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Avian Diversity in Nyangezi Wetlands: The Case of Nyamubanda Swamp in the Territory of Walungu, Sud-Kivu, Eastern Democratic Republic of the Congo

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Abstract

In this work, we assessed the diversity of bird species in the Nyamubanda swamp in Nyangezi, Walungu Territory, Sud-Kivu Province in the Eastern Democratic Republic of the Congo. Field observations with binoculars with optical magnification 10 × 42.6 and capture with mist nets allowed us to explore four habitats: Papyrus, Sorghum fields, Woody landscape and Rice fields. A total of 203 individuals belonging to 27 species and regrouped in 19 families and 8 orders were found. The distribution of abundance of birds in the four plants' habitats was statistically equal (χ^2 = 0.884; df = 3; p-value = 0.829). Correspondence Analysis (CA) with 80.2% for the two first axes showed that the rice and papyrus landscapes are close in diversity in terms of species richness. A connection between these two habitats means that species frequent in rice rest in papyrus. This demonstrates that cereal cultivation in Nyamubanda swamp has an impact on the avifauna biodiversity. Future works should focus on the seasonality and diet of these birds with ecological approaches as well as crop cultivation stages to deepen the understanding of the wetland bird diversity in the Nyangezi swamps.

Subject Areas

Environmental Sciences

Keywords

Avian Diversity, Nyangezi Wetlands, Habitat Types, Nyamubanda Swamp

1. Introduction

Wetlands underpin the survival of many organisms and human development in all regions of the world [1]. They host different types of vegetation distributed along water depth gradients creating a complex mosaic of microhabitats that can range from nearly terrestrial to open water [2]. Each of these microhabitats or some combination of them can provide water, food, and shelter for certain groups of birds and other species [3] [4]. The global evolution of avifauna shows that many groups of birds have adapted anatomically, morphologically, and physiologically to different wetland microhabitats. They performed the ecology according to the prevalent environment. Collectively, they are referred to as wetland birds [5]. There are many species of birds but the most commonly associated with freshwater wetlands are ducks and waders [2] but little studied in the swamps. A certain number of studies revealed that birds are excellent bio-indicators of the quality and functioning of aquatic ecosystems as well as flooded forests [6] [7] [8] [9]. Some are migratory and very useful in the ecological balance [10], while others are useful in agriculture acting on the populations of insects and rodents which are harmful to crops [11]. For example, some granivores and frugivores also participate intensively in the regeneration of certain plants [12] [13]. All these aspects are services that birds provide in wetland ecosystems, including swamps, as demonstrated by [14] in the Debo and Walado lakes area of the lower Niger River delta.

The exploitation of wetlands for diverse activities, in particular, the cultivation of vegetables is increasing in developing countries, as in the case of the Democratic Republic of the Congo (DRC) in Sud-Kivu province (East of the Country). This is one of the causes of the reduction of their extent by nearly 35% since 1970 at the global level as highlighted in the report on the state of the world's wetlands in 2018 by the Ramsar Convention [15]. Yet, African wetlands are disappearing despite a rich avian diversity [16] [17].

In Sud-Kivu, the Nyamubanda swamp is vulnerable and its ecological and biological potentialities are not known. Despite their enormous ecosystem services beyond those of land including essential food, fiber and fuelwood, the Nyamubanda swamp does not escape intense destruction leading to a decrease in fauna and flora diversity [18] (unpublished data). Observations showed that the riparian population uses this swamp for commercial gardening and foraging for livestock throughout the year. These aspects remain of considerable concern as they indicate trends in avian diversity disturbance that would generally indicate an increase or loss of appropriate biodiversity at national and regional scales [8]. While any presence or absence, increase or decline in bird diversity has been

used as an indicator of ecosystem quality in regional swamps [6] [19].

