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Bird species richness and diversity at montane Important Bird Area (IBA) sites in south-eastern Nigeria

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Summary

The mountains of south-eastern Nigeria are a western extension of the Cameroon mountain range, which is classified as an endemic bird area (EBA). Unlike its eastern extension in Cameroon, most of the ornithological surveys in the western extension of the Cameroon highlands in Nigeria have produced only limited checklists and inventories. There is a clear need for quantitative baseline data so that conservation problems can be identified. Twenty line transects covering a total transect length of 28.8 km were used to survey five sites (Afi Mountain Wildlife Sanctuary, Oban Division and Okwangwo Division of Cross River National Park, Sankwala Mountains and Mbe Mountains) in the westernmost extension of the Cameroon Mountains EBA in south-eastern Nigeria. Vegetation measurements were taken to control for the potential confounding effect of variation in vegetation density and structure on detectability of birds between sites. The 193 bird species recorded in Afi, 158 in Sankwala, 124 in Oban, 100 in Mbe and 73 in Okwangwo Division included most of the Cameroon highlands restricted range species. The results show that the mountains of south-eastern Nigeria are important parts of the Cameroon EBA, particularly Afi Mountain Wildlife Sanctuary. However these sites are threatened by fire and livestock grazing on the hilltops, shifting agriculture on the hillsides and lowlands, and logging for timber in some parts, as well as wildlife hunting for bushmeat.

Introduction

There are over 1,230 Important Bird Areas (IBAs) in Africa which hold either globally threatened species, restricted-range species, biome-restricted assemblages or significant congregations (Fishpool and Evans 2001). Nigeria has 27 IBAs, of which several are clustered in the south-east as part of the Cameroon lowland and mountain Endemic Bird Areas (EBAs 085 & 086) which include 21 restricted range species (Fishpool and Evans 2001). The south-east Nigerian IBAs are important because they retain primary rainforest, but such habitats are under threat from anthropogenic degradation and are often under only limited effective protection (Buchanan *et al.* 2009).

The mountains of south-eastern Nigeria are a western extension of the Cameroon mountain range that rises to about 1,950 m asl. The mountains comprise a large area of montane grassland with numerous perennial streams flowing through valleys that support patches of relict montane forest as well as lowland rainforests. The mountains lie within the Lower Guinea forest, one of the world's great lowland rainforests. The high endemism of the area qualifies the Cameroon mountains as an endemic bird area (EBA) (Stattersfield *et al.* 1998). Within the region, the designated protected areas are Korup National Park in Cameroon and Cross River National Park and Afi Mountain Wildlife Sanctuary in Nigeria. Cross River National Park, comprising Oban Division and Okwangwo Division (Boshi, Boshi Extension), is protected by the Federal

Government of Nigeria. The Afi Mountain Wildlife Sanctuary (AMWS) is protected and managed by the Cross River State Forestry Commission. The Mbe Mountains forest is managed by the local community.

Unlike its eastern extension in Cameroon, most of the ornithological surveys in the western extension of the Cameroon highlands in Nigeria have produced only limited checklists and inventories (Ash and Sharland 1986, Ash 1990, Ash 1991, Elgood *et al.* 1994, Gartshore 2004, 2005). For example, although the Sankwala Mountains are contiguous with the Obudu Plateau, no mention is made in any ornithological literature of its significance (Borrow and Demey 2001, Elgood *et al.* 1994), although its importance as a primate refuge has been discussed (Oates *et al.* 2004). There is a clear need for quantitative baseline data so that conservation threats can be identified.

The aim of this work was to produce quantitative baseline data on abundance, species richness and diversity of the avifauna of the Afi Mountain Wildlife Sanctuary, Cross River National Park (Ekonganaku area), Sankwala Mountains and Mbe Mountains.

The study sites

The study sites were the mountain ranges that form part of the westernmost extension of the Cameroon Mountain EBAs (Stattersfield *et al.* 1998). Except for the Sankwala Mountains, all the other sites have been designated as IBAs (Ezealor 2001, 2002). The sites have been described in detail elsewhere (Oates *et al.* 2004).

Site 1 (6°18.302′N, 8°57.370′E) was the Afi Mountain Wildlife Sanctuary (AMWS), which covers a total area of 380 km², and is located at the headwaters of the Afi River in Northern Cross River State. The sanctuary is mountainous and rises to an altitude of *c.* 1,300 m.

