Research Article
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Distribution of birds in the Adamawa Plateau (Cameroon) and the impact of the anthropogenic activities: ecological study and conservation approach leading to recommendations for endangered species

Abstract

Birds are an essential group of the food chain in the ecosystem; they are contributing to the pollination, fighting against insect pests of crops and constitute also a source of income by the tourism. An ornithological study has been led in the Adamawa Plateau during two years, from 2018 to 2020. Indeed, the distribution of birds and the impact of the human activities upon them have not been sufficiently studied these last decades. This study aims to determine occurrences and the distribution of bird species in the Adamawa Plateau as well the impact of the anthropogenic activities in this area. To accomplish these purposes, several methods have been used. Thus, transect and Japanese mist nets methods were employed to capture bird specimens in the field, and then sampled birds were identified, photographed and instantly released in their wild environment. Ecological analyses were performed by the PAST v2.17 software. For that, the occurrences and the analysis of variance (ANOVA) in order to test the main element of variability in bird distribution between forest and savannah have been made. In addition, a modeling analysis has also been carried out to evaluate the impact of the anthropogenic activities. As results, 186 specimens have been collected from the study area and 61 species were identified. The most frequently species encountered in the Adamawa Plateau were *Pycnonotus barbatus* and *Turdus pelios* with 66.67% and 60%, respectively. According to our analysis of variance, the distribution of bird species in the study area is depending to the vegetation and we also carried out an aggregative spatial distribution pattern of bird species in the Adamawa Plateau. Our analyses have also confirmed the declining of the abundance of several sedentary bird species, and that is related to the fragmentation and the loss of their habitats by the anthropogenic activities.

Keywords: conservation, distribution, fragmentation, occurrence, vegetation

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Introduction

Cameroon is one of the most noticeable countries of the Congo Basin Forest Reserve, in view of its avifauna and its diverse habitats such as forest, savannah, mountain areas, mangrove forests, rivers and lakes.[1] These various natural habitats contribute to the development and evolution of tremendously diverse avifauna in this geographical area.[1] Thus, over about 973 bird species reported in Cameroon, 11 are endemic and 39 currently threatened, 16 of which are geographically distributed in the Adamawa region.[2] Among these 16 threatened species we can list *Sagittarius serpentarius*, *Chelictinia riocourii*, *Trigonoceps occipitalis*, *Necrosyrtes monachus*, *Gyps africanus*, *Terathopius ecaudatus*, *Aquila rapax*, *Falco vespertinus*, *Ploceus bannermani*, etc.[2] More generally, birds have a multidimensional importance and constitute a source of economic growth, providing income and motivation for conservation through ecotourism.[3]

Ecologically, birds help to control pests and disperse seeds and several studies used some of them as indicators of the natural or degraded environment. [4-6] In the wild, birds are one of the groups of animals which are showing a strong sensitivity to fragmentation of the environment.[7] However, threats to biodiversity inherent to rapid urbanization are raising concern over the future of the already reduced diversity by environmental degradation.[8,9] Within the wildlife community, although birds are common in urban areas many avian populations have been declined as a result of landscape changes due to human activities.[10,11] The natural environment of the Adamawa Plateau harbors an important number of wild birds that include specialists, generalists, and as well locally endemic populations.[12]

Early studies conducted in Cameroon reported about 748 passerines and non-passerines birds.[13,14] Other studies have also provided some interesting data on Cameroon's birdlife with about 848 species of migratory and sedentary birds, including those from the Adamawa Plateau defined as a forest-savannah transition area.[15] Another study carried out in Cameroon has mentioned about 344 bird species of which 179 species have been recorded from the Adamawa Plateau.[12] These researches have provided a good dataset on the diversity of Cameroonian birds, but are relatively old and would not reflect the current avifauna in different areas of Cameroon given the ongoing increase in desertification and habitat fragmentations.