This study aims to understand the avian diversity of the Nyamubanda swamp in the Nyangezi sector in an attempt to assess the effects of agriculture on the biodiversity component, avifauna in this case. Most of this swamp is used for shifting agriculture and another part for artisanal brickworks. [20] showed that agricultural activities such as the culture of rice had been influenced by some bird species in Ngozi (Burundi) and in the Ruzizi plain (DRC). Some bird species may cause damage to cereal crops [21], which often leads farmers to hunt them and it therefore contributes to the decrease in the bird species population. In the same way, human activities could significantly reduce bird diversity in the Nyamubanda swamp. The purpose of this study is to determine bird diversity based on four types of habitats including rice and sorghum fields, papyrus and woody (*Eucalyptus*) landscapes in order to understand the distribution of the avifauna of the Nyamubanda swamp and contribute to the knowledge of the biodiversity of the wetlands of Nyangezi Territory in particular and DRC's in general. Frequency analysis and species classification (Clustering) is an approach to understanding the effect of rice and sorghum cultivation on avian diversity in the Nyamubanda swamp.

2. Materials and Methods

2.1. Study Area

The Nyamubanda swamp is located in the Nyangezi sector, Walungu Territory, Sud-Kivu Province in the East of the DRC. It straddles the road to the town of Uvira and the Kaziba chiefdom. The area of the swamp is 831.75 ha. The Nyamubanda swamp basin is a plain joined by channels and rivers in relation to the seasons [22] making great floods in the rainy season leading often to the loss of crops. Through its two major rivers, Mukubyo and Mugera, this swamp receives rainfall that promotes high evaporation in the dry season [2] and classifies it as a river swamp [23]. The Mukubyo River flows into Mugera carrying a large body of water to the Ruzizi River. The Nyamubanda swamp is not yet integrated into the local development plan, despite its important role in year-round agriculture. This means that each farmer cultivates according to his or her own will or without any regulation. Some farmers have formed an association to protect their sites. Agriculture is mainly centered on the cultivation of sorghum, corn and beans from August to February, which constitutes the first season. The second season is focused on the cultivation of cabbage and yams. This swamp is divided into 4 sectors: 1) the fallow sector where cattle are fed; 2) the sector for food crops cultivation; 3) the sector for rice production by the International Institute of Tropical Agriculture (IITA) and private individuals; and 4) the sector for artisanal brick production. This last sector is specific to Nyangezi, which produces the majority of bricks for construction in the city of Bukavu [24] [25] which has more than 1.6 million inhabitants suggesting a high demand. The Nyamubanda swamp heated geothermally temperatures varying between 30˚C and 75˚C serve

a large segment of the population for bathing [26] (unpublished data). Around this swamp, the belt is covered by a vegetation of *Eucalyptus sp.* For this study, four (4) stations were chosen according to habitats to better explore the entire swamp. Figure 1 shows the location of the sampling sites in the Nyamubanda swamp.

The rice habitat is a large area dedicated to rice cultivation bordered by small streams on both sides. In this area, all stages of rice growth are present throughout the year. Fanfares and craft robots are installed in the fields to disperse the predators, particularly birds. People take activities frequently in this area from 05:00 am to 06:00 pm. The habitat of the sorghum plant is characterized by the cultivation of sorghum between August and February of each year. The rest of the crop remains in the fields until the field preparation season. This habitat is bordered by the Mukubio and Mugera rivers to the east and the road from Nyangezi Parish to Weza Institute to the south. The Papyrus habitat contains a large abundance of Papyrus species. Some rice keepers use this vegetation for hut construction for shelter from the rains or sun; others use it for brick cover. The woody landscape is much dominated by *Eucalyptus sp.* In this area, there are bee niches for the riparian population.

