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The Effects of Forest Land Use Types and Fragmentation on Two Endemic Bird Species (Cameroon Montane Greenbul *Andropadus montanus* and Yellow-Breasted Boubou *Laniarius atroflavus*) on the Obudu Plateau, South-Eastern Nigeria

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Abstract
The Obudu Plateau is the most important single site in Nigeria for globally threatened bird species and has continued to be degraded causing declines in the populations of endemic birds. This study examined how forest land use types and fragmentation through changes in forest patch size and isolation distances between the patches affect endemic bird species. Birds heard or seen, and their distances were recorded from points laid 100 metres apart in forest patches that varied from less disturbed, completely protected, partially protected, patches with houses and farms inside, and patches degraded by nomadic activity. There was significant difference in the densities of Cameroon Montane Greenbul in the different forest patch categories: the greenbuls were more common in protected patches than unprotected patches. There was no significant difference in the densities of Yellow-breasted Boubou in the forest patches. Patch size had a significant positive effect on the densities of Cameroon Montane Greenbul and was not significant for Yellow-breasted Boubou. Isolation distance had no significant effect on the density of Cameroon Montane Greenbul but had Yellow-breasted Boubou. Forest patches with partial protection should be fully protected and there should be environmental education on the need to adequately protect those forest patches that are already designated as reserves.

Key words: Forest fragmentation, Endemic bird species, Obudu Plateau, Forest land use.

Introduction

Many of the world's forests are under threat. Despite all the national and international efforts, the annual loss of forest during the last decades amounted to approximately 15 million hectares worldwide [1]. Annual loss of forest area between 2000 and 2005 was 7.3 million hectares per year, an area about the size of Sierra Leone or Panama [2]. Forest loss exposes the remaining forest to the process of fragmentation.

Fragmentation is the process of sub-dividing a continuous suitable habitat into smaller patches thereby altering its original configuration [3, 4]. Fragmentation is the most important threat to forested ecosystems [5] and can occur naturally through fire [6] and windfall [7] but the most important and large-scale cause is the expansion of human land use [8]. Habitat fragmentation has been implicated as a primary factor in the loss of bird species [9] but there are species that can persist in a matrix of fragments, secondary undergrowth and large forest patches. The level of connectivity between fragmented forest patches has a strong influence on the population dynamics of species residing in these areas [10].

The two important consequences of fragmentation are a reduction in total size of the habitat available and the breaking up of the remaining habitat into patches that are isolated to varying degrees [9], thereby increasing the vulnerability of biota to environmental and demographic threats [9, 11-14]. Reduction in habitat leads to species loss [13, 15, 16] and montane species are disproportionately threatened because they tend to occupy smaller areas initially compared to the lowland forest [17]. Isolation of forest patches disrupts distribution patterns

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of species and forces individuals to transverse sub-optimal matrix habitat (which might be a threat) between suitable habitat patches, leading to local extinction of bird species [18-20].

The Obudu Plateau is the most important single site in Nigeria for globally threatened and endemic bird species [21]. Anthropogenic activities have fragmented this area, resulting in a mosaic landscape containing some patches of high quality forest, dominated by forest species such as *Andropogon distachyos*, various *Ficus* species, *Polyscias fulva*, and the tree fern *Cyathea manniana* with a humidity that promotes a rich vegetation of epiphytes on trunks of trees [22]. The Obudu Plateau is one of the most important single sites in Nigeria for globally-threatened bird species e.g., the White-throated Mountain Babbler *Kupeornis gilberti*, Bannerman's Weaver *Ploceus bannermani* and Green-breasted Bush-shrike *Malaconotus gladiator*. The Obudu Plateau forms part of the Cameroon Mountain Endemic Bird Area which has continued to be degraded causing declines in the populations of these threatened bird species.

This paper describes how fragmentation (particularly patch size and isolation distance) and forest land use affect the density and distribution of two endemic bird species on the Obudu Plateau. This is the first study to assess the effects of fragmentation and land use of montane forest on the endemic birds of the Obudu Plateau, Southeastern Nigeria.

Materials and Method

Study Area

The Obudu Plateau (6°30′N 9°15′E) is an afro-montane region with an area of 720 ha situated in Cross River State, southeastern Nigeria, close to the border with Cameroon. The Plateau is part of the Cameroon Mountain Endemic Bird Area (EBA) and is an Important Bird Area (IBA). The area is wet, mountainous and consists of vast areas of montane grasslands covering valleys and hills that supply patches of relict mountain forests with water [23].

