ml/kg), Lead (0.12±0.001ml/kg) and cadmium had the least concentration (0.08±0.02ml/kg). In sand Zinc had the highest concentration (8.61±0.41ml/kg), followed by THC (4.16±0.57ml/kg), Lead (0.63±0.23ml/kg) and cadmium had the least concentration (0.07±0.02lm/kg).

Table 6. *Heavy metal and total hydrocarbon concentrations in soil and water at Eagle Island, Nigeria.*

	ml/mg/kg ± SE			
Samples	**Cadmium**	**Lead**	**Zinc**	**THC**
River water	0.05±0.001	0.14±0.001	2.20±0.001	1.17±0.001
Sandfill water	0.08±0.02	0.12±0.001	3.30±0.56	2.42±0.03
Soil	0.63±0.23	0.07±0.02	8.61±0.41	4.16±0.57

The ANOVA result indicates that there is no significant difference in the THC and heavy metal concentration between different treatments ($F_{2, 21}$ = 0.59, P=0.57, Table 7). The result reveal that Zinc had the highest concentration in all the treatments followed by THC and cadmium.

Table 7. *Heavy metal and total hydrocarbon concentrations in soil and water in a bird breeding site GRA Port Harcourt, Rivers State Nigeria.*

	ml//mg/kg± SE			
Samples	**Cadmium**	**Lead**	**Zinc**	**THC**
Soil water	0.16	0.08	1.57	0.8
Drainage water	0.21	0.03	5.63	0.78
Swamp soil	0.21	0.04	6.55	0.21

4. Discussion

A total of 13 avian species from the population of 559 birds were identified in both the coastal (Eagle Island) and urban area (GRA Phase 3) as seen in Table 1. The species were identified with the aid of Birds of West Africa (Nik and Ron, 2013). The 13 avian species identified were composed of 6 orders and 8 families. The orders recorded were Accipitriformes, Charadriiformes, Falconiformes, Passeriformes, Pelecaniformes, Suliformes. The families recorded were Accipitridae, Ardeidae, Charadriidae, Corvidae, Falconidae, Phalacrocoracidae, Pycnonocidae, and Turdidae. The most abundant order and family in Eagle Island and GRA Phase 3 was Pelecaniformes (had greater abundance in GRA Phase 3) while the most abundant family was the Ardeidae (had a higher abundance in GRA Phase 3). The least abundant order in Eagle Island and GRA Phase 3 was Accipitridae and Turdidae but they were more abundant in Eagle Island (with 6 and 5 species respectively) than in GRA Phase 3 (with 1 specie each).

This result is compared to the results of Utami *et al* (2017) who conducted a study on bird species biodiversity in the coastal area of Panjang Island, Jepara, Central Java, Indonesia which identified 27 bird species across 15 families, with Ardeidae dominating. In comparison, this research also highlights Ardeidae as the most abundant family in the coastal region. This similarity suggests a potential commonality in the ecological dynamics of bird species between the two distinct geographical locations. Similarly, studies by Okosodo and Sarad (2021) identifies Ardeidae as the most abundant bird family. They highlighted the negative impact of anthropogenic changes on the ecosystem's structure, potentially leading to a decline in bird species. The study recommends thorough monitoring of physicochemical properties to assess and mitigate harmful pollutant influx into the ecosystem.

Eagle Island had a total of 159 birds and GRA Phase 3 had a total of 400 birds. The observed differences in avian species distribution and abundance between the coastal and urban areas of River State, Port Harcourt, provide valuable insights into the impact of habitat characteristics on avian communities. The observed higher bird count in the urban area compared to the coastal area aligns with expectations, considering the more abundant vegetation and less disturbance in the urban area.

The coastal area is characterized by water bodies, limited tree cover and human disturbance. The presence of waterways in the coastal area, utilized for transportation, might contribute to the differences in avian abundance, as certain bird species are known to prefer specific aquatic habitats. Most birds that cannot cope with human disturbance migrate to a more suitable environment. Bird diversity and abundance are negatively affected by habitat disturbance (Girmay *et al*., 2020). The coastal area stands in contrast to the urban area with abundant trees and shrubs, creating distinct ecological niches. This variation in habitat structure plays a pivotal role in shaping avian community composition. Habitat structure is a major predictor of habitat choice by avian species (Dami *et al*., 2014)

The higher bird population in the urban area, specifically 400 individuals compared to 159 in the coastal area, indicates a preference for the more vegetated and undisturbed environment found in the urban settings. This result is in line with Musa *et al* (2023) who carried out a study on the abundance and diversity of dry season avian species in Katsina Metropolis, Katsina State, Nigeria, and found that bird species diversity, abundance, and distribution varied across different land uses. Their findings also revealed that avian species were more abundant, diverse, and richer in less disturbed areas, while areas with high anthropogenic disturbance showed lower values.