Furthermore, other biological factors such as competition, predation and migration could strongly act on the distribution of birds in the space as well as in the time. Studies based on conservation of birds reported that the Cameroon Volcanic Line montane forests to which belonging those of the Adamawa Plateau, host specific avian assemblages with many endemic species.[16,17] Several mountain forests of Cameroon are well known for their endemism but are also locations where agricultural encroachment, overgrazing, and hunting pressure

have been increasingly intense.[18] Then, it was therefore important to update the list as well as the current knowledge of the birds of Cameroon but mainly those of the Adamawa Plateau for highlighting diversity in this transition area with a focus on the biodiversity conservation component. In this study, we aim to determine the frequencies of occurrence of bird species and their distribution in the Adamawa Plateau as well the impact of the anthropogenic activities.

Material and methods

Study area

The Adamawa Plateau is a part of the Volcanic Line of Cameroon and is located between the 6th and the 8th degree of North latitude and between the 10th and the 16th degree East longitude.[19] It is bounded to the north by the Benoue basin, to the southwest by the western highlands and to the south by the South-Cameroonian plateau. The Adamawa Plateau extends between 900 and 1500 meters above at the sea level; but some summits can reach 2000 meters.[15] The entire plateau covers an area of more than 100 000 square kilometers.[15] The Adamawa Plateau is found in the Guinean savannah belt.[15,20] This forest-savannah belt is dominated by the omnipresence of two plant species, *Daniellia oliveri* and *Lophira lanceolata* and these species are prolific thanks to zoo-anthropogenic factors such as fire, grazing and crop clearing.[21] Overall, vegetation is characterized above all by its great development and apparent homogeneity. Extensive shrubby and tree savannas stretch for kilometers without interruption. Some areas are very high, dense or sparse and others are low. The isolation of the Adamawa Plateau dry forests has promoted the diversification of many taxa resulting in a high number of endemic species.[20,21] For this reason, this is one of the most studied and most appreciated regions in terms of its value for biological conservation in Cameroon.[12] Thus, three sites were investigated: the meadow (07°33.272'N and 13°33.607'E) area characterized mainly by bushes and grass, the dry-woodland (07°37.649'N and 13°32.888'E) characterized by shrubs heavily degraded by human activities, and the forest zone (06°37.892'N and 11°57.319'E) characterized by degraded undergrowth and trees (Figure 1).

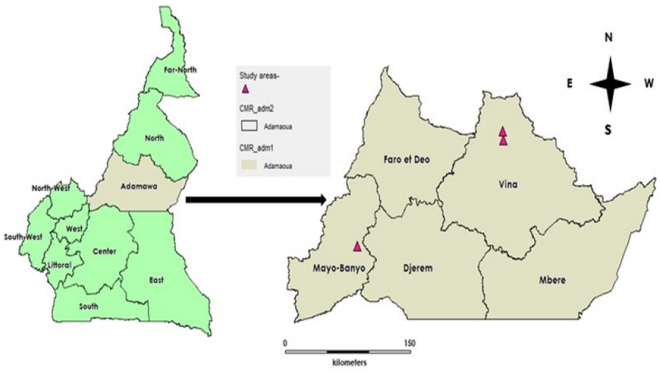

Figure 1 Localization of the study areas in the Adamawa Plateau

Data collection and identification of threats to avian fauna in the study area

The targeted sites (meadow, dry-woodland and forest) were surveyed each month on a 500 square meters' line-transect. We used the transect method to lead monthly censuses in each site.[22] Thus, a total of 36 line-transects were carried out during two years (from October 2018 to September 2020) with 15 field runs to determine the species richness in the study area. For each site, 08 Japanese mist nets were used to capture birds during our field works and these 08 mist nets were randomly deployed in each transect (Figure 2). Mist nets were opened early in the morning (5: 00 AM) and closed at sunset (6: 30 PM). The mist nets were fixed with the mounting poles. The choice of an appropriate mist-netting site was important for the capture success. To ensure the capture success, we mainly identified the birds preferred flight paths, feeding areas, roosting and shaded sites. Captured specimens were removed from the nets, photographed and identified based on the main morphological characteristics such as size, plumage coloration, the shape of the bill, the color of the eyes, the arrangement of the fingers, etc.[23,24] Each transect was closely surveyed and the mainly anthropogenic threats to biodiversity, especially to bird populations in the different sites studied were carefully investigated at each field mission and systematically noted with a view to an appropriate recommendation.