Field Study

A preliminary survey was conducted between April and June 2005 to get familiar with bird species of the Obudu Plateau and to identify the various forest patches on the Plateau and identify categories of forest. Forest patch categories were identified based on their level of protection and type of human impact on the forest patch such as farming, grazing and human habitation (Table 1). All 31 forest patches were given codes and their actual sizes and locations determined by walking round each forest patch using the track log of the Garmin Global Positioning System (GPS Map 60).

Point transects were used in this study because the terrain at Obudu Plateau is rugged with undulating hills and thick secondary growth that made access difficult. Using the Map source programme, points were laid out systematically to cover the forest interior, forest edge and surrounding grass-lands. Points were laid at least 100m apart. Points were downloaded to the GPS so that they could be identified in the field during survey and the forest patches, their categories and number of points are as shown in Table 1.

Table 1: Forest Patch, their Categories and Number of Points

Forest Patch	Category	No. of points
Balegete	0	30
Becheve Nature Reserve	1	34
Becheve Nature Reserve Extension	1	24
Intact	2	5
Grotto	2	12
Okpazange	2	13
Anape A Forest	2	16
Kejeku	2	23
Emba	2	18
Golf Course	2	25
Apergili	3	14
Etoto	3	30
Mile One Extention	4	6
Avasie Agese	4	15
Holy Mountain	4	17
Yaya B	5	3
Yaya A	5	3
Yaro B	5	4
Aeroplane Field B	5	4
Mile One	5	8
Yaro Overside	5	5
Farm Fresh Forest	5	4
Yaro A	5	3
Aeroplane Field A	5	5
Aeroplane Field C	5	6
Woodwork Forest	5	7
Usmaila Forest	5	8
Fulani Area	5	10
Boka's	5	9
Baker's camp	5	12
Okezor	5	15

Legend: **Category 0**=Less disturbed forest**; Category 1**=Completely protected forest; **Category 2**=Partially protected forest; **Category 3**=Farming inside; **Category 4**=Houses inside; **Category 5**=Forest degraded by nomads grazing.

Different forest patches were surveyed between April 2006 and September 2008 between 6.00am and 11.00am. At each point, a 3-minute settling time was allowed before birds were recorded. The two bird species and number of individuals heard or seen using a pair of binoculars (magnification 8×24) were recorded and radial distances to sighted bird species were noted using a laser range finder. The duration of recording was 4 minutes, timed by an alarm clock – with methods generally following those for point counts as in Bibby et al. [24].

Statistical Analysis

Densities of the two bird species were estimated in each of the forest patches using the Distance software version 5.0 Release 2 *(http://www.ruwpa.st-and.ac.uk/distance).* The Conventional Distance Sampling (CDS) engine was used with a parametric key function haft-normal and adjusted by cosine terms.

A Generalizes Linear Model (GLM) using Statistical Package for Social Sciences (SPSS) version 17.0 was used to test the effect of patch size and isolation distance on the density of Cameroon Montane Greenbul and Yellow-breasted Boubou in the different forest patches.

Results

Effects of Different Forest Land Use Types on Density of Cameroon Montane Greenbul

There was a significant difference in the mean density of Cameroon Montane Greenbul (GLM, $F_{5, 25}$=2.76, p=0.041) in different forest types and their densities in the various forest patches with different land use types are shown in Table 2 and Figure 1. The density of Cameroon Montane Greenbul was highest in Aeroplane Field A, 8.55/hectare and least in Emba and Becheve Nature Reserve with 0.11/hectare.

Table 2: Density of Cameroon Montane Greenbul in Forest Patches With Different Land Use Types and Sizes

Forest Patch	Forest Land Use Type	Patch size (ha)	Density of Cameroon Montane Greenbul (Numbers/hectare)
Balegete	0	40	6.79
Becheve Nature Reserve	1	22.9	0.11
Becheve Nature Reserve Extension	1	23.3	1.86
Intact	2	0.8	1.13
Grotto	2	4.2	0
Okpazange	2	7.4	0.44
Anape A Forest	2	8.6	0.47
Kejeku	2	10.1	0.3
Emba	2	10.5	0.11
Golf Course	2	17.8	0.86
Apergili	3	5.9	0.53
Etoto	3	19.6	0.12
Mile One Extention	4	0.7	0
Avasie Agese	4	6.9	0.49
Holy Mountain	4	9.3	0
Yaya B	5	0.7	0
Yaya A	5	0.5	0
Yaro B	5	0.7	0
Aeroplane Field B	5	0.8	0
Mile One	5	0.9	0.66
Yaro Overside	5	1.2	0.57
Farm Fresh Forest	5	1.2	0
Yaro A	5	1.6	0

Table 2 contd.