Sites 2 and 3 were in the Cross River National Park (CRNP) which consists of Oban Division (3,000 km²) and Okwangwo Division (1000 km²). Surveys were carried out in the Ekanganako area of Oban Division (Site 2, 6°09.796′N, 8°41.284′E) and Boshi extension of Okwangwo Division (Site 3, 6°25.826′N, 9°19.284′E).

Site 4 (6°30.608′N, 9°17.258′E) was the Sankwala Mountains that reach to over 1,900 m asl. The mountains occur north of Cross River National Park and west of the Obudu Plateau. Lowland rainforest covers the lower slopes of the mountains while montane forest occurs on the slopes higher up. Montane grassland covers the tops of these mountains. The mountains drop sharply towards Obudu town into a woodland savanna.

Site 5 (6°15.273′N, 9°4.687′E) was the Mbe Mountains, a community-managed forest with a total area of about 100 km². It lies between Okwangwo Division of CRNP and AMWS and is also mountainous with an elevation reaching *c.* 900 m.

Methodology

Line transects

Line transects (Bibby *et al.* 2000) were carried out during the early morning (for 4 hrs, starting soon after dawn) in each site. The surveys took place between 12 January and 31 May 2005; data were collected in the same season to minimise seasonal and other effects. A total of 27 transects ranging between 600 and 1,800 m in length and covering a total length of 28.8 km were surveyed. Each transect was surveyed once: Afi Mountains (seven transects), Oban Division (seven transects), Okwangwo Division (five transects), Sankwala Mountains (three transects) and Mbe Mountains (five transects). Transects were placed along existing trails and tracks in the forest. The start and end times for each transect and the start and end times for each 200 m section were recorded. During each survey, SM and SI walked slowly along the transect listening, looking for and recording birds. Binoculars were used to confirm identification of birds

located by eye. The number of every bird species seen from the transect line was recorded, as well as the number of every species heard or flying over. Count information was recorded separately for each 200 m section of each transect.

Vegetation measurements

Vegetation measurements were taken to control for the potential confounding effect of variation in vegetation density and structure on detectability of birds between sites (Bibby *et al.* 2000, Buckland *et al.* 2008, Lee and Marsden 2008). Within each 200 m section of each transect, a 10 × 10 m quadrat was taken at random and vegetation variables in the quadrat were recorded to characterise variation in detectability across the study sites. The number of trees > 2 m tall within a 10 × 10 m area was recorded. Five 1 × 1m quadrats were then randomly selected from within the larger quadrat and the following measurements recorded from each: 1) the number of trees taller than 1 m that were saplings (1–10 cm dbh) and mature trees (>10 cm dbh); 2) circumference at breast height and visual estimates of the height (to the nearest 5 m) of mature trees (i.e. diameter > 10 cm); 3) the number of trees emerging from the canopy (emergents); 4) the number of woody climbing species; 5) the percentage of ground cover (to the nearest 5%), estimated by eye; 6) the percentage of visible sky estimated by viewing the sky through the canopy from the wrong end of a pair of binoculars (Jones *et al.* 1996).

Mean vegetation measurements for the five quadrats were then calculated for each 200 m section. Vegetation variables were highly correlated with each other in many cases: density of saplings and percentage sky visible ($r = -0.63$, $n = 144$, $P < 0.001$); density of saplings and percentage ground cover ($r = 0.47$, $n = 144$, $P < 0.001$); density of saplings and circumference at breast height ($r = 0.56$, $n = 123$, $P < 0.001$); density of saplings and density of trees ($r = -0.24$, $n = 144$, $P = 0.009$); density of trees and climber density ($r = -0.24$, $n = 144$, $P = 0.008$) density of trees and mean tree height ($r = 0.34$, $n = 144$, $P < 0.001$); density of trees and emergent density ($r = 0.23$, $n = 144$, $P = 0.005$. For this reason, a reduced subset of variables that were most representative of overall vegetation density was used in further analyses to simplify models, namely: density of trees, density of small saplings (small trees) and density of emergents. If all vegetation variables are included in the analyses the results remain broadly unchanged.

Data analysis

All species recorded were included in the analysis including non-forest, forest edge or other marginal species, as well as forest birds, both conspicuous and cryptic, because we are interested in overall avian species richness, and because classification of forest and non-forest or marginal species is at best subjective. The majority of species recorded were heard (83.1% of 2,440 records): Site 1 84.7%, Site 2 80.9%, Site 3 78.0%, Site 4 74.6% and Site 5 88.0%.