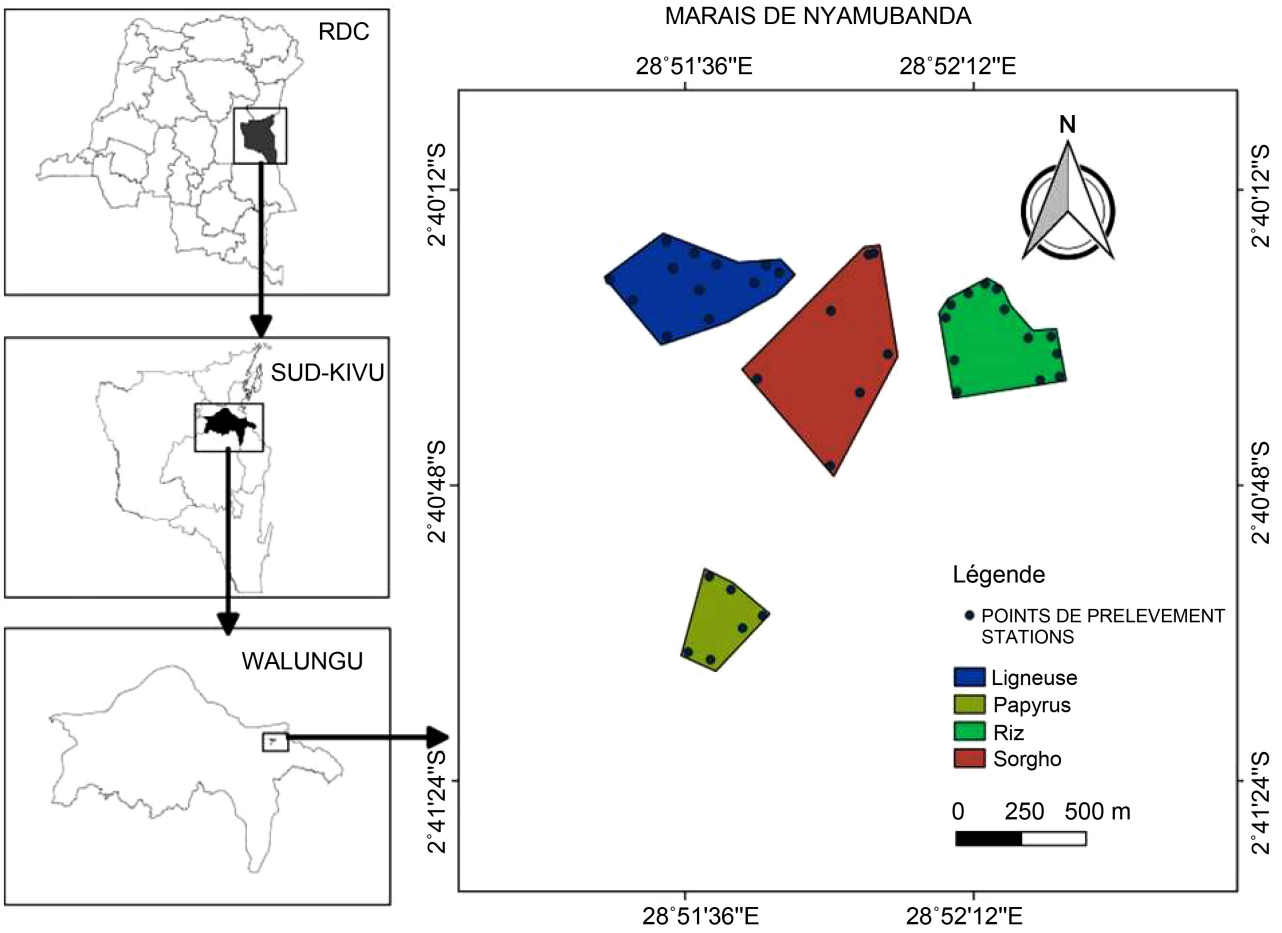

Figure 1. Location of sampling station in the Nyamubanda swamp Legend = Rice (Riz), Sorghum (Sorgho), Woody = Ligneuse.

2.2. Sampling and Identification of Birds in Nyamubanda Swamp

Capture method (Lincoln Petersen principle) [27] was used to collect abundance and richness data for bird species during mist-netting. Data collection was conducted in 6 days per week, two weeks in December 2019 covering the rainy season and two weeks in June 2020 for the dry season. In each site, birds were captured between 06:00 am and 06:00 pm [28] using mist nets of 1.5 cm mesh size, 12 m in length and 2.5 m in width placed between two wooden sticks 1 m from the ground [29]. Three (3) nets were installed at different locations in each station. In the rice habitat, nets were placed according to the stage of rice growth. In other sites, they were placed according to the differential characteristics of the biological components. We used Nikon binoculars with optical magnification 10 × 42.6 between 06:00 am and 6:00 pm for bird observations. This technique was carried out in two stages: a static observation at the first 10 minutes during which all bird species seen were noted, and the rest of the time was used for moving along the practicable paths around the sites [30]. Specimen identification of observed and captured birds was made possible by a range of references and guides [31] [32] [33] [34]. Once the individual was captured and kept quietly in a cloth bag for identification, it was released into the wild by placing ink on its fingers to prevent double sampling. The recaptured individuals were not taken into account in the Abundance. Photos of captured birds were taken for identification purposes at the Biology Laboratory of the State University of Bukavu (Université Officielle de Bukavu).