Aeroplane Field A	5	1.7	8.55
Aeroplane Field C	5	2.5	0
Woodwork Forest	5	3.3	0
Usmaila Forest	5	3.4	0.39
Fulani Area	5	3.8	0
Boka's	5	4.6	1.36
Baker's camp	5	7.6	0.31
Okezor	5	9	1.04

Legend: 0=Less disturbed forest; 1=completely protected forest; 2=partially protected forest; 3=Houses inside; 4=Farming inside; 5=Degraded by cattle grazing.

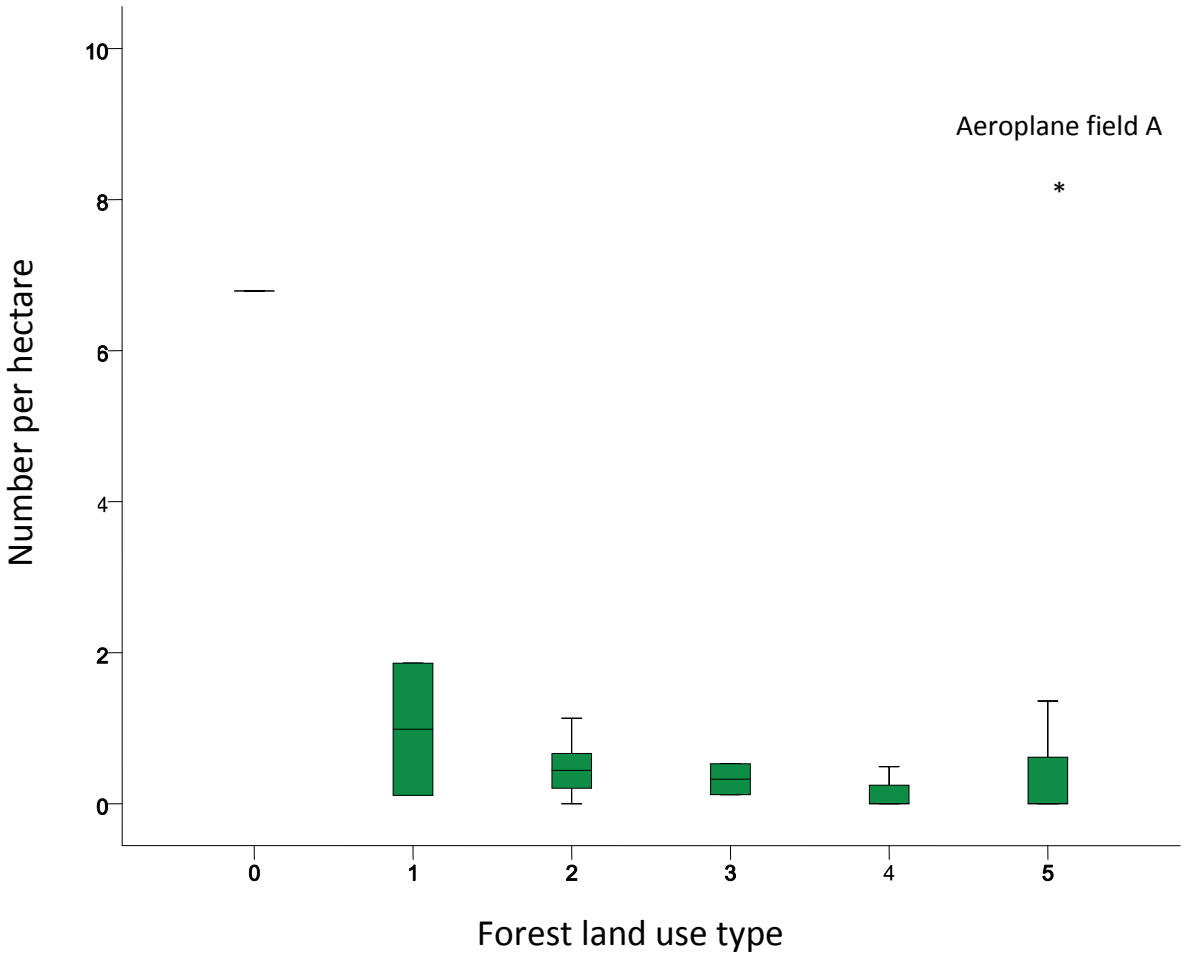

Fig. 1: Density of Cameroon Montane Greenbul in different forest patch categories.