For each transect section, the total number of birds was calculated as: (number of birds seen) + (number of birds heard). The Shannon diversity index, H was calculated for each section of each transect for site as:

$$H = sum\ across\ all\ species\ of\ ((total\ abundance\ of\ species\ i)/(total\ abundance\ of\ all\ species) \times (ln(abundance\ of\ species\ i)/(total\ abundance\ of\ all\ species)))$$

The number of bird species detected increased with total transect length. We calculated the mean number of species seen in the first 200 m, the first 400 m, the first 600 m and so on for all transects at a site, to obtain a mean species accumulation curve across the transects for each site (mean aggregate transect length was 1,240 ± 64 SE, $n = 27$ transects). We used an 'asymptote analysis' to check whether sufficient transect effort had been carried out on average to record

most species at a site (Manu *et al.* 2007). In this we compared the number of new species added in the last quarter of the transect with the first three quarters. Asymptote values averaged 0.0125 ± 0.001 SE ($n = 5$ sites) showing that most species had been recorded by the end of the transect and that 1,000 m of transect is on average sufficient to record nearly all species present. Asymptote values were uncorrelated with altitude and the vegetation variables ($P > 0.10$). Nevertheless the probability of recording species was dependent on transect length so analyses used each 200 m transect section as a sampling unit to control for variable effort across sites.

We compared the rank abundance of species across sites graphically and by pairwise comparisons of the frequency distributions using one-way ANOVAs. We used Generalised Linear Mixed Models (GLMMs, McCulloch and Searle 2001) to investigate the variation in species number and diversity index (the dependent variables) with site: procedure GLIMMIX in GLIM for SAS, (SAS Institute Inc. 1996). Species number and diversity count were normally distributed (one-sample Kolmogorov-Smirnov test: $P = 0.998$, $n = 27$ and $P = 0.594$, $n = 27$ respectively) and so a normal error structure was used for models. The three vegetation variables - density of trees, density of small saplings (small trees) and density of emergents were also included as covariates in all models to control for any confounding effect of vegetation variation between sites, either on detectability or habitat quality. Altitude of a transect was included as a covariate in all models to control for any confounding effects of altitude. To control for any confounding effects of time of day on bird detectability, transect section (distance from the start of the transect) was included as a covariate as a surrogate for time of day because each 200 m of survey was carried out sequentially taking approximately the same time, and all transects were started just after dawn. All models are presented as conservative full models. Degrees of freedom vary across models because of small amounts of missing vegetation data. These analyses were all at the level of the transect section (i.e. total sample size equals the total number of 200 m transects walked ($n = 144$ with complete data) with site and transect specified in the model as random factors to control for the variable number of transect sections, and transects across sites.

Results

Species abundance and diversity across sites

In total, 193 bird species were recorded in Afi, 158 in Sankwala, 124 in Oban, 100 in Mbe and 73 in Okwangwo Division (Appendix 1: online supplementary material). Bird species abundance and diversity varied significantly between sites: most of the significant pairwise differences between sites were because Afi had particularly high diversity (Table 1, Figure 1). Site differences in species richness were still evident when controlling for the confounding effects of survey effort, altitude and vegetation characteristics: Okwangwo had particularly low species abundance and Afi particularly high species abundance (Table 2). Site differences in bird diversity were evident when controlling for the confounding effects of survey effort, altitude and vegetation characteristics. Okwangwo had particularly low diversity (Table 3).

Restricted range species

Most of the Cameroon highlands restricted range species that occur in Nigeria were recorded during this survey, but some of the elusive and rarer species may have been overlooked.

Cameroon Olive Pigeon *Columba sjostedti:* One individual was seen perched high up the canopy at Sankwala Mountains. There may have been more birds in the area but the closed canopy may have affected detectability once the birds were not singing. Flocks of 10 birds have been reported on the Obudu Plateau (Elgood *et al.* 1994 and SM pers. obs.).

Cameroon Montane Greenbul *Andropadus montanus:* Several pairs of this species were recorded on transects in Sankwala.

Table 1. A comparison of rank abundance of bird species between study sites using one-way ANOVA. (1) Afi Mountain, (2) Oban Division, (3) Okwangwo Division, (4) Sankwala Mountains, (5) Mbe Mountains. P values in bold are those that are significant after a sequential Bonferroni adjustment (K = 10) to account for the increased likelihood of a Type I error with multiple tests.