2.3. Data Processing and Statistical Analysis

Data processing was done by R software [35] and Excel. Species frequency in the swamp was determined following the formula [36]:

$$F = \frac{p \times 100}{P}$$

with F = Frequency, p = the number of times a species was found in our sample, P = the total number of samples.

Thus, we distinguished 3 groups: $F > 50\%$ = very common species, $F > 25\% < 50\%$ = accessory species, $F < 25\%$ = rare species. The occurrence (presence-absence) of species was determined using PAST software (PAleontological STatisctics, Version 2.16) [37] according to the four habitat plants. This allows understanding the number of characteristic species of each station. Correspondence Analysis (CA) was performed with the packages FactoMineR [38] and factoextra [39] under R. The CA indicates whether different studied sites can be grouped together (showing their degree of similarity) or whether they are separate blocks (they are not similar). For Chi-square statistical test alpha was 0.05.

3. Results

3.1. Inventory and Frequency of Birds

A total of 203 individuals, belonging to 27 species, regrouped in 16 families, and

8 orders were inventoried in four habitats of Nyamubanda swamp. The order of Passeriformes is the most represented with 9 families, 19 species and 188 individuals (92.6% of all individuals). The other orders are poorly represented with only one family and one species. The analysis of the frequency of species in the Nyamubanda swamp showed that 12 species are very common in this marsh holding more than 50% of frequency. These species are: *Crithagra mozambica*, *Cinnyris cupreus*, *Vidua macroura*, *Estrilda astrild*, *Euplectes ardens*, *Euplectes axillaris*, *Ploceus cuculatus*, *Ploceus xanthops*, *Ploceus tricolo*, *Spermetes bicolor*, *Spermetes fringilloides* and *Spermetes cucullatus.* The species *Ploceus xanthops* and *Centropus monachus* with a frequency of > 25% < 50% are accessory. The other species are rare with the frequency < 25%. Table 1 shows the avian list of Nyamubanda swamp with the frequency rate for each species.

Table 1. Bird species inventoried in Nyamubanda swamp.

Species	Rice	Sorghum	Papyrus	Woody	Total	*F* (%)
Passeriformes						
Family of Acrocephalidae						
Acrocephalus schoenobanus	1	0	0	0	1	17%
Family of Cisticolidae						
Cisticola erythrops	0	0	1	0	1	17%
Family of Estrildidae						
Estrilda astrild	1	8	0	0	9	100%
Spermestes cucullata	17	9	23	8	57	100%
Spermestes fringilloides	17	4	0	6	27	100%
Spermestes bicolor	0	4	0	0	4	67%
Family of Fringillidae						
Crithagra monzambica	1	2	0	6	9	100%
Crithagra sulphurata	0	0	1	0	1	17%
Family of Laniidae						
Lanius mackinnoni	0	0	0	1	1	17%
Family of Nectarinidae						
Cinnyris venustus	0	0	0	1	1	17%
Cinnyris cupreus	0	0	0	5	5	83%
Family of Ploceidae						
Euplectes axillaris	11	0	11	0	22	100%
Euplectes ardens	0	4	1	0	5	83%
Euplectes hordeaceus	1	0	0	0	1	17%

Continued

Ploceus ocularis	0	5	0	0	5	83%
Ploceus xanthops	0	2	0	0	2	33%
Ploceus cucullatus	0	2	6	0	8	100%
Family of Pycnonotidae						
Pycnonotus tricolor	0	0	4	11	15	100%
Family of Viduidae						
Vidua macroura	5	6	3	0	14	100%
Anseriformes						
Family of Anatidae						
Anas undulata	0	0	1	0	1	17%
Anas sparsa	0	0	1	0	1	17%
Cuculiformes						
Family of Cuculidae						
Centropus monachus	0	1	1	0	2	33%
Columbiformes						
Family of Columbidae						
Streptopelia semitorquata	0	0	0	7	7	100%
Coliiformes						
Family of Coliidae						
Colius striatus	0	0	0	6	6	100%
Coraciformes						
Family of Alcedinidae						
Ispidina picta	1	0	0	0	1	17%
Pelecaniformes						
Family of Ardeidae						
Ardea melanocephala	1	0	0	0	1	17%
Accipitriformes						
Family of Accipitridae						
Lophaetus occipitalis	0	0	1	0	1	17%