Legend: 0= Less disturbed forest 1= Completely protected forest patch 2= Partially protected forest patch 3= Houses inside forest patch 4= Farming inside forest patch 5= Forest patch degraded by grazing activity
*=Outlier

Effects of Different Forest Land Use Types on Density of Yellow-breasted Boubou

There was no significant difference in the mean density of Yellow-breasted Boubou in the different forest land use types (GLM, $F_{5, 30}$=0.56, p=0.727, R^2=0.23) and their densities in the various forest patches with different land use types are shown in Table 3 and Figure 2. The density of Yellow-breasted Boubou was highest in Aeroplane Field A, 8.55/hectare while least in Avasie Agese (0.65/hectare).

Table 3: Density of Yellow-breasted Boubou in Forest Patches with Different Land Use Types and Patch Size

Forest Patch	Forest Land Use Type	Patch size (ha)	Density of Yellow-breasted Boubou (Numbers/hectare)
Balegete	0	40	3.39
Becheve Nature Reserve	1	22.9	0.97
Becheve Nature Reserve Extension	1	23.3	5.2
Intact	2	0.8	1.89
Grotto	2	4.2	0.7
Okpazange	2	7.4	2.22
Anape A Forest	2	8.6	1.87
Kejeku	2	10.1	2.74
Emba	2	10.5	1.02
Golf Course	2	17.8	2.15
Apergili	3	5.9	2.1
Etoto	3	19.6	3.09
Mile One Extention	4	0.7	1.33
Avasie Agese	4	6.9	0.65
Holy Mountain	4	9.3	1.48
Yaya B	5	0.7	0
Yaya A	5	0.5	0
Yaro B	5	0.7	1.17
Aeroplane Field B	5	0.8	2.77
Mile One	5	0.9	1.64
Yaro Overside	5	1.2	2.87
Farm Fresh Forest	5	1.2	2.23
Yaro A	5	1.6	2.98
Aeroplane Field A	5	1.7	8.55
Aeroplane Field C	5	2.5	1.55
Woodwork Forest	5	3.3	2.23
Usmaila Forest	5	3.4	1.17
Fulani Area	5	3.8	1.17
Boka's	5	4.6	5.46
Baker's camp	5	7.6	2.44
Okezor	5	9	4.67

Legend: 0=Less disturbed forest; 1=completely protected forest; 2=partially protected forest; 3=Houses inside; 4=Farming inside; 5=Degraded by cattle grazing.

