



ALTITUDINAL VARIATION: WHAT FUTURE FOR BIODIVERSITY CONSERVATION?

Environmental Science

Dr. Oka, Peter Onen

Department of Geography and Environmental Science (Biogeography and Biodiversity conservation) University of Calabar, Calabar, Nigeria.

ABSTRACT

The importance of understanding altitudinal variation in biodiversity protection has witness less patronage in sub-Sahara Africa. The physiognomy of Okwangwo Range, Cross River National Park, Nigeria is highly variable; rich in plants and animals. This study evaluates the influence of altitudinal variation on wildlife with focus on avifauna. Three distinct elevation zones were delineated: low, mid and high elevation. Time-species count method was used in obtaining data on bird species. The study employed analysis of variance (ANOVA) to analyze the differences in bird richness along the low, mid high altitudes. Result obtained show that the calculated-F value (10.19) is greater than the critical-F value (3.35) at 0.05 significant levels. This implies that there is a significant difference in bird species richness along the altitudinal zones of the study area. The observed percentage representation of exclusiveness of bird species richness along the altitudes in the study area was in the following order: exclusive to low altitude only, 3.33 per cent; exclusive to mid altitude only, 5.24 per cent; and exclusive to high altitude only, 36.19 per cent. Also, exclusive to both high and mid altitudes only, 9.05 per cent; exclusive to both mid and low altitudes only, 25.24 per cent; exclusive to both high and low altitudes, 0.95 per cent; and exclusive to high, mid, and low altitudes together, 20 00 per cent. This suggests important conservation implication: the entire range need equal conservation attention.

KEYWORDS

Avifauna, Richness, Sub-Sahara Africa, Exclusiveness, Conservation,

INTRODUCTION

The altitudinal setting of the sub-Sahara Africa and its significance for present day faunal distribution is very important. Africa has very few endemic avian taxa above species level and species richness low that need continuous update for conservation planning. Bird species compositions and distribution in montane ecosystem is determine by physical and biological factors such as elevation, prevailing winds, slope, precipitation, humidity, and plant richness (Poulsen, 2002). Until the importance of these factors is correctly appropriated first individually and secondly collectively the gap on conservation will continue to grow wide. Physical factors have a predominant effect on the higher altitude biological factors are often seen as the predominantly processes affecting diversity and distribution in the lower altitude. A crucial but often very difficult task was to understand the natural functioning of the montane ecosystem under any study and its interrelationships with neighbouring systems. There was attempt to understand the functioning of the altitudinal gradients, as important drivers at different scales.

It is important that the relationship between elevation variables and avian community structures was in order to provide efficient landscape management and protection.

Different drivers can create changes in species richness and species composition. This is noticed particularly along altitudes in montane ecosystems. Nöske, Hilt, Werner, Brehm, Fiedler, Sipman and Gradstein (2008), observe that different factors such as height of trees and altitude may influence changes of species composition among plants and moth taxa. Increased species turnover have occurred within elevation zones with no significant elevational changes. Thus, bird species composition differed significantly between defined habitat types. It became obvious that elevation changes of bird assemblage indicated that community parameters responded largely independently to changing elevation. These imply further that difference in occurrence of bird species may be less prominent at group levels when inventories taken are based on altitudinal zones. On this premise, Rahbek (1995) observed a monotypic decline in species number with increased elevation.

Brown and Gibson (1983) observed that the association between plants and animals, create a dome-shaped curve when defined in relationship with increase in elevation; with a mid-elevation peak of bird species richness (Able and Noon, 2007). These distributions are so bound up with local phenomena that it is difficult to make general statements, especially as the boundaries between lowland and highland vegetation vary greatly from one part of the world to another in response to latitude and climate. The relationship between birds and trees frequently vary with one floristic province from one mountain range to the next and even between slopes of the same mountain;

decline and latter disappearance of certain lowland floristic elements. Oka (2014) observed that tree height, crown stratification and lianas that birds rely on are not well developed in highland compare with lowland in the same region. Hence, within the same range, elevation effect will lead to the lowland forest losing its physiognomic and floristic characteristic at high altitude. This change will lead to greater changes in avian composition and richness. Orian (1969) has observe that species richness of birds decreases enormously at altitudes above 1,000m; largely affected are insectivorous species with substantial decline in all feeding types of bird community.