(I) site	(J) site	Mean Difference (I-J)	SE	*P*
1	2	−0.5	0.16	**0.021**
	3	−1.1	0.18	**<0.0001**
	4	−1.3	0.19	**<0.001**
	5	−0.6	0.16	**0.002**
2	3	−0.7	0.20	**0.041**
	4	−0.6	0.02	**0.02**
	5	−0.1	0.18	1
3	4	−0.1	0.22	1
	5	0.4	0.20	0.24
4	5	0.5	0.21	0.12

Western Mountain Greenbul *Andropadus tephrolaemus:* Several pairs were recorded on every transect at Sankwala and Afi Mountain. On 18 January 2005, one bird was seen with nest material on Afi Mountains. That this greenbul has not been recorded in Afi and Sankwala previously must be a consequence of the limited prior survey effort.

Cameroon Olive Greenbul *Phyllastrephus poensis:* A few pairs were recorded at Sankwala Mountains.

Grey-headed Greenbul *P. poliocephalus:* A flock of four birds was recorded at Mary's Camp in Boshi Extension. Many more were recorded at Sankwala Mountains.

Crossley's Ground Thrush *Zoothera crossleyi:* Several birds were heard near Mary's Camp and Sankwala Mountains.

Bangwa Forest Warbler *Bradypterus bangwaensis:* Recorded in Okwangwo in January 1997 (SM pers.obs.) and Sankwala during this study.

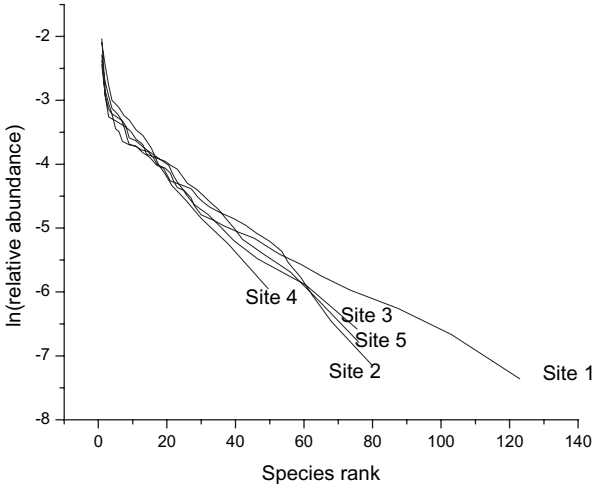

Figure 1. Graph of Rank abundance of bird species. (1) Afi Mountain, (2) Oban Division, (3) Okwangwo Division, (4) Sankwala Mountains, (5) Mbe Mountains. Lines with long slowly descending tails indicate more diverse sites – therefore Site 1 is the most diverse site.

Table 2. Differences in the number of bird species at the five survey sites controlling for the confounding effects of altitude, survey effort and vegetation characteristics. (1) Afi Mountain, (2) Oban Division, (3) Okwangwo Division, (4) Sankwala Mountains, (5) Mbe Mountains. Parameter estimates are the gradients of the lines relating covariates with the dependent variable, or the mean difference between sites relative to the overall mean for Site 5.

Effect	Parameter estimates	SE	df	*t*	*P*
Intercept	3.40	0.31	32.4	10.7	<0.0001
Site 1	0.14	0.17	35.6	0.7	0.43
Site 2	−0.16	0.27	22.6	−0.6	0.55
Site 3	−0.75	0.21	52.1	−3.4	0.001
Site 4	−0.24	0.20	22.7	−1.1	0.24
Site 5	0	—	—	—	—
Transect section	−0.00043	0.00010	107	−4.3	<0.0001
Altitude (m)	0.000036	0.00015	13.6	0.2	0.82
Tree density	−0.047	0.023	112	−2.0	0.045
Density of emergents	0.0021	0.081	114	0.03	0.91
Density of small trees	−0.013	0.12	113	−0.1	0.91

Chubb's Cisticola *Cisticola chubbi:* Several pairs were seen and heard on the way to Mary's Camp, Boshi Extension as well as Afi Mountain and the montane grassland on Afi Mountain.

Green Longtail *Urolais epichlora:* A few birds were heard near Mary's Camp and at Sankwala Mountains.

Black-capped Woodland Warbler *Phylloscopus herberti:* A few birds were recorded on transects at Sankwala Mountains. The bird may have been overlooked especially in dense canopy when not singing.

Red-headed Rockfowl *Picathartes oreas:* Two colonies each were seen at Afi and Mbe Mountains. One of the colonies at Afi had one old nest that was probably used in the previous breeding season. The other colony had five old nests that were probably used earlier than the previous breeding season. There was evidence of an old hunter camp which may have disturbed the birds. The colonies at Mbe had eight and six nests respectively. There were feathers of the birds in the vicinity of the nests. This probably means that the birds were using the colonies for roosting.

