



International Journal of Animal Research (ISSN:2575-7822)



A Study on Bird Diversity and Abundance in a Lowland of the Centre Region of Cameroon (Ekoko II village) confirm High Diversity in the Congo Basin Forest and a Greater Dominance in the Distribution of Species in the Lowlands

Billy. Nguembock^{1,2,*}, Hervé. Nkingop Djopmou¹, Sali. Mahamat¹, Esther Diane Olivia. Azang¹

¹Laboratory of Zoology, Ornithology Unit, Department of Animal Biology and Physiology, University of Yaounde I, P. O. Box 812 Yaounde, Cameroon; ²Department of biological sciences, University of Montreal, C.P. 6128, succursale of Center of town, Montreal, QC, H3C 3J7, Canada

ABSTRACT

Cameroon is one of the six Congo Basin Forest countries. The Centre region of Cameroon (Central Africa) is a relictual site in which several expeditions by naturalist ornithologists have permitted to describe many new birds' specimens. Only in recent years, very few bird surveys have been conducted in this area to get an idea about the new or old taxa that make up this region. We conducted a bird survey in a locality of the Centre region of Cameroon, Nsimalen district of Mfou (more precisely in the Ekoko II village) to investigate the avifauna as well as to explore the abundance, diversity and distribution and eventually their reasons. To obtain the abundance of bird species, we used the mist-netting method and captured birds during eleven months. In order to analyse diversity and distribution of this avifauna in their life environment, we performed analyses with SAS/STAT and PAST software. We caught 227 individuals belonging to 24 birds' families. Compared with previous surveys in this region, we newly recorded one family (Phylloscopidae), one genus (*Phylloscopus*) and two species: *Phylloscopus bonelli* and *Criniger ndussumensis*. In the Ekoko II avifauna, many are sedentary but there is also a great mixture of birds described as seasonal migrants, intra-African migrants, residents, etc. Values of the obtained diversity indexes show that the Nsimalen village exhibits a great avifaunistic diversity. Our results show an absence of the supremacy of one species ($H'=3.14$) and the value of the Equitability index ($J'=0.80$) supports an equal distribution of the individuals. Then the pattern of distribution of the species also appears to lean on ecological factors and in this case, the vegetation which would have played a main role in their distribution with a mix of specialists and generalists birds or even migratory birds due to the abundant vegetation. Otherwise, our study also reveals that the composition and structure of the vegetation play a main role in the variety of bird species at least at the local scale. Compare to mountainous areas, our study establishes some similarities in the pattern of distribution of the species between mountain areas and lowlands but diversity has clearly been higher in the mountains while dominance is more pronounced in the lowlands.

Keywords: bird survey, Congo Basin Forest, mist-netting method, diversity and distribution analyses, diversity index, vegetation

*Correspondence to Author:

Billy. Nguembock
Laboratory of Zoology, Ornithology Unit, Department of Animal Biology and Physiology, University of Yaounde I, P. O. Box 812 Yaounde, Cameroon; Department of biological sciences, University of Montreal, C.P. 6128, succursale of Center of town, Montreal, QC, H3C 3J7, Canada

How to cite this article:

Billy. Nguembock, Hervé. Nkingop Djopmou, Sali. Mahamat, Esther Diane Olivia. Azang, A Study on Bird Diversity and Abundance in a Lowland of the Centre Region of Cameroon (Ekoko II village) confirm High Diversity in the Congo Basin Forest and species variety due to luxuriant vegetation. International Journal of Animal Research, 2019; 4:31.



eSciPub LLC, Houston, TX USA.
Website: <https://escipub.com/>

Introduction

Country of the Africa mainland, Cameroon is a country located in Central Africa and it is one of six countries that make up the Congo Basin Forest, the second largest tropical in the world, with nearly 2 million square kilometers of rainforest (WWF, 2010). The Centre region of Cameroon which is a relictual site showed different types of vegetation and is crossed by several mountains; the conducted surveys in this region are very old (DeLancey and Mbuh, 2010). This region is mainly located on the southern Cameroon Plateau and shows a mountain area which often varies between 200 and 1000 meters above sea level; it is characterized by mountain forests that often give way to savannah and sometimes to patchily vegetation (Franqueville, 1968; Olivry, 1986).

Ekoko II (3°44'06" North; 11°32'48" East) is a small village located on the Centre region of Cameroon and it is bordered to the north by the village Ekoko I, to the south by Nkolinda and Nsimalen, to the east by the villages Benebaloe and Ekok II (Figures 1-2) (Centre ORSTOM, 1966; Mougoué, 1989). Ekoko II village has the same climate as the rest of the city of Yaounde which is Guinean type to four seasons (two rainy seasons and two dry seasons) (Suchel, 1987). With an annual thermal amplitude of 3.1°C, the temperature of the city of Yaounde varies very little and it is the same in the Ekoko II village (Olivry, 1986). The vegetation in the Ekoko II village is of the Guineo-Congolese type, composed initially of a rainforest but with the increase in human activities, the vegetation is degraded and in places it gives way to a secondary forest intermixed with scrubland and fallows (Achoundong, 1985; Olivry, 1986); otherwise, the Nsimalen vegetation belongs to the large area of semi-deciduous moist dense forest corresponding to the semi-deciduous at Sterculiaceae and Ulmaceae (Letouzey, 1985; Santoir and Bopda, 2005). In addition, in this vegetation, we can note the presence of several types of seeds, various types of fruits including

berries, many trees with flowers and other cultivated plants.

Surveys in this region began during the colonization period and several expeditions by naturalist ornithologists have thus taken place in the Centre region of Cameroon which resulted in the description of new species (DeLancey and Mbuh, 2010; Sharpe, 1904; Sharpe, 1908; Bates, 1926). After these preliminaries surveys, just some birds' surveys have been carried out in the large Centre region of Cameroon, although no bird survey has been particularly focused on the Ekoko II village (Monard, 1951; Good, 1952-1953; Germain et al., 1973; Louette, 1981; Decoux and Fotso, 1988). Based on these few bird surveys carried out in this region, passerine representatives are systematically more numerous than non-passerine (Monard, 1951; Good, 1952-1953; Germain et al., 1973; Louette, 1981); thus, several orders of the birds have been reported Passeriformes, Columbiformes, Coliiformes, Cuculiformes, Piciformes, etc. but the order Passeriformes always remains the most representative (Good, 1952-1953; Germain et al., 1973; Louette, 1981).