3.2. Relative Abundance and Frequency of Bird Families by Habitat Type

In Nyamubanda swamp, the most abundant family is Estrildidae with 94 individuals. The less abundant families are: Ploceidae, Pycnonotidae, Viduidae and Fringillidae having respectively 43, 15, 14, and 10 individuals. Rice and Papyrus

habitats were found to be almost equally abundant with 56 and 54 individuals. Sorghum and woody plants also have almost the same abundance, 47 and 46 individuals respectively. Statistical analysis of the distribution of bird abundance by habitat type doesn't show any significant difference ($\chi^2 = 0.884$, $df = 3$, $p = 0.829$). Families with a frequency of ≤ 50% are more present in Nyamubanda swamp including Estrildidae, Fringillidae, Nectarinidae, Ploceidae, Pycnonotidae and Viduidae. Three families are accessory with a frequency > 25% < 50% (Anatidae, Cuculidae and Columbidae). The other families are rare in the Nyamubanda swamp. Table 2 further explains the relative abundance of bird families in the habitats and in the swamp as well as their frequency.

Table 2. Relative abundance and frequency of bird families.

Families	Rice	Sorghum	Papyrus	Woody plants	Total	*F* (%)
Acrocephalidae	1	0	0	0	1	17%
Cisticolidae	0	0	1	0	1	17%
Estrildidae	35	25	23	14	97	100%
Fringillidae	1	2	1	6	10	100%
Laniidae	0	0	0	1	1	17%
Nectarinidae	0	0	0	6	6	100%
Ploceidae	12	13	18	0	43	100%
Pycnonotidae	0	0	4	11	15	100%
Viduidae	5	6	3	0	14	100%
Anatidae	0	0	2	0	2	33%
Cuculidae	0	1	1	0	2	33%
Columbidae	0	0	0	2	2	33%
Coliidae	0	0	0	6	6	100%
Alcedinidae	1	0	0	0	1	17%
Ardeidae	1	0	0	0	1	17%
Accipitridae	0	0	1	0	1	17%
Abundance	**56**	**47**	**54**	**46**	**203**	**100%**

3.3. Presence/Absence of Bird Species in the Nyamubanda Swamp per Habitat Plants

In the Nyamubanda swamp, the species *Lonchura cucullatus* is the only one common in all four (4) explored habitats and similarly, only one species (*Vidua macroura*) was present in three (3) habitats, all except the woody landscape. In sorghum and rice plant habitats, four species are common including *Estrilda astrild*, *Vidua macroura*, *Crithagra mozambica* and *Spermetes fringilloides*. In both papyrus and woody habitats, the species *Pycnonotus tricolor* is the unique common species. Other species were present in only one habitat type (Table 3).

Table 3. Presence (1) and Absence (0) of bird species in Nyamubanda swamp.

Species	Rice	Sorghum	Papyrus	Woody
Acrocephalus schoenobanus	1	0	0	0
Cisticola erythrops	0	0	1	0
Estrilda astrild	1	1	0	0
Spermetes cucullata	1	1	1	1
Spermetes fringilloides	1	1	0	1
Spermetes bicolor	0	1	0	0
Crithagra monzambica	1	1	0	1
Crithagra sulphurata	0	0	1	0
Lanius mackinnoni	0	0	0	1
Cinnyris venustus	0	0	0	1
Cinnyris cupreus	0	0	0	1
Euplectes axillaris	1	0	1	0
Euplectes ardens	0	1	1	0
Euplectes hordeaceus	1	0	0	0
Ploceus ocularis	0	1	0	0
Ploceus xanthops	0	1	0	0
Ploceus cucullatus	0	1	1	0
Pycnonotus tricolor	0	0	1	1
Vidua macroura	1	1	1	0
Anas undulata	0	0	1	0
Anas sparsa	0	0	1	0
Centropus monachus	0	1	1	0
Streptopelia semitorquata	0	0	0	1
Colius striatus	0	0	0	1
Ispidina picta	1	0	0	0
Ardea melanocephala	1	0	0	0
Lophaetus occipitalis	0	0	1	0