White-throated Mountain Babbler *Kupeornis gilberti:* Flocks of 5–10 birds were seen at Sankwala Mountains.

Table 3. Differences in the diversity of bird species at the five survey sites, controlling for the confounding effects of altitude, survey effort and vegetation characteristics. (1) Afi Mountain, (2) Oban Division, (3) Okwangwo Division, (4) Sankwala Mountains, (5) Mbe Mountains. Parameter estimates are the gradients of the lines relating covariates with the dependent variable, or the mean difference between sites relative to the overall mean for Site 5.

Effect	Parameter estimates	SE	df	*t*	*P*
Intercept	1.21	0.11	113	10.5	<0.0001
Site 1	−0.0086	0.063	113	−0.1	0.89
Site 2	−0.097	0.094	113	−1.0	0.30
Site 3	−0.38	0.062	113	−6.1	<0.0001
Site 4	−0.12	0.65	113	−1.9	0.053
Site 5	0	—	—	—	—
Transect section	−0.00018	0.000042	113	−4.4	<0.0001
Altitude (m)	−0.0000061	0.000052	113	0.1	0.90
Tree density	−0.017	0.0092	113	−1.9	0.054
Density of emergents	−0.023	0.029	113	−0.8	0.42
Density of small trees	−0.010	0.049	113	−0.2	0.83

Cameroon Blue-headed Sunbird *Nectarinia oritis:* Several seen at Sankwala Mountains.

Yellow-breasted Boubou *Laniarius atroflavus:* Several birds encountered on Afi and Sankwala Mountains.

Green-breasted Bush-Shrike *Malaconotus gladiator:* One bird was called in with playback at Mary's Camp during this survey.

Rachel's Malimbe *Malimbus racheliae:* Five birds were observed in mixed-species bird parties near the base camp at Ekang Nako. There have been previous records of these malimbes in the Oban sector near Akin where a flock of 10 was recorded in a mixed species flock (Ash *et al.* 1989 and SM pers. obs.).

Discussion

Bird species richness was particularly high at the Afi Mountain Wildlife Sanctuary, whereas the Boshi extension of Okwangwo Division had relatively low species richness and diversity. Although bird species richness has been reported to be lowest at high altitudes (Armstrong and van Hensbergen 1997), in our study this variation was not particularly important as we covered only a relatively narrow altitudinal range.

The ornithological importance of the survey sites cannot be overemphasised. Most impressive of these sites was Sankwala Mountains which holds some Cameroon highland endemics. No reference has been made to this range of mountains in the literature about the Cameroon highland endemics and threatened species; reference has always been made to Obudu Plateau (Elgood *et al.* 1994, Borrow and Demey 2001). The diverse habitat in Sankwala is probably responsible for the occurrence of range restricted species and species that are near threatened in both the lowland forests and the montane vegetation. For example, the Yellow-casqued Hornbill *Ceratogymna elata* was recorded in Oban Division and Afi Mountain Wildlife Sanctuary probably because of the high density of emergent trees in these reserves. This further adds to the ornithological significance of the entire range.

Prior checklists of birds in the study area are hardly exhaustive. The Grey-throated Rail *Canirallus oculeus* was thought to be extinct in Nigeria (Elgood *et al.* 1994) but our sighting in the Oban Division suggests that the area is likely to hold other bird species yet unrecorded: for example, the Mount Kupe Bush-shrike *Malaconotus kupeensis* has recently been recorded on the Sankwala Mountains (Gartshore 2005). Although bird species like the rockfowl were not sighted during the study, their colonies, feathers and droppings in some of these colonies was evidence of their continuing presence in both Afi and Mbe Mountains, where these birds had previously been recorded as breeding (Ash 1991). Suitable habitat exists on Sankwala Mountains and the birds may be present there as well.

Conclusion

This study has shown that the biodiversity significance of the study sites is considerable. However, at all sites we observed threats from fire and livestock grazing at high altitudes and in the valleys. Slash and burn agriculture is common on the hillsides and lowlands. Logging for timber in some parts is common as well as wildlife hunting for bush meat.

Action should be taken to reduce the threats of habitat destruction in the area. This could be achieved by updating the EBAs in Nigeria to include Sankwala Mountains. The Cross River State Forestry Commission should initiate action towards active protection of the entire range of the Sankwala Mountains. More detailed surveys of each of these areas at different times of the year should be made in order to make the checklist as complete as possible. A specific nest search for the rockfowl should be carried out on Sankwala Mountains. Regular surveys should be carried out here from time to time in order to monitor any changes in these range-restricted species.

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