During the long time and even now, the most surveys carried out in Cameroon never focused specially on the relationship between the biodiversity in general, and in our case birds, and their life's environment (Stuart, 1986; Collar and Stuart, 1988; Dowsett and Dowsett-Lemaire, 1989; Dowsett and Forbes-Watson, 1993; Dowsett-Lemaire and Dowsett, 2001; Bowden, 2001; Fotso et al., 2001; Bobo et al., 2005; Languy et al., 2005; Sedlacek et al., 2007). Thus before Nguembock et al. (2017) and Azang (2017) in the mountains of the Centre region of Cameroon, very few studies carried out in Cameroonian ecosystems had briefly mentioned the relationship between birds and their living environment (Louette, 1981; Dowsett, 1989). However, several old and recent studies have established a correlation between the distribution of species and environmental factors on the one hand, and the abundance of taxa and

the presence or absence of food on the other hand (MacArthur, 1964; Telleria and Santos, 1994; Thebault and Loreau, 2006; Parsons et al., 2006; Rajpar and Zakaria, 2011; Girma et al., 2017).

Our study, which carried out in the Ekoko II village during eleven months, has two goals fold: firstly, we thoroughly investigated the avifauna of this area of Cameroon from base to tip and secondly, we tried to explore the abundance, diversity and distribution within the Ekoko II avifauna to suggest hypotheses about the pattern of distribution of the species in a lowland area and on the basis on these results to cast a comparative glance in the pattern of species distribution in the lowlands to that of the mountains.

Material and Methods

Investigation of the Ekoko II avifauna: In order to investigate the avifauna, we used an appropriate method: the mist-netting method. This method is widely used for catching small to medium-sized wild birds such as passerines and shorebirds. According to this method, an inconspicuous mesh net is erected vertically on poles and deployed in areas of high activity to intercept birds as they go about their normal daily routines.

In our captures, we used dark-coloured nylon nets and smaller mesh for smaller species. Otherwise, our mist nets have a series of 3 pockets running horizontally along the length of the net. Our mist nets were fixed with the mounting poles which had been chosen carefully and the choice of an appropriate mist-netting site was important for the capture success. Thus in order to ensure the capture success, we mainly identified their preferred flight paths, feeding areas, roosting and shaded sites. Generally, we start catching very early in the morning (5: 00 AM) and we finish very late in the evening (sometimes 6: 30 PM). In order to avoid a skew in our survey, we used the same eight mist nets in our different field mission and we did eleven field missions during eleven months.

Method for the calculation of the relative Abundance of the Ekoko II avifauna: In order to calculate the relative Abundance, we chose to use the Statistical Analysis System (SAS Institute, 1985). We input data as explained in the user guide and ran software until the obtaining of the results. Otherwise, we used Excel software program to obtain our histograms and curves (Microsoft Excel, 2016).

Method for the calculation of the Occurrence of the Ekoko II avifauna: In order to calculate the Occurrence, we used the same software, the Statistical Analysis System (SAS Institute, 1985). As for the calculation of the relative Abundance, we input data as explained in the user guide and ran software until the obtaining of the results.

Methods for the measure of the distribution of the Ekoko II avifauna in keeping with their environment

Shannon index (H'): The Shannon's diversity index represents the measure of the sum of degree of the uncertainty when it suggests predicting to which species would belong to an individual taken by chance in a collection of S species and N individuals. $H' = 0$ if the community has only one species; H' takes the maximal value $\log_2 S$ only when all species are represented by the same number of individuals. This index is determined by the following relationship:

$$H' = - \sum_{i=1}^S (p_i \times \log_2 p_i) \quad p_i = n_i/N$$

Where p_i = proportion of individuals of the species "i"; S = total number of species of the sample.

n_i = number of individuals of the species "i";

N = total number of individuals of the sample.

The Shannon index (H') increases when the number of the species of the community grows and, theoretically, it can reach elevated values. The value of H' varies from 1 to $\log_2 S$. In our study, the Shannon index was calculated with the PAST software (Pearson and Rosenberg, 1978).

Simpson index (λ): The Simpson index represents the proportion of abundance of the species “i” (Pearson and Rosenberg, 1978). This index measures the degree of concentration when individuals are classified into types. It is determined by the following relationship:

$$\lambda = \sum_{i=1}^S \frac{n_i(n_i - 1)}{n(n - 1)}$$

where n_i = number of individuals of the species “i”; n = total number of individuals of the sample.

Nevertheless, the most popular of such indexes have been the inverse Simpson index ($1/\lambda$) and the Gini-Simpson index ($1 - \lambda$) and both have also been called the Simpson index in the ecological literature. In our study, the Simpson index was calculated with the PAST software (Pearson and Rosenberg, 1978).

Equitability index: The Equitability index measures the distribution of individuals within species independently to the specific richness. Its value varies from 0 (supremacy of one species) to 1 (equal distribution of individuals within species).

Thus, the Equitability index of Pielou (J') is determined by the following formula:

$$J' = H'/H' \max$$

H' = Shannon index

$H' \max = \log_2 S$ (S = the total number of species).

In our study, the Equitability index was calculated with the PAST software (Pearson and Rosenberg, 1978).

All these indexes have been obtained with a confidence threshold of 95%.

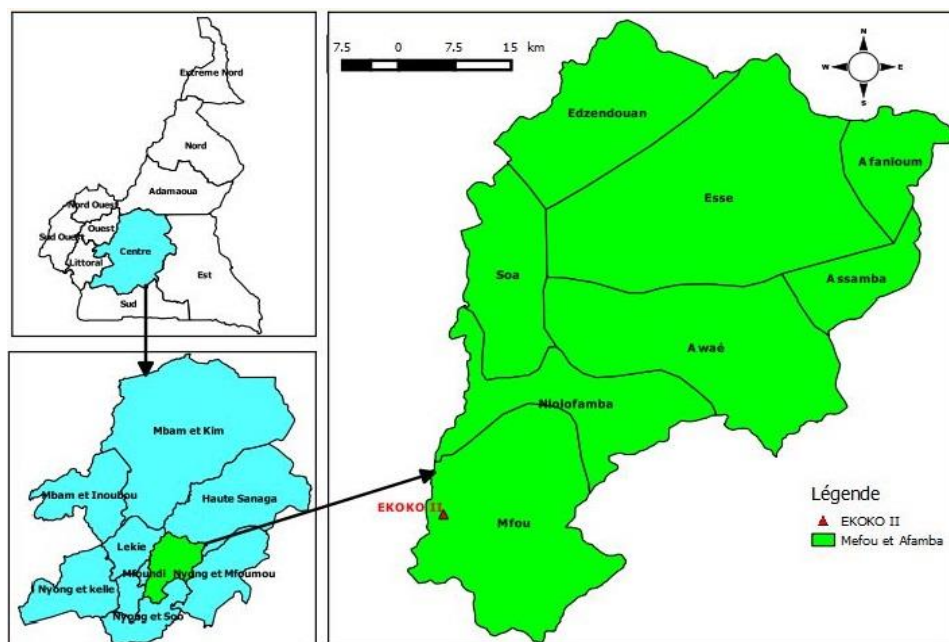


Figure 1: Localization of the Ekoko II lowland (Congo Basin Forest, Cameroon).