3.4. Clustering of Bird Species Diversity According to the Four Habitats

According to the distribution of birds, the four Plant habitats show an avian difference due to their clustering. Axes 1 and 2 of the Correspondence Analysis (CA) cumulatively explain 80.2% of the total inertia. **Figure 2** shows a close match between two plants habitats (Rice and Papyrus) in terms of species with 15 common species. The woodland habitat contains 7 species while the sorghum habitat is the least diverse with only 5 species.

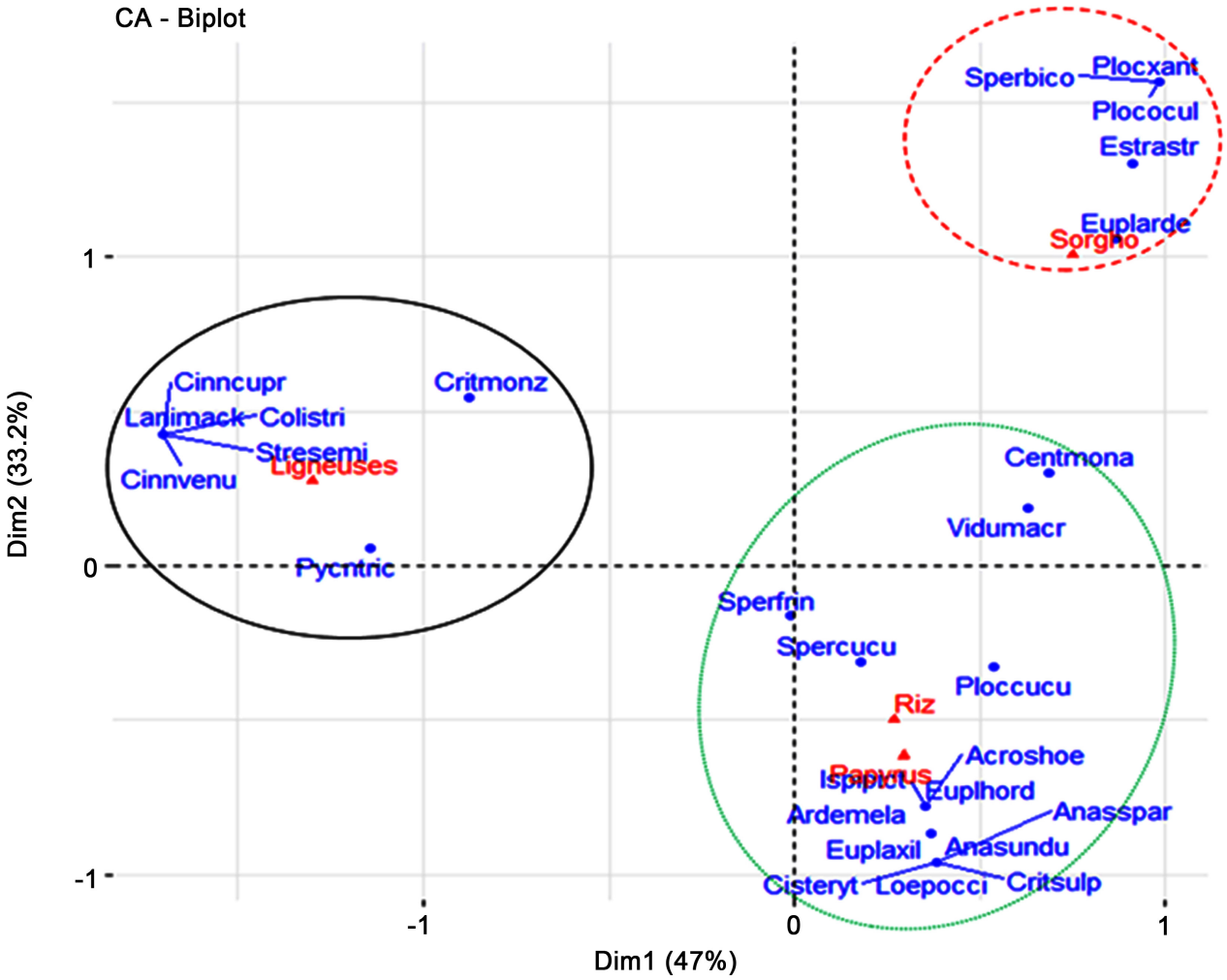

Figure 2. Clustering of the bird diversity in the Nyamubanda Swamp. Rice (Riz), Woody = Ligneuse. Red border = Sorghum (Sorgho), Green border = Rice (Riz) and Papyrus, Black border = Wood (Ligneuse).