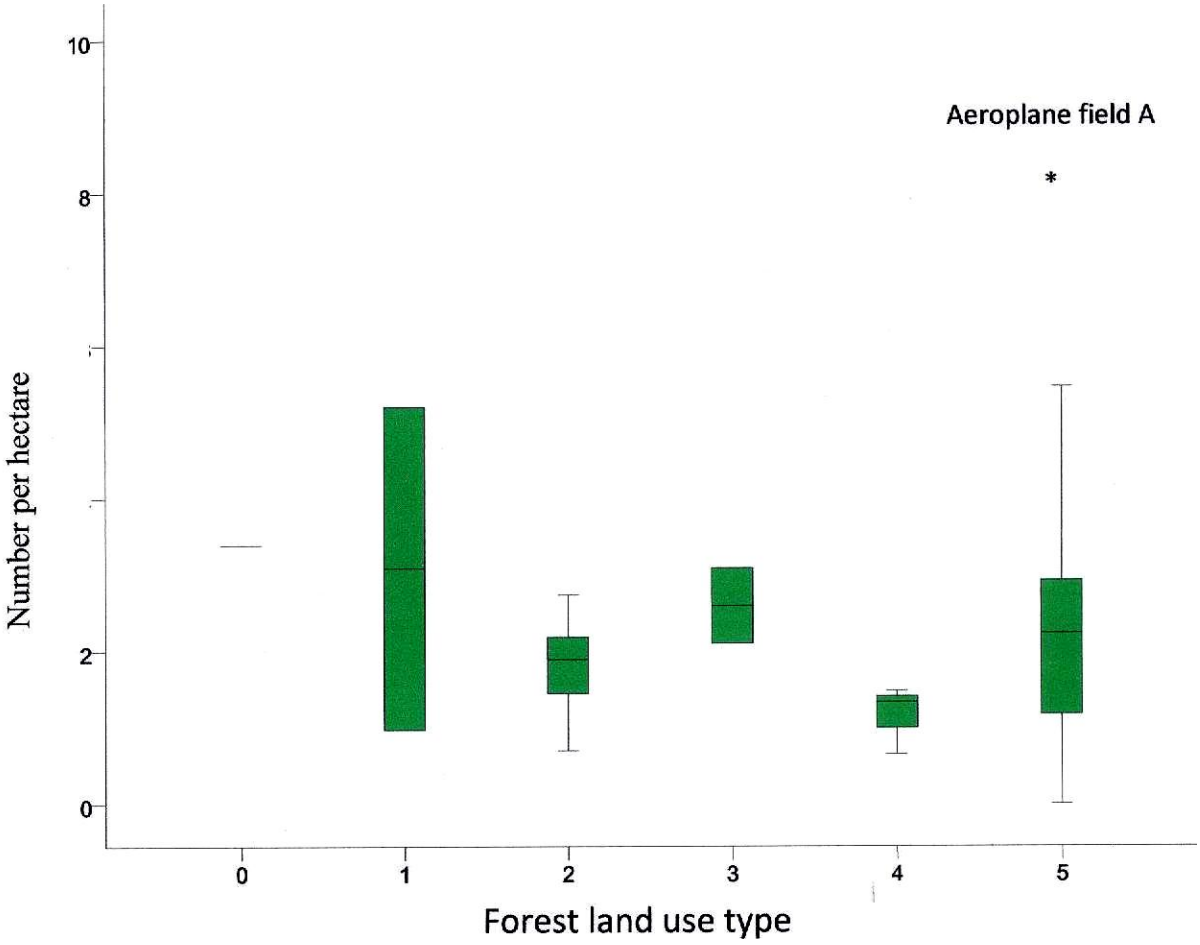

Fig. 2: Density of Yellow-breasted Boubou in different forest patch categories.

Legend: 0= Less disturbed forest 1= Completely protected forest patch 2= Partially protected forest patch 3= Houses inside forest patch 4= Farming inside forest patch 5= Forest patch degraded by grazing activity
*= Outlier

Effect of Patch Size on Density of Cameroon Montane Greenbul and Yellow-breasted Boubou

The densities of Cameroon Montane Greenbul and Yellow-breasted Boubou in the different forest patch sizes are shown in Tables 2 and 3. Patch size had significant effect on the densities of Cameroon Montane Greenbul but had no significant effect on the density of Yellow-breasted Boubou (Table 4). Densities of both species were found to increase with patch size (Figures 3 and 4).

Table 4: Effect of Patch Size on the Densities of Some Endemic Bird Species

Bird Species	df	F value	P value
Cameroon Montane Greenbul	1,25	4.41	0.04*
Yellow-breasted Boubou	1,25	1.21	0.28

*= significant level.