Results

Abundance and Occurrence of the Ekoko II avifauna

Familial abundance of the Ekoko II avifauna:

During our survey, we caught 227 individuals belonging to 24 birds' families (Table 1). We found that 75% of the captures were from the passerine families and 25% from non-passerine (Table 1). The most representative family is the

Ploceidae family (40.1%), followed by the family Pycnonotidae (21.6%) and the Nectariniidae family (6.17%) (Figure 2; Table 1). The most diversified families, in terms of number of genera and species, were Pycnonotidae with five genera and eight species, followed by Cisticolidae with four genera and five species, and Estrildidae with three genera and four species (Tables 2 and 3).

Table 1: Familial abundance of the Ekoko II avifauna after the bird survey between October 2016 and September 2017 in the Ekoko II village (Nsimalen district of Mfou, Cameroon, Congo Basin Forest).

Family name	Absolute abundance	Relative abundance (%)
Alcedinidae	4	1.76
Cisticolidae	8	3.52
Coliidae	4	1.76
Columbidae	13	5.73
Cuculidae	5	2.2
Estrildidae	11	4.84
Fringillidae	1	0.44
Hirundinidae	1	0.44
Laniidae	1	0.44
Lybiidae	3	1.32
Macrosphenidae	1	0.44
Malaconotidae	1	0.44
Meropidae	6	2.64
Monarchidae	1	0.44
Muscicapidae	3	1.32
Nectariniidae	14	6.17
Nicatoridae	2	0.88
Phylloscopidae	1	0.44
Platysteiridae	2	0.88
Ploceidae	91	40.1
Pycnonotidae	49	21.6
Turdidae	3	1.32
Viduidae	1	0.44
Incertae sedis	1	0.44
Total	227	100

Generic abundance and occurrence of the Ekoko II avifauna: Thirty-six genera were identified at the end of our sampling (Table 2). Among them, the most representative genera were those of three passerine, *Ploceus* (39.65%) (Ploceidae), *Eurillas* (9.7%) (Pycnonotidae) and *Cyanomitra* (5.73%) (Nectariniidae), and one non-passerine, *Turtur* (5.73%) (Columbidae) (Figure 3; Table 2). In contrast, the less representative genera with a relative abundance of 0.44% were those belonging to passerine, *Apalis* and *Cisticola* (Cisticolidae), *Cinnyris* (Nectariniidae),

Cossypha (Turdidae), *Criniger* (Pycnonotidae), *Euplectes* (Ploceidae), *Hylia* (Hylidae), *Lanius* (Laniidae), *Lonchura* (Estrildidae), *Phylloscopus* (Phylloscopidae), *Psalidoprocne* (Hirundinidae), *Serinus* (Fringillidae), *Sylvietta* (Macrosphenidae), *Tchagra* (Malaconotidae), *Terpsiphone* (Monarchidae) and *Vidua* (Viduidae), all represented by one individual each (Table 2).

According to Dajoz (1982), two genera have been omnipresent, *Ploceus* and *Eurillas* (FO = 80%), and one has been regular, *Turtur* (FO =

66.6%) (Table not shown). In addition according to the same author (Dajoz, 1982), 75% of the genera sampled appeared accessories while 16.67% of these genera were constant (Table not shown). We also noted that according to Dajoz (1982), none of the sampled genera was rare (Table not shown).

Specific abundance and occurrence of the Ekoko II avifauna: The 227 captured individuals in our study were identified and subdivided into 50 species of passerines and non-passerines. With a relative abundance of 15.86%, *Ploceus nigerrimus* is appeared as the species the most represented followed by *Ploceus nigricollis* (12.33%), *Ploceus cucullatus* (11.45%) and *Eurillas virens* (7.93%) (Table 3). Respectively

twenty-three species of passerine and two of the non-passerine were represented by one individual; it's about *Apalis binotata*, *Camaroptera superciliaris*, *Cinnyris superbus*, *Cisticola erythrops*, *Cossypha niveicapilla*, *Criniger ndussumensis*, *Cyanomitra verticalis*, *Estrilda astrild*, *Euplectes* sp., *Eurillas gracilis*, *Hylia prasina*, *Lanius mackinnoni*, *Lonchura bicolor*, *Muscicapa comitata*, *Ochrospiza mozambica* (*Serinus mozambicus*), *Phylloscopus bonelli*, *Platysteira castanea*, *Platysteira cyanea*, *Psalidoprocne fuliginosa*, *Sylvietta brachyura*, *Tchagra senegala*, *Terpsiphone viridis* and *Vidua macroura* for passerines, and *Chrysococcyx klaas* and *Pogoniulus atroflavus* for non-passerines (Figure 4; Table 3).

Table 2: Generic abundance of the Ekoko II avifauna obtained after the bird survey between October 2016 and September 2017 in the Ekoko II village (Nsimalen district of Mfou, Cameroon, Congo Basin Forest).

Name of genus	Absolute abundance	Relative abundance (%)
<i>Apalis</i>	1	0.44
<i>Camaroptera</i>	3	1.32
<i>Chlorocichla</i>	11	4.85
<i>Chrysococcyx</i>	5	2.2
<i>Cinnyris</i>	1	0.44
<i>Cisticola</i>	1	0.44
<i>Colius</i>	4	1.76
<i>Cossypha</i>	1	0.44
<i>Criniger</i>	1	0.44
<i>Cyanomitra</i>	13	5.73
<i>Estrilda</i>	3	1.32
<i>Euplectes</i>	1	0.44
<i>Eurillas</i>	22	9.7
<i>Hylia</i>	1	0.44
<i>Ispidina</i>	4	1.76
<i>Lanius</i>	1	0.44
<i>Lonchura</i>	1	0.44
<i>Merops</i>	6	2.64
<i>Muscicapa</i>	3	1.32
<i>Nicator</i>	2	0.88
<i>Phylloscopus</i>	1	0.44
<i>Platysteira</i>	2	0.88
<i>Ploceus</i>	90	39.65
<i>Pogoniulus</i>	3	1.32
<i>Psalidoprocne</i>	1	0.44
<i>Pycnonotus</i>	10	4.42
<i>Schistolais</i>	3	1.32
<i>Serinus</i>	1	0.44
<i>Spermophaga</i>	7	3.08
<i>Sylvietta</i>	1	0.44
<i>Tchagra</i>	1	0.44
<i>Terpsiphone</i>	1	0.44
<i>Thescelocichla</i>	5	2.2
<i>Turdus</i>	2	0.88
<i>Turtur</i>	13	5.73
<i>Vidua</i>	1	0.44
Totals	227	100

Table 3: Specific abundance and occurrence of each captured species of the Ekoko II avifauna during the bird survey between October 2016 and September 2017 in the Ekoko II village (Nsimalen district of Mfou, Cameroon, Congo Basin Forest).