Figure 2 Japanese mist net suitable for catching birds

Data analysis

Frequencies of occurrence: The frequency of occurrence (Fo%) is the ratio between the number of records concerning one species over the total number of field runs in the area, multiplied by 100. The PAST v2.17 software has enabled to highlight this index to observe the occurrence of different taxa in the wild environment and that index is defined as:

$$Fo = \frac{P*100}{R}$$

P is the number of records concerning the species studied and **R** represents the total number of field runs. Thus, according to this author[25], the frequency of occurrence is interpreted as follows: - at Fo = 100%, the species is ubiquitous; - if Fo% is defined between 75 % ≤ Fo% < 100 %, the species is very constant in their environment; - if Fo% is located between 50 % ≤ Fo% < 75 %, this is regular species in the area; - if Fo% is defined between 25 % ≤ Fo% < 50 %, this is accessory species in the area; - if Fo% is defined between 5 % ≤ Fo% < 25 %, that is accidental species in the study environment; - if Fo% < 5 %, that is uncommon species in the study area.

Examination of the distribution of inventoried taxa and the impact of the anthropogenic activities

To test the differences between the taxa distributions within the different sites investigated in the Adamawa Plateau, a one-way analysis of variance (ANOVA) was performed. The element of variability tested in this study is the vegetation since the Adamawa Plateau constitutes a complex mosaic of forest and savannah. Indeed, the samples were collected independently (birds from forest areas on the one hand, and those from savannah areas on the other). Thus, the basic hypothesis ($\mathbf{H_0}$) corresponds to the case where distributions follow the same normal law whereas the alternative hypothesis ($\mathbf{H_1}$) would define the difference of distributions of the taxa within the investigated sites.[26] This analysis highlights the Fisher test as well as its probability on a confidence interval of 95%. Thus, the basic hypothesis is rejected if the probability (**p**) obtained is lower than

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the threshold value of 5%; otherwise, the alternative hypothesis is rejected. The Fisher test is defined by the formula below:

$$F = \frac{CME}{CMR} = \frac{\frac{SCE}{p-1}}{\frac{SCR}{n-p}}$$

Where F indicates the Fisher test law at p-1 and n-p freedom degree, CME= explained mean squares; CMR= residual mean squares; SCE= sum of the explained squares; SCR= sum of the residual squares. In this study, this analysis was performed by PAST v2.17.

In addition, the Tukey diagram was produced by the PAST v2.17 software to observe the current average distribution of bird populations in the various sites investigated in the Adamawa Plateau.[27,28] To determine the spatial distribution of taxa inventoried in the Adamawa Plateau, Ripley's K function which defines the distances between points in the space has been plotted. This function is defined by the following formula:

$$L(d) = \sqrt{\frac{A\sum_{i=1}^{N}\sum_{j=1, j\neq i}^{N} k(i,j)}{\pi N(N-1)}}$$

A = surface; N = number of points, d = distance and k(i, j) = balance

The function L(d) defined above is proportional to the distance; and the difference L(d)-d must be zero if the points are randomly distributed. On the other hand, if the points are grouped into aggregates, the difference L(d)-d is greater than zero and the function shows breaks between the points.[29] Furthermore, to determine the impact of the anthropogenic activities in the Adamawa Plateau, a modeling analysis was carried out to predict the evolution of taxa in their natural environment over the time by the PAST v2.17 software.

Results

Frequencies of occurrence of the species captured in the Adamawa Plateau

A number of 186 specimens belonging to 61 species have been collected in the Adamawa Plateau. Thus, values of the frequencies of occurrence of taxa inventoried in this study area varied from 6.67% to 66.67%. According to our analysis, three species have presented the biggest values of the frequencies of occurrence: these are species *Pycnonotus barbatus* (66.67%), *Turdus pelios* (60%) and *Turtur afer* (53.33%) (Table 1). In 15 field missions carried out in the Adamawa Plateau, several species such as *Accipiter badius*, *Cinnyricinclus leucogaster*, *Cinnyris venustus*, *Lagonosticta sanguinodorsalis*, *Laniarius poensis*, etc. have showed a very low frequency of occurrence of 6.67% (Table 1).