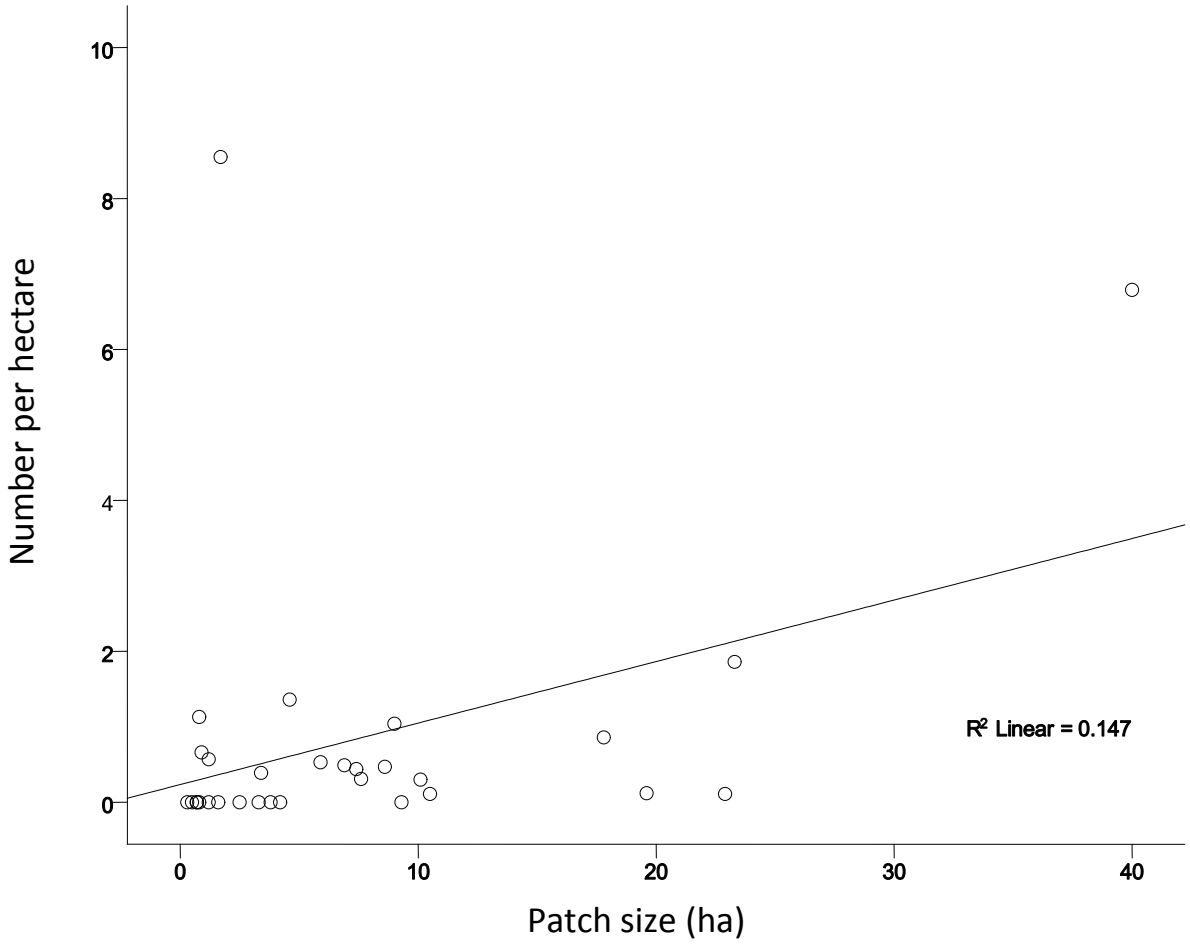

Fig. 3: Relationship between density of Cameroon Montane Greenbul and patch size.