Scientific name	Common name	Absolute abundance	Relative abundance (%)	Frequency	Occurrence (%)
<i>Apalis binotata</i>	Masked Apalis	1	0.44	1	6.6
<i>Camaroptera brachyura</i>	Green-backed Camaroptera	2	0.88	2	13.3
<i>Camaroptera supercilialis</i>	Yellow-browed Camaroptera	1	0.44	1	6.6
<i>Chlorocichla falkensteini</i>	Yellow-necked Greenbul	4	1.76	3	20
<i>Chlorocichla simplex</i>	Simple Greenbul	7	3.1	5	33.3
<i>Chrysococcyx cupreus</i>	African Emerald Cuckoo	4	1.76	3	20
<i>Chrysococcyx klaas</i>	Klaas's Cuckoo	1	0.44	1	6.6
<i>Cinnyris superbus</i>	Superb Sunbird	1	0.44	1	6.6
<i>Cisticola erythrops</i>	Red-faced cisticola	1	0.44	1	6.6
<i>Colius striatus</i>	Speckled Mousebird	4	1.76	3	20
<i>Cossypha niveicapilla</i>	Snowy-crowned robit-chat	1	0.44	1	6.6
<i>Criniger ndussumensis</i>	White-bearded Greenbul	1	0.44	1	6.6
<i>Cyanomitra obscura</i>	Tufted Olive Sunbird	12	5.3	4	26.6
<i>Cyanomitra verticalis</i>	Green-headed Sunbird	1	0.44	1	6.6
<i>Estrilda astrild</i>	Common waxbill	1	0.44	1	6.6
<i>Estrilda nonnula</i>	Black-crowned Waxbill	2	0.88	2	13.3
<i>Euplectes sp</i>		1	0.44	1	6.6
<i>Eurillas gracilis</i>	Grey Grenbul	1	0.44	1	6.6
<i>Eurillas latirostris</i>	Yellow-whiskered	3	1.32	3	20
<i>Eurillas virens</i>	Little Greenbul	18	7.93	12	80
<i>Hylia prasina</i>	Green Hylia	1	0.44	1	6.6
<i>Isidina picta</i>	African Pygmy-Kingfisher	4	1.76	4	26.6
<i>Lanius mackinnoni</i>	Mackinnon's Shrike	1	0.44	1	6.6
<i>Lonchura bicolor</i>	Black-and-white Mannikin	1	0.44	1	6.6
<i>Merops pusillus</i>	Little Bee-eater	4	1.76	2	13.3
<i>Merops variegatus</i>	Blue-breasted Bee-eater	2	0.88	2	13.3
<i>Muscicapa caerulescens</i>	Ashy flycatcher	2	0.88	2	13.3
<i>Muscicapa comitata</i>	Dusky-blue flycatcher	1	0.44	1	6.6
<i>Nicator vireo</i>	Yellow-throated Nicator	2	0.88	1	6.6
<i>Phylloscopus bonelli</i>	Western Bonelli's Warbler	1	0.44	1	6.6
<i>Platysteira castanea</i>	Chestnut Wattle-eye	1	0.44	1	6.6
<i>Platysteira cyanea</i>	Brown-throated Wattle-eye	1	0.44	1	6.6
<i>Ploceus cucullatus</i>	Village Weaver	26	11.45	8	53.3
<i>Ploceus nigerrimus</i>	Viellot's Black Weaver	36	15.86	10	66.6
<i>Ploceus nigricollis</i>	Black-necked Weaver	28	12.33	10	66.6
<i>Pogoniulus atroflavus</i>	Red-rumped Tinkerbird	1	0.44	1	6.6
<i>Pogoniulus bilineatus</i>	Yellow-rumped Tinkerbird	2	0.88	2	13.3
<i>Psalidoprocne fuliginosa</i>	Mountain Saw-wing	1	0.44	1	6.6
<i>Pycnonotus barbatus</i>	Common Bulbul	10	4.4	6	40
<i>Schistolais leucopogon</i>	White-chinned Prinia	3	1.32	2	13.3
<i>Serinus mozambicus</i>	Yellow-fronted Canary	1	0.44	1	6.6
<i>Spermophaga haematina</i>	Western Bluebill	7	3.1	6	40
<i>Sylvietta brachyura</i>	Northern Crombec	1	0.44	1	6.6
<i>Tchagra australis</i>	Brown-crowned Tchagra	1	0.44	1	6.6
<i>Terpsiphone viridis</i>	African Paradise-Flycatcher	1	0.44	1	6.6
<i>Thescelocichla leucopleura</i>	Swamp Palm Bulbul	5	2.2	2	13.3
<i>Turdus pelios</i>	African Thrush	2	0.88	2	13.3
<i>Turtur afer</i>	Blue-spotted Wood Dove	11	4.85	9	60
<i>Turtur tympanistria</i>	Tambourine Dove	2	0.88	1	6.6
<i>Vidua macroura</i>	Pin-tailed Whydah	1	0.44	1	6.6
Totals		227	100	/	//

Table 4: Diversity indexes of the Ekoko II avifauna within their life environment obtained from the PAST software (Pearson and Rosenberg, 1978).

Taxonomic level	Family	Generic	Specific
Taxa S	24	36	50
Simpson (λ)	0.78	0.82	0.93
Dominance (D)	0.22	0.18	0.07
Shannon (H')	2.09	2.51	3.14
H'max	3.17	3.54	3.91
Equitability (J)	0.66	0.7	0.8

Table 5: Comparative values of the diversity indexes of the avifaunas at the specific level between lowland and mountains areas obtained from the PAST software (Pearson and Rosenberg, 1978).