4. Discussion

Previous studies conducted in some marshes in the Sud-Kivu region and close to Nyamubanda marsh, identified 22 species, 9 families and 4 orders, in Mweze marsh according to the stage of rice cultivation [40], unpublished data); and 36 species, 19 families and 8 orders in the Dundazi and Gombo marshes in the papyrus habitat [18] (unpublished data). These results are similar to those found in this current study. The timing of crops is thought to be the basis for fluctuating bird diversity in marshes. These results are different from those of [30] who worked on rice cultivation and its surroundings in the Ivory Coast and found 11 orders, including the 8 orders of Nyamubanda. This variability would be explained by microhabitat and geographic distance. Our results are very similar to those of [41] in the Kagogo-Gisumo swamp in Burundi which shows that non-random depredation in granivorous birds underlies high diversity in the swamp with cereal crops. This explains why rice and sorghum cultivation contributes to the abundance of birds in this swamp. The Passeriformes order was

the most diverse in terms of species, families and individuals. It is the most diverse order worldwide [42] [43] [44], as also encountered in West Africa [45]. The works of [28] [46] and [30] also point out that this order contains most of the crop-depredator species. This suggests that rice and sorghum cultivation would be the basis for the highest species diversity of the order Passeriformes in Nyamubanda swamp. This order is more distributed in marshes in the Sud-Kivu region following former research [18] [40].

The rice and papyrus habitats are almost similar in abundance because it is easy to leave the rice field to rest in the papyrus, generally when the rice farmers are in the fields. The sorghum and woody plants are also close because the sorghum fields are near the woody landscape. When farmers are working in their fields, birds fly to the woody landscape. Regarding the families recorded in Nyamubanda swamp, the most present are Ploceideae, Estrildideae, Fringillideae, Coliidae, Nectarinidae, Pycnonotideae and Viduidae which are the top families based on their frequencies. These families were already recognized as frequent in cultivated fields in West Africa [28] and in Ivory Coast [30] in wetlands. Some of these birds are granivorous, frugivorous and insectivorous and are very abundant in Africa [47]. This explains why agriculture in the marsh has an impact on the abundance of local wetland birds. These results are close to those found in Burundi by [48] who found that Ploceideae is the most represented family, followed by Estrildideae, and Fringillideae. On the other hand, among the three families identified (Ploceideae, Estrildideae and Passerideae) by [20] in the Ruzizi plain, only the Passerideae family was identified in the Nyamubanda swamp but we identified more families than those found by [20] in Burundi. These results fall in the same observations as [49] [50] [43] who found that the Pycnonotidae family is more diverse at lower altitudes and in Sud-Kivu [51] with 12 species between 1200 m and 3000 m. Besides this family, 3 other families were found in the Nyamubanda swamp at 1500 m including Fringilidae, Estrildidae and Nectarinidae. Habitat type and elevation gradient [20] are thought to be among the factors influencing the distribution of families in the swamps. In this swamp, each habitat has its morphological approaches, especially the type of vegetation and feeding, which could be the cause of this inequity of families in the Nyamubanda marsh. The families of Estrildidae, Fringillidae, Nectarinidae, Ploceidae, Pycnonotidae and Viduidae are more present in the Nyamubanda marsh according to their high frequency (+50%). It is also observed that families such as Anatidae, Cuculidae and Columbidae are rare in this swamp.

