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RESEARCH ARTICLE

Diversity and Richness of *Ciconiiformes* Species in Badagry Wetland Southwestern Nigeria

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ABSTRACT

We examined the richness and diversity *Ciconiiformes* species in Badagry wetland southwestern Nigeria. Point count method was used to collect data on the richness and diversity of *Ciconiiformes* in the study area. Counting bands of the 50 m radius were used for all the stations. The minimum distance between two counting stations was 200 m, and 25 stations were used for this study. On arrival at the sites, birds were allowed time to settle before recording all the birds seen or heard for a predetermined time 20 min. From the result obtained, it indicates that the study area is rich *Ciconiiformes* species. A total of 16 *Ciconiiformes* species belonging to four families were recorded in the study area. The family Ardeidae has the highest number of bird species (11), this is followed by Ciconiidae family (3), Threskiornithidae and Scopidae families have one bird species each**.** The Shannon H index revealed that dry season (2.153) was lower than a wet season (2.357); this was based on the data collected during the period of the research study. From the result obtained of the relative abundance of bird species in the study area, it was revealed that the following four bird species *Ardea cinerea*, *Ardea melanocephala*, Scopus umbretta, and *Bostrychia hagedash* have the highest relative (4.44) individual bird species per square kilometer within the study area.

Key words: *Ciconiiformes* species, diversity, mangrove ecosystem, richness, wetland

INTRODUCTION

The order *Ciconiiformes* are any member of the five or six families of stork-like birds: Herons and bitterns (Ardeidae), the shoebill (sole species of the Balaenicipitidae), the hammerhead (sole species of the Scopidae), typical storks and wood storks (Ciconiidae), and ibis and spoonbills (Threskiornithidae), with the partial exception of the flamingos, the structural characteristics of the order are well marked, and the same is true of the families.[1] The storks, even including the wood storks, form a recognizable group of birds of from medium to large size. The ibis form an even more homogeneous group.Birds of medium size with marked down curved, slender bills and the spoonbills, of the same family, differ in this respect, as the name implies.[2] The herons are more diverse, with a greater size range, the bitterns standing a little apart in behavior more than in structure. Each of the remaining two families contains a single species with some peculiar characteristics.[3]

Wetland is an important ecological significance area in the tropical region, which serves as a major link between the natural resource management and agricultural practices. It is a storehouse or hot spot for the conservation of important species that rural inhabitants mostly depended on as a source of protein and at the same time serving the deep interest of the conservationists for protection.[4] Mangrove ecosystems provide an excellent habitat for birds. The most common birds in the mangrove forests are the members of the family Ardeidae, Charadriidae, Laridae, Ciconidae, Accipitridae, and Alcedinidae.[5] Migratory birds visiting the

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mangroves may fly long distances to find food and nesting places there. This may be particularly true in the neotropics,[6] Some of the resident bird species are highly dependent on mangroves for their survival. Due to this dependence, disturbances to the forest may reverberate through the bird populations. This may be particularly true where the bird species show stray site fidelity.[7,8] Anthropogenic changes in the mangrove forest are caused by human activities. Protection of the mangrove inhabiting birds will require effective management of the entire mangrove habitat. Many of the nest sites are in dead trees, suggesting that a comprehensive eagle management plan is required for preservation of both living and dead mangroves.[9] The mangroves are highly important for the survival of many species of birds, but information on birds associated with mangroves in Nigeria is scanty; thus, this research study will provide baseline information on the status of bird species and tree species composition in the study area.

MATERIALS AND METHODS

Study area

The Badagry wetland, which is approximately 60 km long and 3 km wide, lies between longitudes 3°0′ and 3°45′ E and between latitudes 6°25′ and 6°30′ N. It is part of a continuous system of lagoons and creeks along the coast of Nigeria from the border with the Republic of Benin to the Niger Delta. Its water depth ranges from 1 m to 3 m. The area experiences two broad seasons: The dry season (December–May) and the wet season (June–November). The area is characterized by fresh and slightly brackish water.[10] The Badagry creek runs across two national boundaries. It directly connects with Nigeria's 960 km of coastline bordering the Atlantic Ocean in the Gulf of Guinea, a maritime area of 46,500 km^2 with the depth of up to 50 m and an exclusive economic zone of 210,900 km^2.[11] The lagoon which runs through the area is approximately equidistant from the entrances of Lagos and Cotonou harbors. As a result, it is influenced by tides and floods from the Lagos Lagoon and Cotonou harbor through Lake Nokoue and Lake Porto-Novo.[12] The Yewa River with its tributaries Isalu and Ijomo is the major river emptying into the lagoon. Creeks connected to the lagoon include Bawa and Doforo. Major weeds occurring in the lagoon yearly in December and January include the common water hyacinth *Eichhornia crassipes* and *Cerotophyllum* and *Pistia* sp. The lagoon is surrounded by large areas of swamps covered with vegetation among which the Raphia palm (*Raphia sudanica*), the African oil palm (*Elaeis guineensis*), and the coconut palm (*Cocos nucifera*) are dominant [Figure 1].[13]