Areas	Abobo-Etetak Hill	Eloumden mountain	Ekoko II lowland
Simpson (λ)	0.95	0.96	0.93
Dominance (D)	0.05	0.04	0.07
Shannon (H')	3.34	3.62	3.14
H'max	3.93	3.93	3.91
Equitability (J)	0.85	0.92	0.8

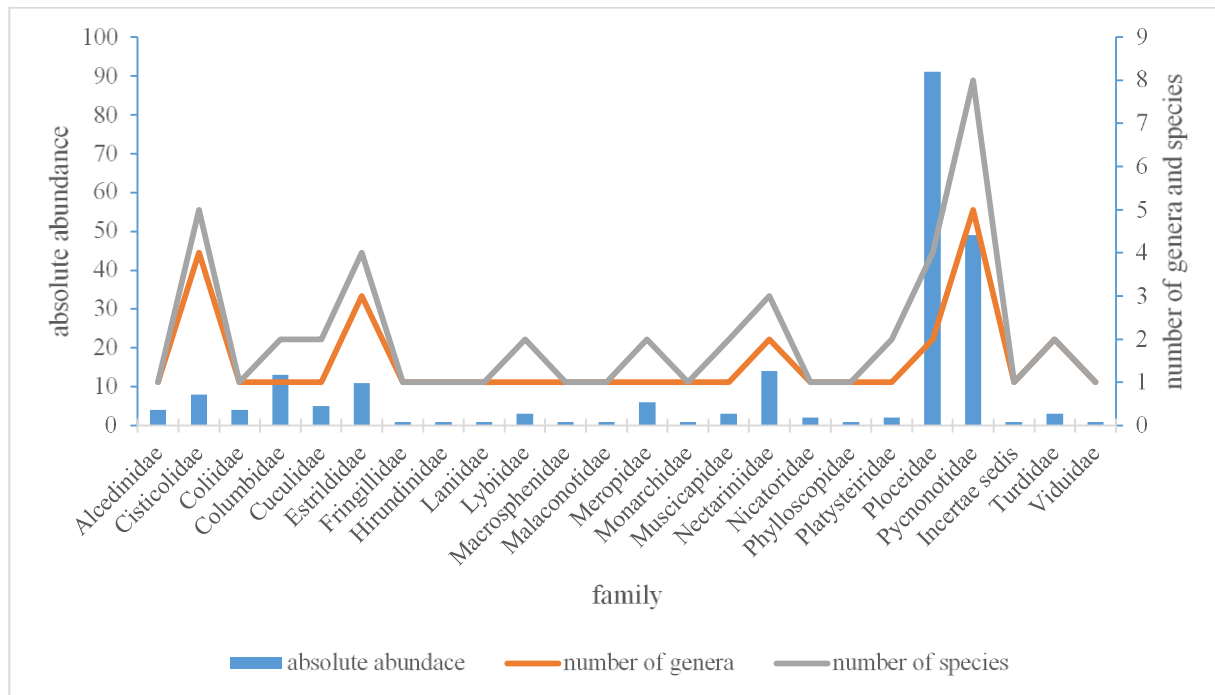


Figure 2: Relative familial abundance histogram in function of genera and species captured during the bird survey between October 2016 and September 2017 in the Ekoko II lowland of the Congo Basin Forest.

Based on intervals of Dajoz (1982), our occurrence results indicate that one of the sampled species was omnipresent, *Eurillas virens*, while none was rare (Table 3). Always according to Dajoz (1982), four sampled species were regular and the most observed were two passerines, *Ploceus nigricollis* and *Ploceus nigerrimus*, and one non-passerine, *Turtur afer*, while five species were constant including four passerines, *Chlorocichla simplex*, *Cyanomitra obscura*, *Pycnonotus barbatus* and *Spermophaga haematina*, and one non-passerine, *Ispidina picta* (Table 3). In addition, forty of the fifty species caught appeared as accessories according to Dajoz (1982) (Table 3).

Diversity index: According to our analyses, the Shannon index has been 2.09 at the familial level, 2.51 at the generic level and 3.14 at the specific level (Table 4). For the Simpson index, values were 0.78 at the familial level, 0.82 at the generic level and 0.93 at the specific level (Table 4). With high obtained values, the general tendency is the same between the Shannon index and the Simpson index (Table 4). In addition, values of the equitability were 0.66 at the familial level, 0.70 at the generic level and 0.80 at the specific level (Table 4); we noted that these last values appeared far from 0 (Table 4).

Discussion

Avifauna of the Ekoko II village: The Ekoko II bird survey is characterized by a high representativity of passerines (75%) compared to non-passerines (25%) (Table 1). This high representativity of the passerines corroborates studies of Good (1952-1953), Germain et al. (1973), Louette (1981), Azang (2017) and Nguembock et al. (2017) carried out in different localities in the Centre region of Cameroon in the Basin Congo Forest. Almost all inventoried bird families in our study site have already been reported in the Centre region (Good, 1952-1953; Germain et al., 1973; Louette 1981; Azang 2017;

Nguembock et al., 2017). However, our study made it possible to mention for the first time the presence of the Phylloscopidae family in this region. In addition, with a relative frequency of 40.1%, the family Ploceidae, commonly called weavers, was the most represented (Figure 2; Table 1); this high representativeness of the Ploceidae can be explained by their ability to colonize several types of biotopes, especially lowlands, mountain forests and more particularly semi-open environments such as savannahs, fields, etc. (Fry et al., 2000).