Table 1 Frequencies of occurrence of the species inventoried in the Adamawa Plateau

Species	Number of captures of each species over 15 field missions	Frequencies of occurrence	Occurrence status
Accipiter badius	1	6.67 %	Accidental
Agapornis sp.	1	6.67 %	Accidental
Amandava subflava	1	6.67 %	Accidental
Anthus cervinus	1	6.67 %	Accidental
Anthus sp.	1	6.67 %	Accidental
Atimastillas flavicollis	2	13.33 %	Accidental
Batis orientalis	2	13.33 %	Accidental
Cinnyricinclus leucogaster	1	6.67 %	Accidental
Cinnyris chloropigius	1	6.67 %	Accidental
Cinnyris sp.	1	6.67 %	Accidental
Cinnyris venustus	1	6.67 %	Accidental
Colius striatus	4	26.67 %	Accessory
Coracina pectoralis	1	6.67 %	Accidental
Cossypha albicapilla	2	13.33 %	Accidental
Cossypha niveicapilla	7	46.67 %	Accessory
Crithagra mozambica	1	6.67 %	Accidental
Cyanomitra obscura	1	6.67 %	Accidental
Dendropicos goertae	1	6.67 %	Accidental
Estrilda nonnula	1	6.67 %	Accidental
Euplectes gierowii	2	13.33 %	Accidental
Euplectes hordeaceus	1	6.67 %	Accidental
Euplectes macroura	1	6.67 %	Accidental
Eurillas virens	2	13.33 %	Accidental
Euschistospiza dybowskii	1	6.67 %	Accidental
Falco vespertinus	1	6.67 %	Accidental
Ficedula hypoleuca	4	26.67 %	Accidental
Halcyon malimbica	2	13.33 %	Accidental
Indicator minor	2	13.33 %	Accidental
Ispidina picta	4	26.67 %	Accessory

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Table 1 Continued....

Lagonosticta sanguinodorsalis	1	6.67 %	Accidental
Laniarius aethiopicus	2	13.33 %	Accidental
Laniarius leucorhynchus	1	6.67 %	Accidental
Laniarius poensis	1	6.67 %	Accidental
Lybius dubius	1	6.67 %	Accidental
Macrosphenus concolor	2	13.33 %	Accidental
Melaenornis pallidus	1	6.67 %	Accidental
Merops bulocki	1	6.67 %	Accidental
Muscicapa aquatica	1	6.67 %	Accidental
Oriolus auratus	1	6.67 %	Accidental
Ploceus baglafecht	1	6.67 %	Accidental
Ploceus cucullatus	1	6.67 %	Accidental
Ploceus intermedius	1	6.67 %	Accidental
Ploceus nigricollis	1	6.67 %	Accidental
Ploceus sp.	3	20 %	Accidental
Pogoniulus bilineatus	1	6.67 %	Accidental
Pogoniulus chrysoconus	3	20 %	Accidental
Pycnonotus barbatus	10	66.67 %	Regular
Pyrrhurus scandens	1	6.67 %	Accidental
Pytilia hypogrammica	1	6.67 %	Accidental
Smithornis capensis	1	6.67 %	Accidental
Streptopelia capicola	1	6.67 %	Accidental
Streptopelia semitorquata	1	6.67 %	Accidental
Sylvietta brachyura	1	6.67 %	Accidental
Tchagra senegalus	2	13.33 %	Accidental
Terpsiphone viridis	2	13.33 %	Accidental
Turdoides plebejus	3	20 %	Accidental
Turdoides reinwardtii	4	26.67 %	Accessory
Turdus pelios	9	60 %	Regular
Turtur afer	8	53.33 %	Regular
Turtur tympanistria	3	20 %	Accidental
Zosterops senegalensis	1	6.67 %	Accidental

Presentation of the results of the analysis of variance and distribution of bird species in investigated sites within the Adamawa Plateau

The analysis of variance (ANOVA) performed have yielded significant probability values; thus, Fisher's F-test gave a value of 3.07 with a probability of 0.04 lower than the conventional probability threshold of 0.05 (Table 2).