Data collection

Point count method[15] was used to collect data on bird species richness and diversity in the study area. Counting bands of the 50 m radius were used for all the stations. The minimum distance between two counting stations was 200 m and 25 stations were used.

On arrival at the sites, birds were allowed time to settle before recording all the birds seen or heard for a predetermined time (20 min). Bird calls were also recorded with a voice recorder and played back later for confirmation. Physical features of birds sighted but could not be identified immediately were taken, and field guidebook of West African birds[16] was used to identify the bird species, and bird calls were used to confirm the presence of nocturnal bird species within the study sites. Data were collected for 6 months, 3 months in the dry season (November, February, and March) and 3 months in the wet season (June, August, and September) in 2017.

From the data collected, avian species diversity was calculated using Shannon diversity index[17]

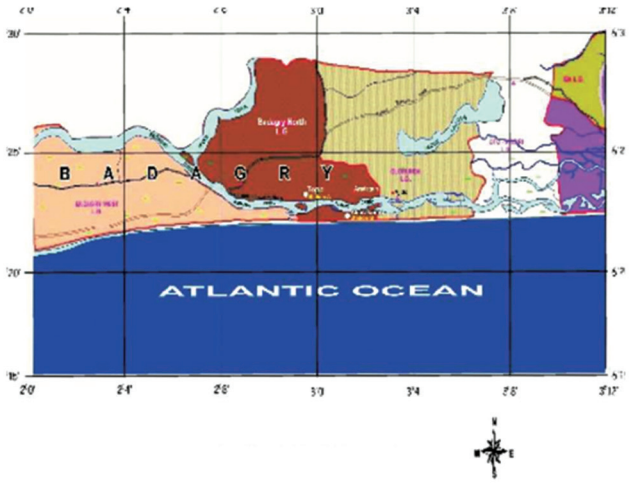

Figure 1: Map of study area showing sampling station A (TOPO) and B (AKARAKUMO) along the Badagry creek. Source[14]

which is given as follows:

$H^i = -\Sigma P_i \ln P_i$

Where, H^i=diversity index

P_i=Is the proportion of the i^{th} species in the sample

InP_i=Is the natural logarithm of the species proportion.

Species relative population density

The relative population density of bird species at various sites and seasons was determined as outlined by Bibby *et al*.[18] as follows:

$D = n_1 + n_2 Log_e [n_1 + n_2]$

$\pi r^2 m\ n_2$

Where, D=Density

r=Radius of the first zone

n_1=Number of birds counted within the zone

n_2=A number of birds counted beyond zone and m = number of the replicate count in such area.

Data analysis

Data collected from the observations were explored with descriptive statistics. PAST model was used to carry out bird species diversity, generalized linear model, and SHE analysis

RESULTS

From the result obtained, it indicates that the study area is rich in *Ciconiiformes* species. A total of 16 *Ciconiiformes* species belonging to four families were recorded in the study area. The family Ardeidae has the highest number of bird species (11), this is followed by Ciconiidae family (3), Threskiornithidae and Scopidae families have one bird species each [Figure 2]. The result of the relative abundance of bird species revealed that the study area is rich in *Ciconiiformes* species [Figure 2]. The result of the relative abundance indicates that the following bird species *Ardea melanocephala*, *Ardea cinerea*, *Bostrychia hagedash,* and *Scopus umbretta* has the highest number of individual birds per square kilometer [Table 1]. The result of diversity index indicates that the wet season (2.257) was higher than the dry season (2.153) [Table 2]. SHE analysis was used to explain the species richness and evenness in the study area. The result indicates that there was a positive relationship between two variables [Figure 3]. There was a positive relationship between the bird species recorded and the ground cover [Figure 4].