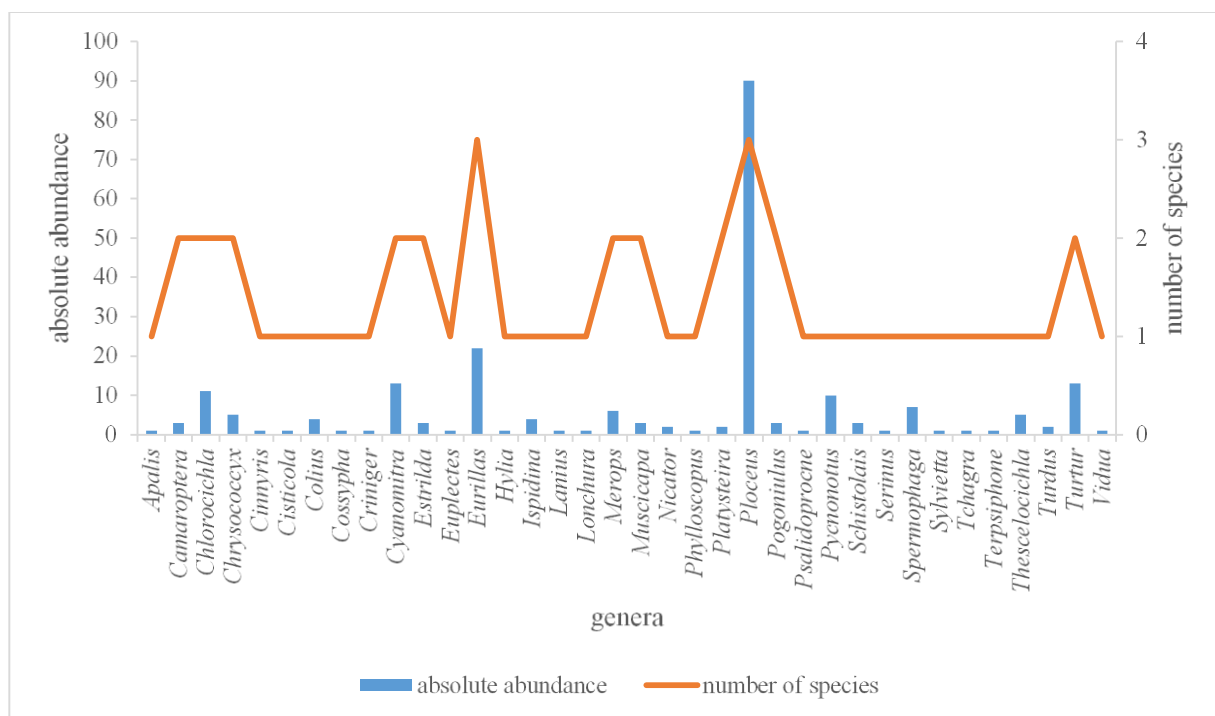


Figure 3: Relative frequency histogram of genera in function of number of captured species during the bird survey between October 2016 and September 2017 in the Ekoko II lowland of the Congo Basin Forest.



Picture I: *Phylloscopus bonelli* Vieillot, 1819 (picture from avesnest.com)



Picture II: *Criniger ndussumensis* Reichenow, 1904 (picture from hbw.com)

As at the family level, all inventoried genera of our study site, with the exception of the genus *Phylloscopus*, have already been reported in the Centre region of Cameroon (Good, 1952-1953; Germain et al., 1973; Louette 1981; Azang 2017; Nguembock et al., 2017). In addition, the genus *Ploceus* appeared the most abundant (39.65%) and one of the most common with *Eurillas* (FO = 80%) on our study site (Figure 3; Table 2). The omnipresence of the genus *Ploceus* was also obtained by Azang (2017) and Nguembock et al. (2017), realized respectively on the Eloumden and Messa (Abobo-Etetak hill) mountains. At the specific level, of the 50 identified species, two had not yet been reported in the Centre region of Cameroon, based on previous studies (Good, 1952-1953; Germain et al., 1973; Louette 1981; Azang 2017; Nguembock et al., 2017). It's about: *Phylloscopus bonelli* belongs to the Phylloscopidae's family (Gill and Donsker, 2017) (Picture 1): also called the Western Bonelli's Warbler, *Phylloscopus bonelli* was formerly regarded as a subspecies but since Helbig et al. (1995), it is now considered as a species. The Western Bonelli's Warbler is a small passerine of about 12 cm found in forest and woodland and living especially in mountainous environments at an altitude up to 2000 m (Svensson et al., 2016). Moreover, it is a migratory bird that spends the winter south of the Sahara (Borrow and Demey, 2001; Svensson et al., 2016).

Criniger ndussumensis belongs to the Pycnonotidae's family (Gill and Donsker, 2017) (Picture 2): the White-bearded Greenbul is a pycnonotid whose body is about 18 cm long; usually in pairs or family parties, it lives in subtropical or tropical moist lowland forests (Borrow and Demey, 2001). Resident, the White-bearded Greenbul is found from south-eastern Nigeria and western Cameroon to eastern Democratic Republic of the Congo and extreme north-western Angola (Borrow and Demey, 2001; Gill and Donsker, 2017). Only until now, it was not formally identified in the Centre region of Cameroon (Good, 1952-1953; Germain et al., 1973; Louette, 1981).

As *Phylloscopus bonelli*, the White-bearded Greenbul is also classified as 'Least Concern' according to the International Union for the Conservation of Nature (www.iucnredlist.org).

Distribution and diversity of the avifauna in the Ekoko II village:

Diversity indices obtained after statistical analyzes show that Ekoko II has a great avifaunistic diversity (see Table 4). Firstly, the Simpson index obtained at the specific level ($\lambda = 0,93$; Table 4) reveals that there is no significant difference between the abundances of the different inventoried species at our study site. Secondly, with a value of 3,14 at the specific level for a H'max equal to 3,91, the Shannon diversity index strongly corroborates that of Simpson and suggests the absence of supremacy of a single species (Table 4). And moreover, the Pielou's equitability index ($J = 0,80$) suggests that all captured individuals are distributed equally among species (Table 4). These results obtained in an open lowland forest are in the same direction as those already obtained in mountains of the Centre region of Cameroon, Eloumden mountain (Azang, 2017) and Abobo-Etetak hill (Nguembock et al., 2017) but they reveal that diversity is higher and dominance is less pronounced in mountain areas of this region (Table 5). Both in the lowlands and in the mountains of this region, the vegetation appears luxuriant throughout the year depending on the exceptional climatic conditions of the equatorial zone, which offers various food resources to sedentary birds but also to migratory, explaining for example their presence among others in the equatorial zone during the winter. In addition, we have indicated that this diversity of birds in the Centre region of Cameroon could also be explained by a reduction in intra and interspecific competition due to the abundance of food resources (Azang, 2017; Nguembock et al., 2017). Thus, according to Louette (1981), the distribution of birds appears directly related to vegetation and, in the same vein, Brown and Lomolino (1998) and Jetz and Rahbek (2002) suggest that species distribution patterns almost invariably use

environmental factors; in the case of our study, this environmental factor is undoubtedly the vegetation. We also noted the multiplicity of biotopes encountered on our study site among other swamps, rivers, secondary forests intermixed with scrubland and fallow, etc. in which several taxa live and where this multiplicity of biotopes also appears as a favorable element to shelter the bird diversity (personal observation of the different biotopes by Billy Nguembock).

Relationship between species diversity and presence of food in the Ekoko II village:

According to the number of individuals captured at the Ekoko II site, results of our investigation revealed that the Ploceidae family was the most abundant, followed by the family Pycnonotidae and finally the family Nectariniidae (Figure 2; Table 1). On the other hand, the Pycnonotidae family was the most diverse, followed by the Cisticolidae and Estrildidae families (Tables 2 and 3). With regard to passerines, in the very abundant family Ploceidae, the genus *Ploceus* (*P. nigricollis* and *P. nigerrimus* with FO=66.6%) appeared omnipresent while in the abundant family Pycnonotidae, the genus *Eurillas* (*E. virens* with FO=80%) also appeared omnipresent; in addition, among the abundant Nectariniidae family as well as in the diverse Cisticolidae and Estrildidae families, no species were regular (Dajoz, 1982). For non-passerines, in the relative abundant Columbidae family, the genus *Turtur* (*T. afer* with FO=60%) appeared regular (see Table 3).