Bird species activities, such as feeding and breeding, caused artificial hump in the species-elevation curve. Grytnes and Vetaas (2002) observed interpolated species presence between the highest and lowest altitude and concluded can cause an artificial lump in the species-elevation curve. Beside the sole type decline of the number and variety of bird with increased altitude, changes in the number and variety of bird are unique in ecotones between different ecosystems such as mixed forest and woodlands. Able and Noon (2007) have used such evidence to explain the importance of transition zones for upland distribution of birds. Hence, areal meshed distribution of different among different ecosystems at transition zones will result to an upward overlap of bird richness. The result will amount to a deviation from the awaited pattern when only altitude is taken into account higher and lower the transition zone. The explanation by Grytnes and Vetaas (2002), Able and Noon (2007) did not account for the effects of spatial scale on emerging pattern of species richness.

Rahbek (2005) on the other hand concentrated on the influence of spatial scale on emerging pattern of species richness. An earlier emphasis had been that this could cause methodological problem (Rahbek 1995) and this imply that a different result will be obtained when comparisons of altitude patterns of species richness do not consider the effect of sampling effort and area on species richness. Rahbek (1995, 1997) concluded that failure to standardize data to account for sampling effort and area could cause artificial results. To overcome this bias Rahbek devised series of indices largely devoid of sampling biases on the elevation distribution of Neotropical land birds.

Many bird species are restricted to particular habitats on montane ecosystem. Where the montane ecosystems are isolated, they act like island in a sea of lowlands and the montane birds are restricted to small areas. This may result in one particular species existing in only small number and being sensitive to changes in this habitat.

The aim of this research is to evaluate the influence altitude on avian community distribution in Okwangwo Range, Cross River National Park with the view of proffering suggestion to the conservation of montane bird communities.

OBJECTIVES

The objectives are to:

1. To identify the birds and the distribution pattern of bird species richness in the study area, and
2. To examine bird species richness along the three classes of altitudes in the study area.

The following research hypothesis guided this study:

H₀: There is no significant difference in bird species richness pattern in the low, mid, and high altitudes of the study area.

SCOPE AND SIGNIFICANCE OF STUDY

The scope of this research is restricted to Okwangwo Range of Cross River National Park due to its high degree of naturalness, less anthropogenic activity, and the availability of appropriate environmental data needed for this research. The study focused on conspicuous and vocal bird species and areas previously mapped as having natural ecosystems. This research will bring to focus understanding of the distribution pattern and the influence of altitude on bird richness in the study area and create the platform for effective planning, management and conservation of the avian community of Okwangwo Range.

STUDY AREA

Okwangwo range is one of the two components of Cross River National Park, Nigeria. It lies South-East of Obudu with the eastern boundary extending along the Nigeria-Cameroon boundary; between longitudes 9°0' - 9°27' E and latitudes 6°4' - 6°29' N (Fig 1a), with an area of about 920Km² representing about 32.48 per cent of Cross River National Park (Natural Resource Institute, 1990; Economic map of CRS resources, 2008).

The predominantly crystalline basement complex in Okwangwo is composed of rocks of high metamorphic grade. The occurrence of iron oxide in the region gives the soil a reddish colour characteristic of highly drained subtropical soil; a red gravelly and sand soil derived from acid crystalline rocks (Ofomata, 1975; Obot & Barker, 1996). Soils in the lowland are highly leached ferrallitic soils while the highlands are generally ferruginous soils.

The topography is hilly and rugged with many disjointed and connecting ridge systems; isolated peaks and rock out-crop (Igbozurike, 1975; Obot & Barker, 1996) with elevations of 150m, rising to about 1500m in Sankwala highlands and to peaks of up to 1700m at Obudu Plateau (Fig 1b). Elevational variations distributed across Okwangwo Range are powerful test system for understanding biodiversity. Three main rivers; Oyi, Bemi, and Okorn, drain the park area. Oyi River is fed by Anyukwo River, which drains Obudu plateau at the Northern extremities of the park around Ochakwe, together with Mache, Asache and Magbe rivers that drain the eastern boundary of the park around Balegete. The Bemi drains the Boshi area of the park and flows south along its western boundary to join Okon River, which collects further drainage from Mbe highland before it crosses into the Cameroon.