DISCUSSION

It is highly important to monitor the species composition, relative abundance, diversity, and habitats of wetland-dependent birds to examine population trends and thus identify and highlight the main causes of species decline due to growing pressure from anthropogenic activities.[8] In all, 16

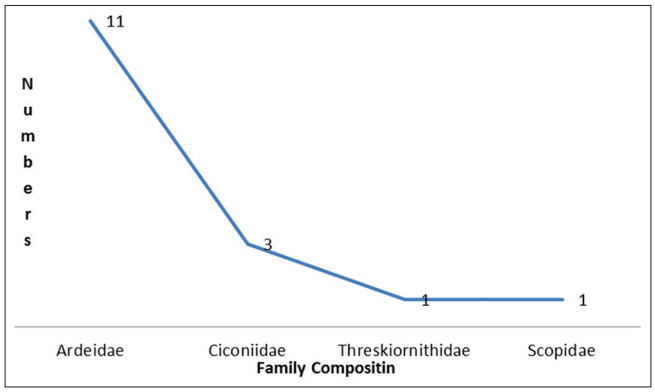

Figure 2: The family composition of *Ciconiiformes* species in the study area

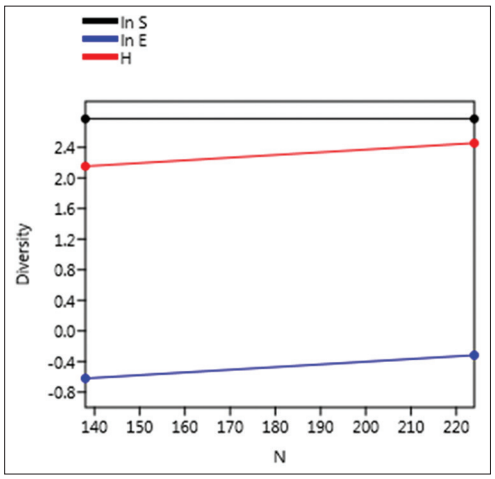

Figure 3: SHE analysis of *Ciconiiformes* species richness and evenness in the study area

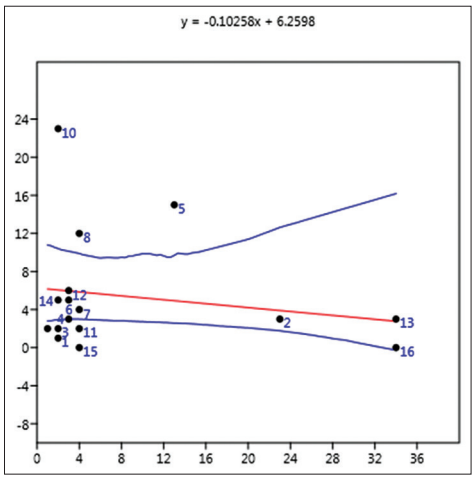

Figure 4: Density of *Ciconiiformes* species against the habitat variables in the study area

Table 1: Relative abundance of *Ciconiiformes* species in the study area

Name of bird species	Scientific name	Family	Numbers	RA
Little bittern	*Isobrycus minutus*	Ardeidae	2	2.22
Little egret	*Egretta garzetta*	Ardeidae	23	2.55
Squaco heron	*Ardeola ralliodes*	Ardeidae	2	2.22
Woolly-necked Stork	*Ciconia episcopus*	Ciconiidae	3	3.33
White stork	*Ciconia ciconia*	Ciconiidae	13	1.44
African openbill	*Anastomus lamelligerus*	Ciconiidae	3	3.33
Hadeda Ibis	*Bostrychia hagedash*	Threskiornithidae	4	4.44
Hamerkop	*Scopus umbretta*	Scopidae	4	4.44
Black-crowned heron	*Nycticorax nycticorax*	Ardeidae	1	1.11
Black Heron	*Egretta ardesiaca*	Ardeidae	2	2.22
Black-headed Heron	*Ardea melanocephala*	Ardeidae	4	4.44
Green-backed Heron	*Butorides striata*	Ardeidae	3	3.33
Cattle egret	*Bubulcus ibis*	Ardeidae	34	3.77
Great egret	*Egretta alba*	Ardeidae	2	2.22
Grey heron	*Ardea cinerea*	Ardeidae	4	4.44
Intermediate egret	*Egretta intermedia*	Ardeidae	34	3.77

Table 2: Diversity of *Ciconiiformes* species in the study area during the dry and wet season in the study area