According to Pearce-Higgins and Murray (2006), variations in the composition, structure and heterogeneity of vegetation significantly affect the abundance of bird species; thus, the authors found that the abundance of bird species in a given environment varies according to their preferences for particular structural and compositional vegetation features. Similarly in their study of several sites in Ethiopia, Kiros et al. (2018) found that the diversity and abundance of species were directly related to the presence of different plants particularly in bushlands which provided a source of food for

birds. The two abundant *Ploceus nigricollis* and *P. nigerrimus* species are insectivorous and seed-eating birds and their presence is often related to an environment in which they can find these foods (del Hoyo et al., 2016). Concerning *Eurillas virens*, this abundant bulbul eats almost all fruits including berries, although it sometimes gleans arthropods (Borrow and Demey, 2001; del Hoyo et al., 2016). The abundant non-passerine, *Turtur afer* eats a variety of seeds including those of castor-oil (del Hoyo et al., 2016). For the remaining of the abundant sunbirds and the diversified African warblers as well as Estrildid finches, their range of food is largely represented in the diet of the previous birds.

Then, the composition and the structure of the Ekoko II vegetation clearly show a diversity of habitats but above all the composition of vegetation such as described by Olivry (1986) (as well as personal observation from Billy Nguembock), which offers a multitude of food preference for birds living in this environment. It should be noted that the vegetation of this Centre region is influenced by a lot of sun and precipitation all year round as all region of the equatorial zone, which allows the growth of plants which constitute an important food source for birds; in addition, human activities particularly some field work, have significantly altered vegetation by adding plantations of various food crops. In the end, the vegetation of the Ekoko II site is therefore a food source for many birds, including fruits, berries, seeds, nectar, and with plantations, the small arthropods that live there are also a food source, which would explain the species diversity caught on the Ekoko II site in the Congo Basin Forest.

Conclusion

The Ekoko II village located in a lowland of the Centre region of Cameroon attests to the high diversity of avifauna in the Congo Basin Forest. On another side, the pattern of variation in distribution of birds at the Ekoko II site in the Congo Basin Forest appears to be based on environmental factors, in particular vegetation,

which plays the main role. In addition, the composition and structure of vegetation that can be a source of food for birds influences the variety of bird species, such as observed at the Ekoko II site. We noted particularly that the Ekoko II village in a lowland area showed overall similarities in the distribution of the species compared to mountain areas, but that diversity was higher in the mountains whereas dominance was more pronounced in the lowlands.

Acknowledgements

We wish to thank Mr Omgba for the reception at Ekoko II village and the assistance he gave us in the field. We also thank Mr Mballa Ndzie Paul Armand for his help during fields' missions. Finally we thank all the ornithology team of the Zoology laboratory of the University of Yaounde I for their contribution and advices in the general achievement of this project.

References

1. Achoundong, G. (1985). *Étude écologique et floristique de la végétation des collines de Yaoundé au-dessus de 1000m*. The University of Yaounde, Cameroon (Unpublished Thesis).
2. Azang, E.D.O. (2017). *Étude préliminaire de l'avifaune de l'un des versants du mont Eloumden et analyse phylogénétique de la famille des Pycnonotidés (Oiseaux, Passériformes)*. Master dissertation, The University of Yaounde I, Cameroon.
3. Bates, G.L. (1926). *Anthreptes seimundi minor*. Sanaga River, North of Yaounde, Cameroon. *Bull. Brit. Orn. Club.* **46**, 107.
4. Bobo, K.S., Waltert, M., Fichtler, M. and Muhlenberg, M. (2015). New bird records for the Korup Project Area, southwest Cameroon. *Malimbus* **27**, 13-18.
5. Borrow, N. and Demey, R. (2001). *A guide to the birds of western Africa*. Princeton University Press, Princeton and Oxford.
6. Bowden, G.R. (2001). The birds of Mount Kupe, southwest Cameroon. *Malimbus* **23**, 13-44.
7. Brown, J.H. and Lomolino, M.V. (1998). *Biogeography*. 2nd Edition. Sinauer, Sunderland.
8. Collar, N.J. and Stuart, S.N. (1988). *Key forests for threatened birds in Africa*. Report of the International Council for Bird Preservation (ICBP), Cambridge, UK.
9. Dajoz, R. (1982). *Précis d'écologie*. Edition. Dunod, Paris.
10. Decoux, J.P. and Fotso, R.C. (1988). Composition et organisation spatiale d'une communauté d'oiseaux dans la région de Yaoundé. Conséquences biogéographiques de la dégradation forestière et de l'aridité croissante. *Alauda* **56**, 126-152.
11. DeLancey, M.D. and Mbuh, R.N. (2010). *Historical Dictionary of the Republic of Cameroon*. 4th Edition, Lanham, Maryland: Scarecrow Press.
12. del Hoyo, J., Collar, N.J., Christie, D.A., Elliott, A., Fishpool, L.D.C., Boesman, P. and Kirwan, G.M. (2016). *Handbook of the Birds of the World and BirdLife International Illustrated Checklist of the Birds of the World*. Volume 2: Passerines. Lynx Edicions and BirdLife International, Barcelona, Spain and Cambridge, UK.
13. Dowsett, R.J. (1989). A preliminary natural history survey of Mambilla Plateau and some lowland forests of eastern Nigeria. Tauraco Research Report. Liège, Belgium, *Tauraco Press* **1**, 56p.
14. Dowsett, R.J. and Dowsett-Lemaire, F. (1989). *Zoological surveys of small mammals, birds and frogs in the Bakossi and Kupe Mts, Cameroon*. Unpublished report for WWF-Cameroon.
15. Dowsett, R.J. and Forbes-Watson, A.D. (1993). Checklist of birds of the Afrotropical and Malagasy regions. Liège, Belgium, *Tauraco Press* **1**, 74-78.
16. Dowsett-Lemaire, F. and Dowsett, R.J. (2001). First records of Scarce Swift *Schoutedenapus myoptilus* and Grass Owl *Tyto capensis* from Mt Cameroon. *Malimbus* **23**, 110-111.
17. Fotso, R., Dowsett-Lemaire, F., Dowsett, R.J., Scholte, P., Languy, M. and Bowden, C. (2001). *Cameroon in important bird areas of Africa and associated islands: priority sites for conservation*. (eds) Fishpool, L.D.C. and Evans, M. I., 133-159. BirdLife Conservation Series N° 11. Pisces Publications and BirdLife International, Newbury and Cambridge, UK.
18. Franqueville, A. (1968). Le paysage urbain de Yaoundé. *Cahiers O.M.* **82**, 113-154.
19. Fry, C.H., Keith, S. and Urban, E.K. (2000). *The Birds of Africa*. Volume 6, Academic Press, London.
20. Germain, M., Dragesco, J., Roux, F. and Garcin, H. (1973). Contribution à l'Ornithologie du Sud-Cameroun II. Passeriformes. *L'Oiseau* **43**, 59-212.
21. Gill, F. and Donsker, D. (2017). IOC World Bird List. Version 7.3. <http://www.worldbirdnames.org/>. Gill, F and Donsker, D (Eds).
22. Girma, Z., Mamo, Y., Mengesha, G., Verma, A. and Asfaw, T. (2017). Seasonal abundance and habitat use of bird species in and around Wondo Genet Forest, south-central Ethiopia. *Ecol. Evol.* **7**, 3397-3405.