The microclimate in Okwangwo is highly influenced by relief and is characterized by alternating dry and wet seasons. The mean annual temperature ranges between 25°C and 28°C. The daily temperature range is between 14°C and 25°C with a daily minima range of 14°C to 16°C and 18°C to 25°C daily maxima on the highland areas of Obudu Plateau and Sankwala Mountains. Annual rainfall varies between 2,500mm - 3,500mm, distributed unevenly between March and November (Obot & Barker, 1996).

The richness of plant families in Okwangwo Range of the Cross River National Park is a driving factor that has listed the area as an important site to study the impact that elevational gradients have on biological diversity. The Okwangwo Range is rich in different families of mammals, reptiles, insects, amphibians and birds (Obot & Barker, 1996). It is classified as an Important Bird Area (IBA) based on the premise that the area is known to hold a significant component of the group of species whose distribution are largely or wholly confined to this biome (Obot & Barker 1996). The plants and birds that transverse in all direction of the Range is among the richest forest reserves in southeastern Nigeria in plants and animals communities.

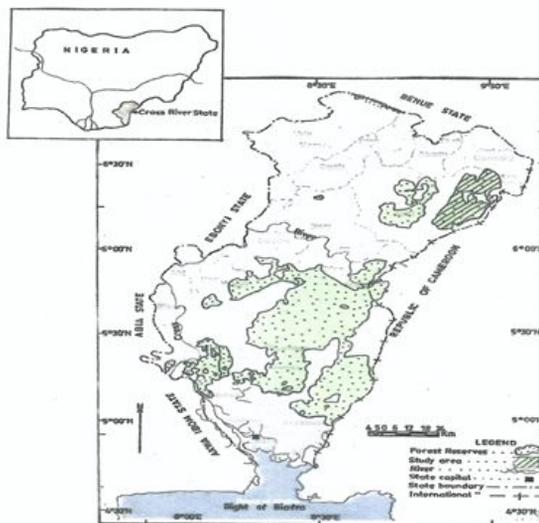


FIG 1a: Cross River State showing Okwangwo Range, Cross River National Park

Source: Researcher's fieldwork, 2016.

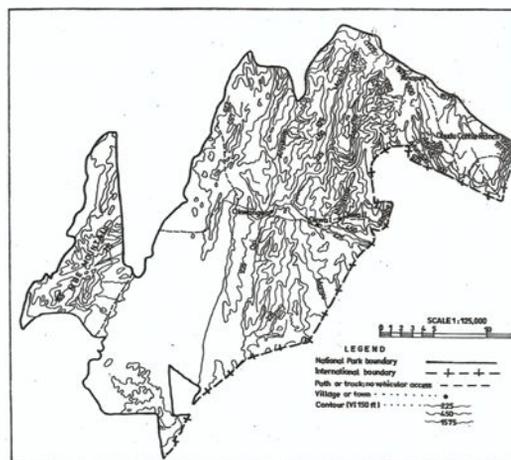


FIG 1b: Physiographic map of Okwangwo Range, Cross River National Park

Source: National Resource Institute, 1990.

METHOD OF STUDY

The altitudes and bearing of the central position of each sampled site was recorded using global positioning system (GPS) device. The altitudes and bearing of the central position of each sampled site was recorded using global positioning system (GPS) device. Hence, three distinct elevation zones immersed: 122-549m range for low altitude comprising of the Bemi block; 549m-1,402m range for mid altitude comprising of Okwangwo/Okwa block and Mbe mountain block; and above 1,402m range for high altitude comprising of Cattle Ranch and Buabre blocks.