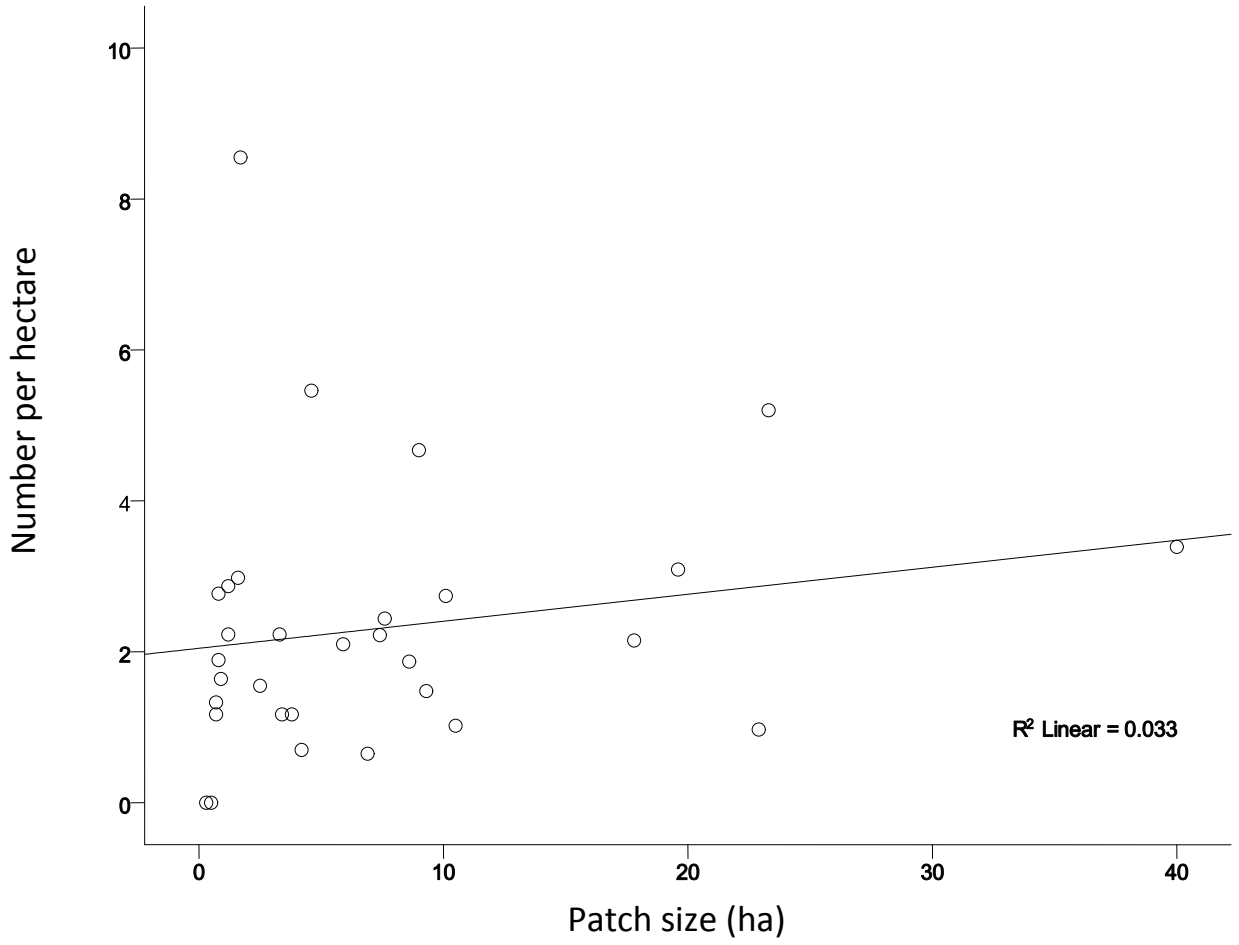

Fig. 4: Relationship between density of Yellow-breasted Boubou and patch size.

Effect of Isolation Distance on the Density of Cameroon Montane Greenbul and Yellow-breasted Boubou

The densities of Cameroon Montane Greenbul and Yellow-breasted Boubou in the different forest patch isolation distances are shown in Tables 5 and 6. Isolation distance had no significant effect on the density of Cameroon Montane Greenbul but had significant effect on the density of Yellow-breasted Boubou (Table 7). As isolation distance increased, the densities of Cameroon Montane Greenbul and Yellow-breasted Boubou were found to decreased (Figures 5 and 6).

Table 5: Density of Cameroon Montane Greenbul in Forest Patches with Different Isolation Distances

Forest Patch	Isolation Distance (m)	Density of Cameroon Montane Greenbul (Numbers/hectare)
Boka's	7	1.36
Grotto	10	0.00
Golf Course	10	0.86
Okezor	11	1.04
Farm Fresh Forest	40	0.00
Apergili	40	0.53
Etoto	40	0.12
Balegete	43	6.79
Becheve Nature Reserve Extension	48	1.86
Woodwork Forest	54	0.00
Becheve Nature Reserve	54	0.11
Okpazange	65	0.44
Kejeku	65	0.30
Emba	74	0.11
Anape A Forest	136	0.47
Intact	205	1.13
Usmaila Forest	230	0.39
Holy Mountain	230	0.00
Aeroplane Field B	240	0.00
Aeroplane Field C	240	0.00
Baker's camp	297	0.31
Aeroplane Field A	318	8.55
Yaro Overside	345	0.57
Mile One Extention	381	0.00
Fulani Area	416	0.00
Yaro B	420	0.00
Yaro A	420	0.00
Mile One	517	0.66
Yaya B	610	0.00
Avasie Agese	610	0.49
Yaya A	923	0.00

Table 6: Density of Yellow-breasted Boubou in Forest Patches with Different Isolation Distances

Forest Patch	Isolation Distance (m)	Density of Yellow-breasted Boubou (Numbers/hectare)
Boka's	7	5.46
Grotto	10	0.70
Golf Course	10	2.15
Okezor	11	4.67
Farm Fresh Forest	40	2.23
Apergili	40	2.10
Etoto	40	3.09
Balegete	43	3.39
Becheve Nature Reserve Extension	48	5.20
Woodwork Forest	54	2.23
Becheve Nature Reserve	54	0.97
Okpazange	65	2.22
Kejeku	65	2.74
Emba	74	1.02
Anape A Forest	136	1.87
Intact	205	1.89
Usmaila Forest	230	1.17
Holy Mountain	230	1.48
Aeroplane Field B	240	2.77
Aeroplane Field C	240	1.55
Baker's camp	297	2.44
Aeroplane Field A	318	8.55
Yaro Overside	345	2.87
Mile One Extention	381	1.33
Fulani Area	416	1.17
Yaro B	420	1.17
Yaro A	420	2.98
Mile One	517	1.64
Yaya B	610	0.00
Avasie Agese	610	0.65
Yaya A	923	0.00