Table 2 Analysis of variance and distribution of bird species in investigated sites within the Adamawa Plateau

	Sum of squares	Degree of freedom	Mean square	Fisher (F)	Probability
Between sites	26.36	2	13.18	3.07	0.04
Within sites	772.59	180	4.29		
Total	798.95	182			
Levene's test	0.10				

This probability value indicates a dissimilarity in the distribution of taxa across the different sites investigated.

In addition, Tukey's HSD test gave a few probability of similarity regarding the distributions of taxa between meadow and dry-woodland ($p = 0.04$); the same was true for the distributions of taxa between meadow and forest, with a probability of 0.16. In contrast, a significant value of 0.86 was obtained between dry-woodland and forest. In the same trend, the mean deviations observed between the distributions of taxa in the different sites investigated were: 3.34 between meadow and dry-woodland, 2.59 between meadow and forest, and 0.74 between dry-woodland and forest (Table 3).

Table 3 Values of the probabilities and mean deviations obtained by Tukey's HSD comparison test between the different sites investigated

	Meadow	Dry-woodland	Forest
Meadow		0.04	0.16
Dry-woodland	3.34		0.86
Forest	2.59	0.74	

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Furthermore, the boxplots showed asymmetrical distribution patterns of taxa in both savannah and forest environments in the study area. In general, the distributions are more elongated towards the minimum values in the plot, and as result, the median values deviate from the average values in the various investigated sites (Figure 3). The analysis of the spatial distribution showed a clustering of points representing the sampled taxa (Figure 4A); additionally, in plotting the curve that indicates the spatial evolution of Ripley's K function, breaks were observed between the points representing the arrangement of taxa in the space and the specific distance observed is 0.5 centimeter (Figure 4B).

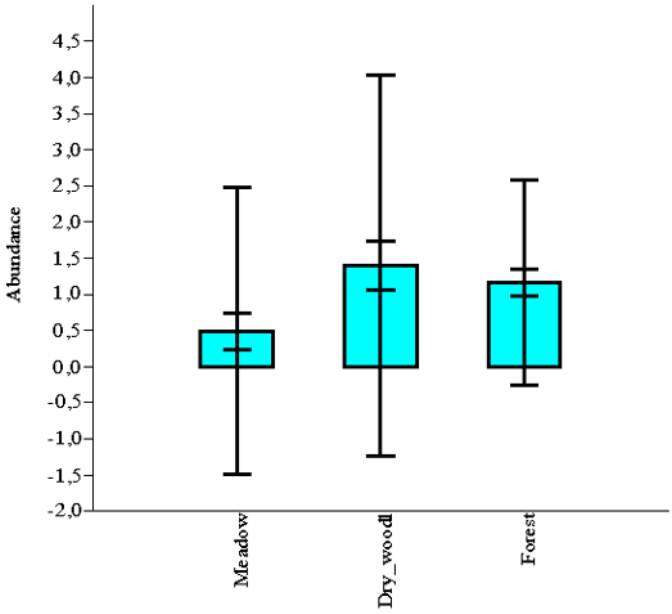

Figure 3 Boxplots showing the distribution patterns of birds in the different sites investigated in the Adamawa Plateau

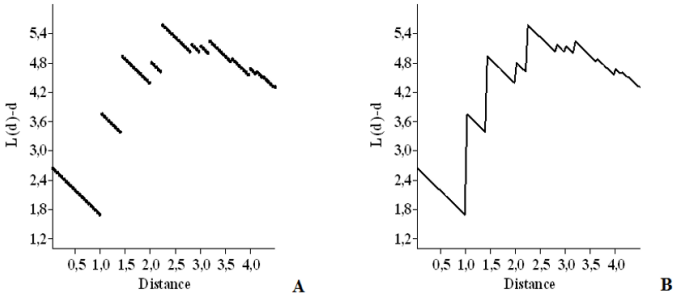

Figure 4 Spatial distribution of birds inventoried in the Adamawa Plateau, (**A**) distribution of points representing birds in space, (**B**) evolution of Ripley's K function defining the type of spatial distribution

Presentation of the results of the modeling analysis for predicting the evolution of taxa over time in the Adamawa Plateau

The modeling analysis through the logarithmic function of the absolute abundances of the sampled species has showed a decreasing function which evolves in the negative direction of the plan of a reference (Figure 5). Thus, we observe that the logarithm of the abundance of several taxa sampled in the Adamawa Plateau is zero; these taxa numbered 32 (52.46%) of the 61 identified species. In contrast, species whose logarithm of absolute abundance was greater than zero represented only 47.46% of the sample (Figure 5).