The availability of trees and shrubs in the urban landscape provided a favorable nesting and foraging sites, contributing to the increased bird diversity. Examining specific species, the Spur-winged Lapwing's dominance (33 individuals) in the coastal area aligns with its affinity for marshes and freshwater wetlands. This finding supports the importance of water bodies in supporting specific avian species. Conversely, the Intermediate Egret's prevalence (223 individuals) in the urban area (GRA Phase 3) may be linked to its behaviour of often nesting with other herons, usually on platforms of sticks in trees and shrubs. In Africa and Australia, the intermediate egrets are reported to be quite successful breeders with 96% and 88% of nests fledging at least a single chick (IUCN-SCC Heron Specialist Group, 2022). Black Heron's habitat preference for shallow open waters resonates with its presence in both coastal and urban areas, highlights its adaptability to varied environments. This adaptability is a crucial factor contributing to its widespread distribution. The higher abundance of Pied Crow in Eagle Island emphasizes the impact of human activities on avian communities. Pied Crow (*Corvus albus*), contributes to biomass recycling and reduced levels of disposable waste as scavengers.

A Shannon-Wiener diversity index of 2.30 in the coastal area indicates a higher diversity of avian species. This suggests that the avian community in the coastal environment is characterized by a greater variety of species, contributing to a more complex and diverse ecosystem. The higher index value implies that many different species are relatively evenly distributed, contributing to the overall richness of the avian community. An evenness index of 0.89 in the coastal area indicates a high degree of evenness in the distribution of avian species. A high value of evenness index indicates a well- balanced and stable avian community in which various species coexist in similar proportions. In the urban area a Shannon wiener diversity index of 1.52 suggests a lower diversity of avian species. This could be indicative of a more homogenous avian community in the urban environment. The specie evenness value of 0.59 indicates a lower evenness distribution of avian species. This shows that certain species are dominating the urban avian community.

A Sorenson similarity index of 0.047 indicates a low similarity between the avian communities in the urban and coastal area. This implies that the composition of avian species in these two environments is notably distinct with only a minimal overlap in species. Various factors like food availability, habitat characteristics and human influences, likely contributes to the observed dissimilarity.

The elevated concentrations of zinc, THC, and other heavy metals in different environmental compartments of Eagle Island, especially in soil, river water, sandfill water, and GRA. Phase 3 (in soil water, drainage water and swamp soil), raise concerns about their potential implications on the local bird population. Eagle Island exhibits a greater THC concentrations compared to GRA Phase 3, and this is primarily attributed to the sandfill serving as a disposal site for hydrocarbon waste such as engine oil, plastics, and metallic products transported by tidal currents. In contrast, the THC levels in river water are lower, influenced by dilution through the mixing and dispersion of hydrocarbon waste by tidal currents across a broader region. Higher zinc concentrations in GRA Phase 3's drainage water (5.63ml/kg) compared to the sandfill water (3.30±0.56ml/kg) in Eagle Island may be linked to urbanization-related pollution, runoff from roads, or industrial discharges. The chemical pollutants that urban areas have in common are generated by traffic and the combustion of fossil fuels give rise to especially high levels of nitrogen oxides and soot (Salmón *et al*., 2018).Variances in land use patterns and human activities between the two locations could contribute to differences in heavy metal and THC concentrations and also variation in avian species abundance. The result gotten from Eagle Island was compared to the results of Numbere (2020b) who found high total hydrocarbon and heavy metal concentrations at Eagle Island.

The difference observed in the concentrations of total hydrocarbons and heavy metals between this research and Numbere (2020b) study may be as a result of variations in environmental conditions, human activities, and pollution levels. This highlights the dynamic nature of ecosystems and underscores the importance of periodic monitoring to assess and adapt environmental management strategies. High zinc concentration can also affect aquatic organisms like fishes in the coastal area (Eagle Island) and avian species that feed on them can also be affected. These metals can accumulate in fishes and biomagnify in birds which can disrupt the reproductive success and immune function in birds. High zinc concentration in fish captured at Eagle Island is as a result of high zinc content in the water, which comes from the bedrock of the sea (Numbere, 2019).

4.1 Implication for Conservation

The comparison of avian species community assembly in the urban and coastal areas of River State, Port Harcourt, provides insights into the interplay of habitat characteristics and avian species distribution. The observed variations in heavy metal and THC concentrations underscore the importance of understanding local environmental conditions when studying avian species community assemblies. The study emphasizes the need for conservation strategies that consider habitat preferences, human activities, and climate variability to ensure the sustainability of avian biodiversity in diverse landscapes. The study on bird species diversity and distribution is important for conservation efforts in different protected area (Abie *et al*., 2019). Understanding how different avian species respond to distinct urban and coastal environments is pivotal for effective conservation strategies.

Conservation initiatives should consider preserving and restoring wetland habitats, especially in coastal areas, to support species like the Spur-winged Lapwing and Western Reef Heron. Areas like Eagle Island should be considered to mitigate the impact of elevated concentrations of heavy metals and

THC. These efforts can include soil remediation, and pollution control measures to enhance bird habitat quality. Also, public awareness programs should be carried out to educate the public about the effect of poor waste management practices as indiscriminate waste disposal contributes to the contamination of the environment which further affects bird population in both urban and coastal areas.

Author Contributions

Study design, data analysis: OOO, AON; fieldwork implementation: OOO, AON; writing: OOO, AON.

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Conflict Of Interest Statement

The authors declare no conflicts of interest

Data Availability Statement

The data that support the findings of this study are available on re-quest from the corresponding author (AON).

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