Diversity index	Dry season	Lower	Upper	Wet season	Lower	Upper
Taxa_S	16	16	16	14	14	14
Individuals	138	138	138	86	86	86
Dominance_D	0.1637	0.136	0.1938	0.1406	0.1136	0.1869
Shannon_H	2.153	2	2.292	2.257	2.056	2.377
Evenness_$e^{H/S}$	0.5381	0.4617	0.6187	0.6823	0.5605	0.7697
Brillouin	1.979	1.838	2.113	2.023	1.839	2.135
Menhinick	1.362	1.362	1.362	1.51	1.51	1.51
Margalef	3.044	3.044	3.044	2.918	2.918	2.918
Equitability_J	0.7765	0.7212	0.8268	0.8551	0.7802	0.9007

bird species in four families were recorded during the survey. All the bird species were hydrophanous species. This finding is consistent with Zakaria *et al.*[2] who reported that wetland bird species are adapted to a semi-aquatic life, being important components of aquatic ecosystems. He further stated that they spend their lives around water that provides food which consists of insects, worms, snails, amphibians, toads, lizards, snakes, mice, and fish[19] reported that wetlands are known for their abundance of birds. He stated further that the use of wetlands and their resources is widespread among many diverse bird taxa of the world, avian adaptation to utilize wetlands, and other aquatic systems are diverse and include anatomical, morphological, and behavioral changes. Anatomically, they include designs for diving and swimming, such as body compression to increase gravity, or adaptation for plunge-diving from great heights. From the result obtained, it indicates that of the bird species move in groups, this is generally consistent with those of previous studies[20] found that white ibises in North Carolina traveled with conspecifics on 17% of the monitored flights, whereas only 3–5% of the Snowy Egret, Tricolored Heron, and Great Egret flights involved more than one individual[21] noted that 29% of the Snowy Egrets and 15% of the Tricolored Herons that departed from a colony in the Everglades did so in groups. The period of the study favored the level of water that is deep enough for wetland birds, especially the water birds to carry out daily activities such as feeding, resting, nesting, and predator escape. An important observation is that the bird diversity and abundance (richness) vary across the wetland. Some of them forage for food in wetland soil, some in the water column, and others use the dry landscape, along with the streams. McIntyre and Wiens[22] reported that bird species may be affected by quality and quantity of food, this is because it is the quality of food which is important to the species but not the quantity.

From the field observations made during the period of this study, there was a positive relationship between percentage ground cover,

shrub density, and tree density for bird recorded. Most *Ciconiiformes* species were observed in areas with higher percentage of ground cover. This finding is consistent with Manu[23] and Prange *et al*.[24] who reported that this observation indicated that some wetland birds used the trees as a roosting site. This was observed with some species such as the Egrets, Ibises, Herons, and Storks. These species were found during the survey on the bare ground feeding on the mudflats fish and another vertebrate. Thus, habitat has long been used as a predictor of bird species abundance, and each variety of birds has developed different preferences for habitat. This result confirms the presence of Black Heron (*Egretta ardesiaca*) in Southwest Nigeria which is in agrees with Sutherland.[15] The SHE analysis was used to examines the relationship between richness and the Shannon-Wiener diversity index and evenness as measured using the Shannon-Wiener evenness. The result indicates that was a positive relationship between the species richness and species evenness in the study area [Figure 3]. This agrees with Krebbs[25] who reported the use of the diversity estimated using Shannon-Wiener, Simpson's index of diversity, and the Brillouin index was high and the evenness index, however, was low (0.1–0.2). The Smith and Wilson's index of evenness is more preferred compared the others because it is independent of species richness and sensitive to both and rare common species.

This study indicates that was a positive relationship between bird species recorded and the percentage ground cover. More birds were observed in areas with higher percentage of tree density increased than ground cover as shown in Figure 3. This observation indicated that some wetland birds used the trees as a roosting site. This was observed with some species such as the Egrets, Ibises, Herons, and Storks. These species were found during the survey on the bare ground feeding on the mudflats fish and another vertebrate. These findings are supported Huston,[26] who reported that habitat has long been used as a predictor of bird species abundance, and each variety of birds has developed different preferences for habitat. Also agrees with Cody[27] who reported that birds select vegetation variables according to the manner by which an individual habitat affects access to food, mates, or its vulnerability to predators.

CONCLUSION

This research study suggests that Badagry wetlands are rich in *Ciconiiformes* species. It is also an important feeding ground for *Ciconiiformes* species and other water birds, especially when resources become limiting on the uplands in the dry season. The wetland sizes, vegetation structure and composition and density of resources explain why they are key habitat in this mangroves ecosystem. Anthropogenic changes due to human actives are affecting the floristic composition and structure ecosystem, leading to bird species decline in the study area. Although the water parameters of the wetlands in this study were not considered; therefore, it is recommended that proper monitoring of the physicochemical properties should be carried out to check pollutant influx that may be harmful to the ecosystem. The soil excavation currently going on in the area should put on hold as this affects fragile mangrove ecosystem.

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