The study employed the analysis of variance (ANOVA) to analyze the differences in the richness of bird species along the low-, mid-, and high-altitudes in the study area. This technique guided the study to make comparisons between pairs and combination of groups. Since altitude was the only variable by which the Okwangwo Range, CRNP was grouped, the approach of one-way ANOVA allowed individual observation to be spread into three components related to the grand mean, the group which the individual belong and the individual observation itself. The difference in mean value is significant at .05 levels. Thus,

$$\text{Total sum of square} = \frac{(\sum x^2) - \frac{(G)^2}{\sum N}}$$

Between sample squares

$$= \frac{(\sum x_1^2)}{N_{x_1}} + \frac{(\sum x_2^2)}{N_{x_2}} + \frac{(\sum x_3^2)}{N_{x_3}} - \frac{(G)^2}{N_x}$$

(Where, N = number of sites, X¹ = bird species richness in the low elevation range, X² = bird species richness in the mid elevation range, X³ = bird species richness in the high elevation range and G = sum of species observed in the study area)

DATA PRESENTATION AND DISCUSSION OF FINDINGS

Bird species richness decreased with increased altitude in the study area. Hence, species number declined with increasing elevation in sites with similar characteristics. The highest number of bird species, 79, was recorded at an altitude of 128m and the lowest, four, was recorded at an altitude of 1,718m. Thus, the number of species observed at a single site varied from four to 79 bird species. The summary of the different species recorded at different elevations as TABLE 5 indicates.

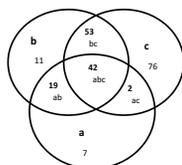
TABLE 1
Altitudinal distribution of birds in Okwangwo Range

LOW ALTITUDE 122m --- 549m		MID ALTITUDE Above 549m --- 1,402m		HIGH ALTITUDE Above 1,402m --- 1,829m	
Elevation	Bird Species	Elevation	Bird Species	Elevation	Bird Species
201	57	669	60	1500	18
189	51	675	55	1517	45
143	37	596	46	1629	17
154	51	614	30	1548	29
189	77	661	27	1667	33
185	36	682	50	1718	4
187	60	579	56	1699	6
196	50	850	45	1698	11
203	54	678	24	1686	8
128	79	832	21	1575	10

SOURCE: Researcher's fieldwork analysis, 2016.

Bemi block recorded 174 bird species (82.38 per cent), the highest bird richness 79, was at Transect T₁₀, 9°09'12"E, 6°13'25"N (bearing at midpoint of transect) at an elevation of 128m. At Okwangwo/Okwa block, 122 bird species (58.10 per cent) were observed. The highest bird richness, 60 was at Transect T₁₁, 9°03'44"E, 6°14'25"N (bearing at midpoint of transect) with an elevation of 669m, and at Mbe mountain 77 bird species (36.67 per cent) were observed; the highest bird richness, 56, at Transect, T₇, 9°19'01"E, 6°22'21"N at an elevation 572m. At Cattle Ranch lock, 62 bird species (29.52 per cent) were observed; the highest bird richness, 45, at Transect T₂₃, 9°23'37"E, 6°20'49"N at elevation 1517m. At Buabre block, 43 bird species (20.48 per cent) were observed; the highest bird richness, 33 at Transect T₂₅, 9°20'09"E, 6°24'48"N at elevation 1,667m.

At the low altitude range (122m - 549m above sea level), 174 species were recorded, the highest number, 79, was observed at an elevation of 128m above sea level (a.s.l.) as against the lowest, 36, at 185m a.s.l. At the mid altitude (549 - 1,402m a.s.l.) 124 bird species were recorded; the highest species number, 60, was observed at the site located 669m a.s.l. and the lowest, 21, at 832m a.s.l. At the high altitude range (above 1,402m a.s.l.) 71 species were recorded with the highest number of bird species, 45, recorded at 1,517m a.s.l. and the lowest, 4, at 1,718m a.s.l. The observed percentage representation of exclusiveness of bird species richness along the altitudes in the study area was in the following order: exclusive to low altitude only, 3.33 per cent; exclusive to mid altitude only, 5.24 per cent; and exclusive to high altitude only, 36.19 per cent. Also, exclusive to both high and mid altitudes only, 9.05 per cent; exclusive to both mid and low altitudes only, 25.24 per cent; exclusive to both high and low altitudes, 0.95 per cent; and exclusive to high, mid, and low altitudes together, 20.00 % (FIG 2).



Key:

- a === bird species exclusive to high altitudes = 7
- b === bird species exclusive to mid altitudes = 11
- c === bird species exclusive to low altitudes = 76
- ab === bird species common to high and mid altitudes = 19
- bc === bird species common to mid and low altitudes = 53
- ac === bird species common to high and low altitudes = 2
- abc === bird species common to all altitude ranges = 42

FIG 2: Venn diagram model illustrating exclusiveness of bird species at different elevation range.