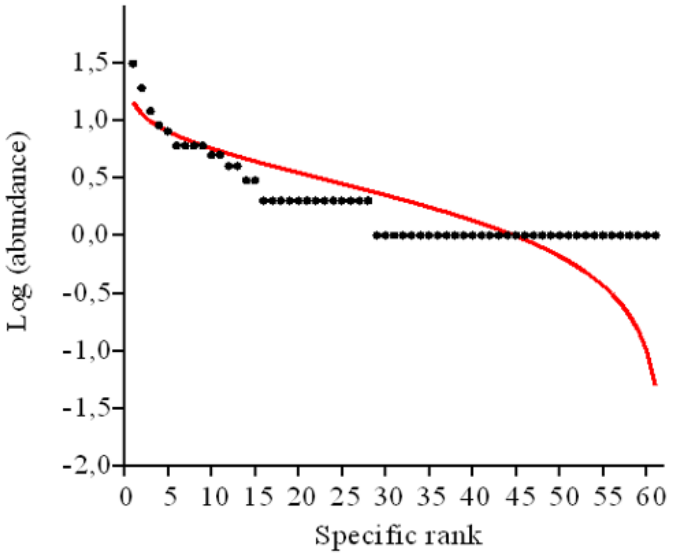

Figure 5 Prediction of the evolution of birds in the environment on the Adamawa Plateau

Discussion

Regularity of bird species sampled the Adamawa Plateau

Our analyses showed that species *Pycnonotus barbatus*, *Turdus pelios* and *Turtur afer* were the most regular in the Adamawa Plateau with some frequencies of occurrence between 50% and 75% (Table 1). This result presented the regularity of these three species and it is going in the same trend that those presented in similar habitats by several authors.[30,31] Indeed, it was demonstrated that *Pycnonotus barbatus* would obtained 70% of its food in secondary forests and only 9% in primary forests.[31] Furthermore, some authors[31,32] have also carried out that the common bulbul (*Pycnonotus barbatus*) shows an adaptive capacity in various habitats and its diet could be changed depending to the availability of the food resources in the environment, reducing the competition and making co-existence possible for closely related species. Concerning *Turdus pelios*, it has been reported that essential of its diet results from the plant matter and insects especially orthopterans.[30,33] The presence of these species in the Adamawa Plateau could be explained by the current degraded vegetation which providing all the basic food resources such as insects and seeds to that species.[12,20,21]

Furthermore, several bird species were newly sampled from the Adamawa Plateau; these are passerine species *Ploceus intermedius, Cyanomitra obscura, Ficedula hypoleuca, Melaenornis pallidus, Batis orientalis, Laniarius aethiopicus* and *Smithornis capensis* as well as non-passerine species *Streptopelia capicola* and *Dendropicos goertae* (Table 1). According to previous studies, *Ploceus intermedius, Melaenornis pallidus, Laniarius aethiopicus*, *Streptopelia capicola* and *Dendropicos goertae* have not been mentioned in the Cameroonian forest; whereas *Cyanomitra obscura, Batis orientalis* and *Smithornis capensis* were already recorded in some localities in southern Cameroon.[12-15,34,35] This presence could be explained by the different sampling methods, but the various habitats as well as the local climate in the Adamawa Plateau providing a variability of food resources would also be explained this specific diversity. Indeed, it has been proved that bird diversity is often highly in areas

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showing a variability of the habitats such as primary and secondary forests.[1,36] Otherwise, among the species sampled and according to their morphological features, four specimens are appeared as probably new species within some families because they have not been found in the identification Guide.[23,24] But a further molecular study is needed to clarify their position; these are specimens belonging to the genera *Ploceus, Cinnyris, Anthus* and *Agapornis* and further molecular biology studies will permit to fully characterize and eventually name them (Figure 6).