The species *Spermetes cucullata* is the only ubiquitous species in all habitats explored. According to [34], this species prefers grassy vegetation and gardens surrounded by trees, but also the genus *Lonchura* has been recognized as a pest of rice, sorghum or small millet [28], and even maize [46]. These characteristics are supported by our findings and observations in the Nyamubanda swamp, which has extensive papyrus vegetation and trees. The cultivation of rice and sorghum is a major human activity in the Nyamubanda swamp, thus promoting

the frequency of birds. [34] showed that the species *Vidua macroura* preferred areas with vegetation belonging to the Cyperaceae family, especially Papyrus, and in fields where cereals were grown. In West Africa, this species was also considered as a pest of rice and sorghum seeds [28]. In Burundi in the Kago-go-Gisumo swamp, [41] confirmed that this species was a predator of rice culture. We observed it feeding on rice and sorghum seeds during our sampling. Four species are present in both sorghum and rice habitats, including: *Estrild astrilda*, *Vidua macroura*, *Crithagra monzambica* and *Spermetes fringilloides*. These species are all granivorous [30] but also insectivorous. They are THEN classified as common wetland birds in view of their frequencies reaching more than 50% in wetlands. These species are widely distributed in Central Africa. They inhabit swamps, brushwood, lush grasslands, grasslands and forest margins [47]. The Nyamubanda swamp is full of all these characteristics making it a swamp to be integrated into the local development plan and landscape management plan.

The Nyamubanda swamp would be an important site for the conservation of wetland birds. Illegal hunting activities should be discouraged and forbidden. According to [2], the habitats of this marsh are a direct source of food for these birds, playing a role in the protection and availability of nesting sites. The correspondence analysis (CA) showed that Rice and Papyrus habitats were very similar (**Figure 2**) and had a large number of species. The diversity of birds in the Nyamubanda swamp is linked to the food requirement approach [9]. As the sampling took place during the cultivation of rice at different stages and the harvesting of sorghum, these birds were preferentially encountered in these two habitats. In addition, Papyrus and woody plants are recognized among the preferred ecological environments for bird species. The lack of high species richness does not explain the decline in these habitats but rather the timing of capture would influence this trend. Many upland birds exploit wetlands seasonally or occasionally for food and water [52]. The Nyamubanda Swamp can be considered as a heterogeneous environment that can be linked to a mosaic of habitats with various environmental conditions, and bird population can also respond to this environmental variability [2]. The hunting of birds even in papyrus and woodland is an act that should be stopped in view of the ecological consideration of these habitats with respect to the birds inhabiting the local marshes.

5. Conclusion

The Nyangezi swamps are considered as a cradle of biological diversity, by the presence of favorable habitats for reproduction, refuge and feeding for different species. In the Nyamubanda marsh, a diversity of 27 species, 16 families and 8 orders has been inventoried for bird species. The order of Passeriformes was the most represented in the 4 habitats including rice and sorghum fields and papyrus grassland and woodland. The rice and papyrus habitats had almost the same abundance of families, while the woody and sorghum habitats were also close. The species *Crithagra mozambica*, *Vidua macroura*, *Estrild astrild*, *Euplectes*

orix, *Euplectes axillaris*, *Ploceus cuculatus*, *Ploceus xathops*, *Ploceus tricolor*, *Spermetes bicolor*, *Spermetes fringilloides* and *Spermetes cucullatus* are more frequent in Nyamubanda swamp. *Spermetes cucullata* is the only species found in all four habitats. Cereal cultivation (sorghum and rice in this case) activity is one of the main causes of the abundance of bird species we found. Farmers should consider the timing of cultivation in this swamp to allow for proper monitoring of bird diversity. Papyrus and woodland habitats should remain a refuge area for birds. Forbidding hunting activities and planned exploitation of non-cereal lands in this area would be an important asset for the conservation of this biodiversity. This preliminary study in Nyamubanda swamp did not take into account monthly sampling for a good understanding of bird diversity. This is a very important aspect to develop in future work in relation to ecological factors to better understand the status of avian diversity of wetland birds in the Nyangezi swamps.

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Authors' Contributions

Gabriel Baguma collected the data and wrote the article. Cirhalwirwa Oliva Mugoli collected most of the field data. Mirindi Pascal Murhula and Ngabo Vianney Mulema participated in the field activities. Legrand Cirimwami supervised the team and reviewed the manuscript draft many times.

Conflicts of Interest

The authors declare that there is no conflict of interest

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