23. Good, A.I. (1952-1953). The birds of French Cameroon. *Mem. Inst. Fr. Afr. Noire. Sér. Sci.* **2**, 1-203; **3**, 1-269.
24. Helbig, A. J., Seibold, I., Martens, J. and Wink, M. (1995). Genetic differentiation and phylogenetic relationships of Bonelli's Warbler *Phylloscopus bonelli* and Green Warbler *P. nitidus*. *J. Avian Biol.* **26**, 139-153.
25. Jetz, W. and Rahbek, C. (2002). Geographic range size and determinants of avian species richness. *Science* **297**, 1548-1551.
26. Kiros, S., Afework, B. and Legese, K. (2018). A preliminary study on bird diversity and abundance from Wabe fragmented forests around Gubre subcity and Wolkite town, Southwestern Ethiopia. *Int. J. Av. Wild. Biol.* **3**, 333-340.
27. Languy, M., Bobo, S., Njie, F.M., Njabo, K.Y., Lapios, J.M. and Demey, R. (2005). New bird records from Cameroon. *Malimbus* **27**, 1-12.
28. Letouzey, R. (1985). *Carte phytogéographique du Cameroun*. Institut de la recherche agronomique (Herbier national) – Yaoundé – Cameroun : Institut de la carte internationale de la végétation – Toulouse – France.
29. Louette, M. (1981). *The birds of Cameroon. An annotated check-list*. Verhandelings Wetenschappen. *Jaargang* **43**, 1-163.
30. MacArthur, R.H. (1964). Environmental factor affecting bird species diversity. *Am. Nat.* **98**, 387-397.
31. Microsoft Excel (2016). Microsoft® Office Excel.
32. Monard, A. (1951). Oiseaux. In : Résultats de la Mission Zoologique Suisse au Cameroun. *Mém. Inst. Fr. Afr. Noire. Sér. Sci. Nat.* **1**, 59-122.
33. Mougoué, B. (1989). Mfou : ville satellite de Yaoundé. *Revue de Géographie du Cameroun* **8**, 139-152.
34. Nguembock, B., Mahamat, S., Kemtchouan, W., Azang, E.D.O., Guehoda, Y., Factheu, C. and Nkingop Djopmou, H. (2017). Bird survey of Abobo-Etetak Hill (Yaounde, Cameroon) and a glance of the avifaunistic diversity of this hill (Abobo- Etetak). *Open Ornithol. J.* **10**, 31-41.
35. Olivry, J.C. (1986). Fleuves et rivières du Cameroun. *Monogr. Hydro. Mesres/Orstom* **9**, 1-733.
36. Centre ORSTOM de Yaoundé (1966). *Dictionnaire des villages de la Mefou*. Répertoire géographique du Cameroun. IRCAM, Yaoundé.
37. Parsons, H., Major, R.E. and French, K. (2006). Species interactions and habitat associations of birds inhabiting urban areas of Sydney, Australia. *Austral. Ecol.* **31**, 217-227.
38. Pearce-Higgins, J.W. and Murray, G. (2006). Relationships between bird abundance and the composition and structure of moorland vegetation. *Bird Study* **53**, 112-125.
39. Pearson, T.H. and Rosenberg, R. (1978). Macrobenthic succession in relation to organic enrichment and pollution of marine environment. *Oceanogr. Mar. Biol. Ann. Rev.* **16**, 229-311.
40. Rajpar, M.N. and Zakaria, M. (2011). Bird species abundance and their relationship with microclimate and habitat variables at natural wetland reserve, peninsular Malaysia. *Int. J. Zool.* 1-17.
41. Santoir, C. and Bopda, A. (2005). *Atlas régional Sud-Cameroun*. IRD Éditions, Bondy, France.
42. SAS Institute (1985). *SAS/STAT guide for personal computers*. Cary, NC; 6th Edition.
43. Sedlacek, O., Reif, J., Horak, D., Riegert, J., Pesata, M. and Klvana, P. (2007). The birds of a montane forest mosaic in Big Babanki area, Bamenda Highlands, Cameroon. *Malimbus* **29**, 89-100.
44. Sharpe, R.B. (1904). "On further Collections of Birds from the Efulen District of Cameroon, West Africa, Part II". *Ibis* **46**, 591-638.
45. Sharpe, R.B. (1908). "On further Collections of Birds from the Efulen District of Cameroon, West Africa, Part V & VI". *Ibis* **46**, 119.
46. Stuart, S.N. (1986). *Conservation of Cameroon montane forests*. Report of the International Council for Bird Preservation (ICBP), Cambridge, UK.
47. Suchel, J.B. (1987). *Les climats du Cameroun*. State Doctorate Thesis. University of Bordeaux III, France.
48. Svensson, L., Zetterstöm, D. and Mullaney, K. (2016). *Le Guide Ornithologique: le guide le plus complet des oiseaux d'Europe, d'Afrique du Nord et du Moyen-Orient N*. Édition Delachaux et Niestle, Paris, France.
49. Telleria, J.L. and Santos, T. (1994). Factors involved in the distribution of forest birds in the Iberian Peninsula. *Bird Study* **41**, 161-169.
50. Thebault, E. and Loreau, M. (2006). The relationship between biodiversity and ecosystem functioning in food webs. *Ecol. Res.* **21**, 17-25.
51. WWF (2010). *Certification and Roudtables: Do they work?* WWF review of multi-stakeholder sustainability initiatives. WWF review, September 2010. Gland, Switzerland.