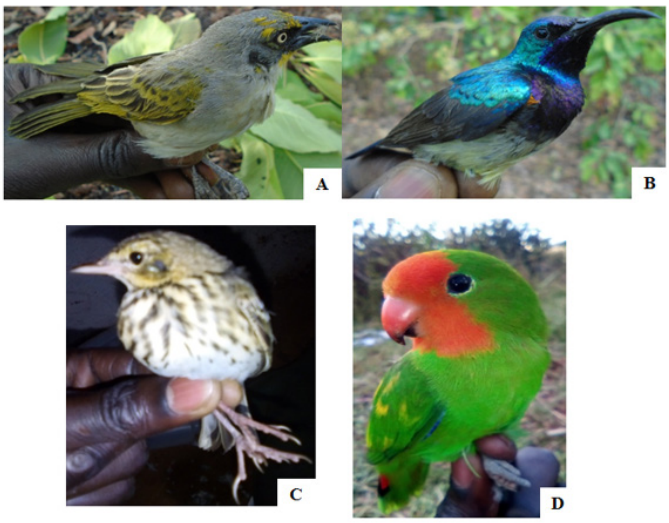

Figure 6 Potentially new bird species sampled in the Adamawa Plateau

Distribution of the birds within the investigated sites and the impact of human activities in the Adamawa Plateau

The Fisher test has provided a value of 3.07 with a probability of 0.04 lower than the threshold value of 0.05 (Table 2). This weak probability indicates that taxa were unequally distributed within the investigated habitats (forest, dry-woodland and meadow); and that is highlighting the strong correlation between the type of vegetation and the distribution of bird species in the environment. Our result is corroborating several studies previously carried out by several authors.[15,37,38] Indeed, the distribution and the survival of bird species in the environment are strongly related to the vegetation. For that, several ecological studies led in other ecoregions have mentioned this closely correlation between birds and the vegetation.[34,37,38] Furthermore, the similarity of the distribution of taxa between meadow and dry-woodland is appeared lower (0.04) than that between dry-woodland and forest environments (0.86) (Table 3). In addition, the boxplots have also showed an asymmetrical repartition of the bird species within the investigated sites indicating an aggregative distribution of the bird species in the forest/savannah transition zone of the Adamawa Plateau (Figure 3). According to this author,[15] the distribution and the abundance of bird species would be significantly related to the vegetation characteristics, and other authors[39] demonstrated that the areas with high plant resources would harbour the most important of the birds in the environment. In another hand, several authors suggest that an aggregative distribution characterizes environments with patchy resources (food, water or nesting sites), social needs (safety, mating) or predator avoidance.[40,41]

The analysis of our results as well as the observations made during the investigations in the Adamawa Plateau showed that largely biodiversity and especially bird species are suffering to the pressure from the anthropogenic activities in this zone. These results are corroborating those carried out previously in Volcanic Line of Cameroon by several authors.[16-18] Several anthropogenic activities were recorded in the study sites, and according to the damage observed, they can be classified respectively: deforestation, overgrazing, bushfires, pesticides, poisoned bait, poaching, hunting, etc. (Figure 7). However, several studies have mentioned that deforestation and overgrazing are the main anthropogenic factors which impact negatively the survival of bird species in their environment as well the biodiversity in general.[12,16-18,38,42] It was also reported that the degradation of the vegetation by anthropogenic activities would decrease the availability and the quality of food resources, as well the resting and nesting sites.[38] Thus degradation of forest would increase to birds the predation risk, the cost of migration in search of food resources and nesting sites.[43]