SOURCE: Researcher's fieldwork analysis, 2016.

Bird distribution pattern along elevational gradients in the study area exhibited the highest species richness at low altitude with increasing elevation. However, a different pattern of species richness was found, resembling an asymmetrical hump-shaped curve that slowly increased, then decreased more quickly within the altitude ranges at mid and high elevations. Factors including sampling, area effect, temperature, water, evolution history, human disturbances and their combinations, impact avian species richness distribution patterns (McCain 2007). The relatively short span of elevational gradient of bird species in this study was particularly sensitive to the effects of sampling regime. Increased species richness at 128m was likely a product of higher foliage height, more heterogeneous habitat, and complex topography in this study. Sites at approximately 128m-203m exhibited the highest tree species richness, with numerous old and tall trees with large buttresses and a great variety of epiphytes. Hence, a more-diverse physical and biotic habitat promotes greater number of species richness along the elevation of the study area (Fig 3).

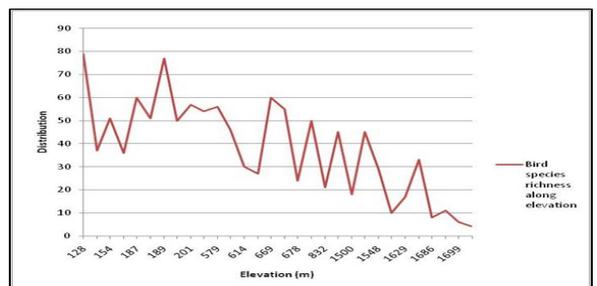


FIG 3: Bird species patterns along elevation gradient, Okwangwo Range, CRNP

SOURCE: Researcher's fieldwork analysis, 2016.

The summary of the distribution of the bird species along the different elevations in the study area is shown as mean and sum of square of the distribution of bird species in the lower (55.2 and 32,302), mid (41.4 and 19,048) and high (18.1 and 4,905). The three separate samples of the lower, mid and high altitude bird species are obtained to evaluate the mean differences among the three populations with unknown means. The purpose is to determine whether elevation affects bird richness in the study area.

Testing of hypothesis 1:

- H₀: There is no significant difference in the bird species richness in the low-, mid-, and high- altitudes of Okwangwo Division, Cross River National Park.
- H₁: There is significant difference in the bird species richness in the low-, mid-, and high- altitudes of Okwangwo Division, Cross River National Park.

The results presented in TABLE 2 indicated that the calculated -F value of 10.19 is greater than the critical -F value of 3.35 at 0.05 significant level. Hence, H₀ is rejected and H₁ accepted. Thus, there is a significant difference in bird species richness in the low-, mid-, and high- altitudes of the study area. The analysis of variance revealed a significant difference, F_(2, 27) = 10.19, p = .05, η² = 0.43. The result showed that the bird species richness in Okwangwo Range, CRNP inversely correlated with elevation, with an r-value of -0.772 exhibiting the highest bird species richness (79) at low elevations and decreasing bird richness (4) with increasing elevation. Four patterns that show individual bird species community along altitude ranges (McCain and Grytnes 2010) was identified in this study.

So far, altitudinal distribution of bird species have been discussed more as side issues in temperate regions (Steiner and Kohler, 2003). These distributions are so bound up with local phenomena that it is difficult to make general statements, especially as the boundaries between low and high elevation vary greatly from one part of the world to another in response to continental climate and latitude. They frequently vary within one floristic provision from one range to the next and even between two slopes of the same range. It is however possible to trace the major outlines of such distributions.

Between 1,500m and 1,575m, there is a decline and later a disappearance of certain low elevation floristic elements. High and mid elevation forests differ from low elevation forests in the reduced tree height, less obvious crown stratification, epiphytic plants, mosses and lichens abundance on the forest floor. Generally speaking and allowing for the mass elevation effect already mentioned, the low elevation loses its physiognomic and floristic characteristics at an altitude of 1,000m where it changes. This minor change in floristic characteristics causes greater changes in bird species composition. Thus the capability of low elevation range to produce materials throughout the year in a wide variety of forms such as fruits, flowers and other materials used for nest building, allows bird species dependent upon these to survive without migration. This accounts for high observation of bird diversity at low elevation range.

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TABLE 2 Analysis of variance of change pattern of bird species richness along the altitudes of the study area.

Anova: Single factor						
Summary						
Groups	Site Count	Bird Sum	Average			
Low altitude	10	552	55.2			
Mid altitude	10	414	41.4			
High altitude	10	181	18.1			
ANOVA						
Source of variation	Sum of squares	df	Variance Estimate	F-ratio	P-value	F-critical
Between Groups	38,228.13	2	19,114.07	10.19	0.05	3.35
Within Groups	50,629.50	27	1,875.17			
Total	88,857.63	29				

SOURCE: Researcher's fieldwork, 2016.

Elevation pattern among bird communities identified by McCain (2007) include mid altitude peak, low altitude that has a mid altitude peak, low plateau common at the low altitude and a decreasing pattern from the base to the summit of a mountain. When the elevation pattern exhibited takes the form of unimodal peak at the center than at the base and top on quantifiable definitions, it is amid altitude peak pattern. In a situation, that high richness occurs across low elevations and a high diversity obtained at the base such pattern is referred to as low plateau with mid altitude. In addition, a pattern that has consistent high richness over the low portion of the elevation pattern and thereafter decrease in species richness forms the low plateau pattern. Further, when the number of species decline in one direction from the low altitude to the peak, this is a decreasing pattern formation. According to McCain and Grytnes (2010) the observed patterns that species show along different elevations is a reflection of the relationships between plants and animals and their environment. Higher mountains generally have smaller land areas, are more isolated and have simple vegetation structures. Bemini and Buabre blocks in this study showed the highest and lowest richness of bird species respectively.

The transition between bird communities' distribution patterns along the elevation gradient in Okwangwo Division of Cross River National

Park (CRNP) manifested as gradual blending across the study area but with few abrupt transition between low and high elevation. Black Cuckoo (*Cuculus clamosus*) appeared at the low (128m) and high (1,517m) altitudes but none at the mid altitude. The *Cuculus clamosus* (Plate 9) has a life span of between 6-8 years, during which they migrates from the low altitude to the high altitude for three reasons: (1) change of diet (2) nest parasitism, and (3) temperature that sustains its fluffy plumage at older age. *Cuculus clamosus* at older age feed on insects almost to the exclusion of other foods in the younger arboreal species; feed on younger and hairy caterpillars, generally rejected by most insectivores. *Cuculus clamosus* show greater diversity in its breeding than any other bird in the Cuculidae family. The most striking adaptation of the *Cuculus clamosus*, is the nest parasitism; in which the eggs are laid in the nest of other birds species, which alone care for and feed the growing nestlings. They bear remarkable resemblance to their host. This is peculiar to the high altitude *Cuculus clamosus*, also known as the non-parasitic cuckoo because they show considerable diversity: construct its nest with twigs in trees and bushes, lay pale blue eggs and both parents take part in the incubation and other birds in the group assist. The fluffy plumage of old age off the body of the bird, for the reason they move where the temperature is favourable (21-24°C). A low-elevation maximum bird species turnover coincided with the formation of a low-elevation peak in species richness and abundance. The fundamental cause of the distributions of birds in the low-elevation species peak can either be the overlap of species ranges or the fact that the low elevations have many unique species.

CONCLUSION

Results showed that the diversity index of the study area varied with different elevations; low 0.006 – 0.059; mid 0.012 – 0.089; high 0.026 – 0.110. The diversity of all birds varied across the gradients. In a total count of 1,147 birds, 209 species were encountered; seven species were exclusive at high altitude, 11 to mid altitude and 76 at low altitude. Most of the low altitude species gradually dropped out along the gradients as the sites became scantier of woody plants.

Okwangwo Range of CRNP hosted exclusive species at the low, mid and high elevations ranges. These species and the environmental conditions that support them now clearly merit increase conservation concern. It should be a key management strategy to ensure that existing blocks of montane environment are protected from disturbance and inappropriate tourist infrastructure. The disparity between the species exclusive to the mid elevation and low elevation is quite high. This suggests important conservation implication; sampled sites in the study should be conserved and the entire range should be given equal conservation attention.

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