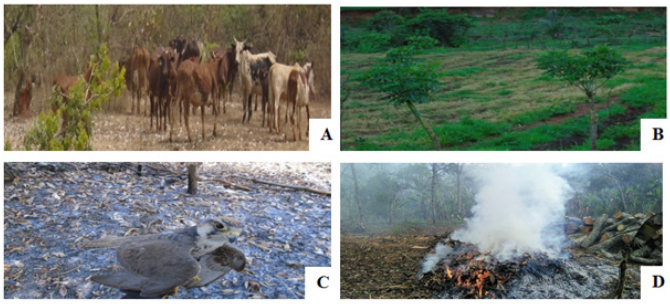

Figure 7 Some anthopogenic activities observed in the Adamawa Plateau, (**A**) overgrazing, (**B**) pesticides, (**C**) bush fires and (**D**) deforestation

In addition, our analyses highlighted an abnormal distribution of bird populations within the Adamawa Plateau (Figure 3). These observations corroborate several results previously carried out in other environments.[44,45] Thus, the fragmentation of habitats by the high anthropogenic activities in the Adamawa Plateau could be explained this abnormal distribution. According to these authors,[46] decreasing of biodiversity in the environment is strongly related to the fragmentation of the habitats by human activities. The abundance of species *Pycnonotus barbatus* and *Turdus pelios* carried out in this study would be indicated the degradation of the habitats, because it was demonstrated that the development of the secondary forest would be provided to these two taxa all their food resources such as insects and seeds.[30-33] Thus, works by this author[47] indicated that expansion of the secondary forests as well the extension of the agricultural areas would be promoted the depending taxa to this degraded environment. Furthermore, degradation of the habitats would strongly impact the specialist taxa to the forestry environment by the losing of their foraging and reproduction sites.[48] According to this author,[42] degradation and pollution of the environment would negatively impact bird species, and today, several populations have drastically declined these last decades.

Temporal prediction of the taxa inventoried within the Adamawa Plateau in Cameroon

Based in our modeling results, 52% of the sedentary species sampled in the Adamawa Plateau would be clearly threatened in this area. Among these species that showed lower frequencies of occurrence, we can list *Pytilia hypogrammica*, *Lagonosticta sanguinodorsalis*, *Euschistospiza dybowskii*, *Muscicapa aquatica*, *Streptopelia capicola*, *Lybius dubius*, etc. (Table 1 & Figure 5). These results are going in the trend to those reported by several authors,[49,50] which have showed that several bird populations are declining in many regions and habitats in the World. These results could be explained both by the loss of the habitats and the rarity of

food resources which are drastically declining the reproduction rate of bird species. Because degradation and fragmentation of the habitats by human activities, bird populations have declined from 20% to 25% since the pre-agricultural time. It was also demonstrated that the large-scale degradation of habitats and the hunting of animals would be favored the extinction of certain species in the environment.[50]

Conclusion and recommendations

The current study has reported 61 species from the Adamawa Plateau and the most frequently in this area were *Pycnonotus barbatus*, *Turdus pelios* and *Turtur afer*. Thus, birds are unequally distributed in this area within forest, dry-woodland and meadow habitats, and this distribution is depending to the type of vegetation in each habitat. In addition, our observations showed that anthropogenic activities have strongly impacted the biodiversity and especially birds with a significant reduce of the abundance of several species in the area. Indeed, 52% of the sedentary species sampled are seriously threatened in the Adamawa Plateau. Overgrazing and deforestation by farming, road construction, human settlements and fuel wood collection have considerably affected bird survival due to loss of foraging areas and reproduction sites. For this, we suggest that stronger and targeted measures for the conservation of biodiversity and ecosystems be applied to save endemic and threatened bird species in this part of Cameroon. Based on the threats to the Adamawa Plateau's wildlife, we suggest that government authorities should not only organize meetings with local populations to advocate for the preservation of their ecosystem, but should also take measures to prevent deforestation, pollution and untargeted poisoning of species by identifying some areas as "Important Bird Areas" (IBAs) for formal protection. We also propose an efficient management by initiating reforestation program, anti-poaching patrols, research and long-term monitoring. Otherwise, there is an urgent need for an intensive education of the local inhabitants by raising awareness of wildlife conservation. Finally, to establish tourist sites that will generate employment for locals and intensify training on domestic livestock farming as well as aquaculture.

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Conflicts of interest

Authors declare that there is no conflict of interest.

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