Table 7: Effect of Isolation Distance on The Densities of Some Endemic Bird Species

Bird Species	df	F value	P value
Cameroon Montane Greenbul	1,29	0.37	0.55
Yellow-breasted Boubou	1,29	4.46	0.043*

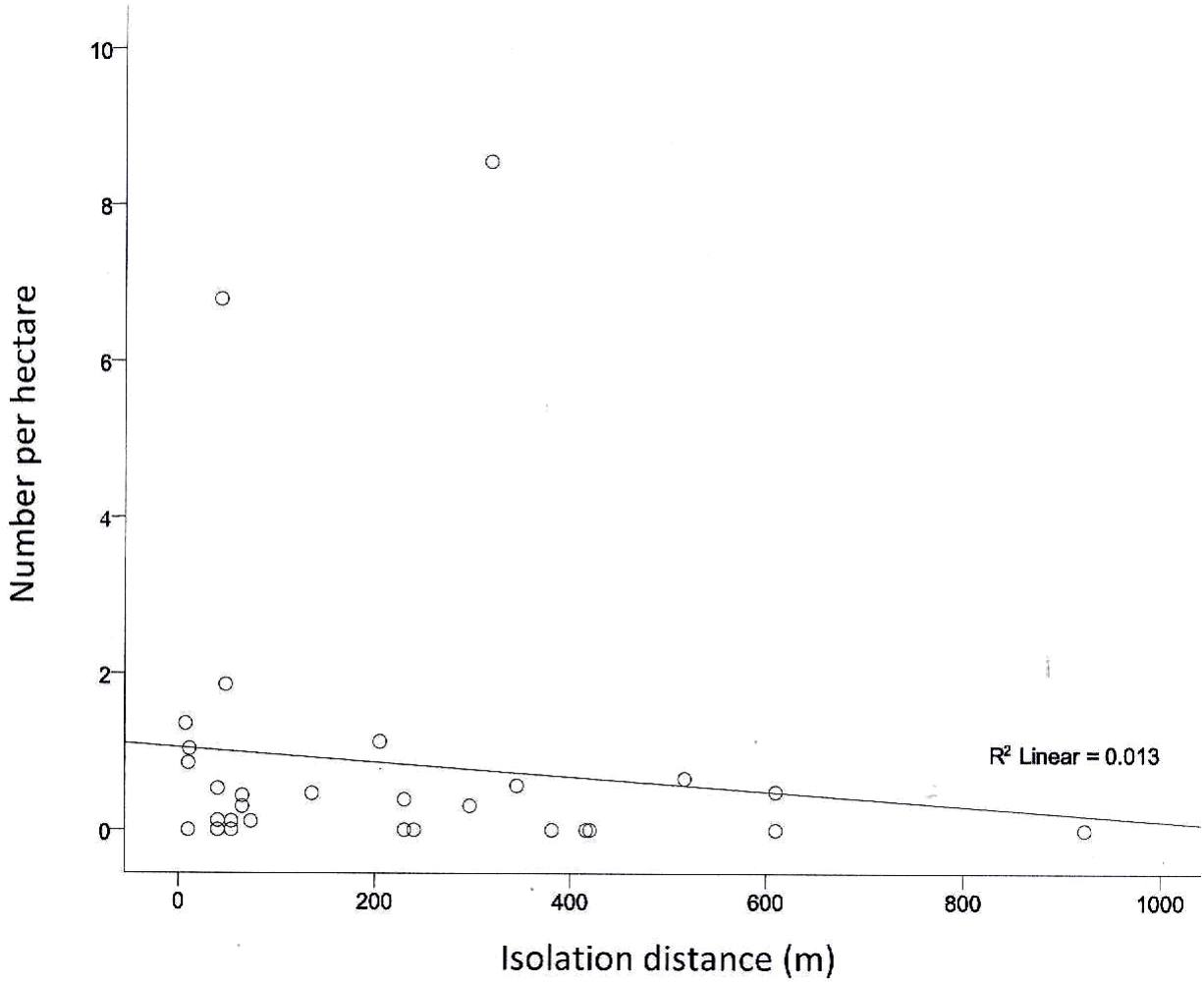

Fig. 5: Density of Cameroon Montane Greenbul in relation to isolation distances.

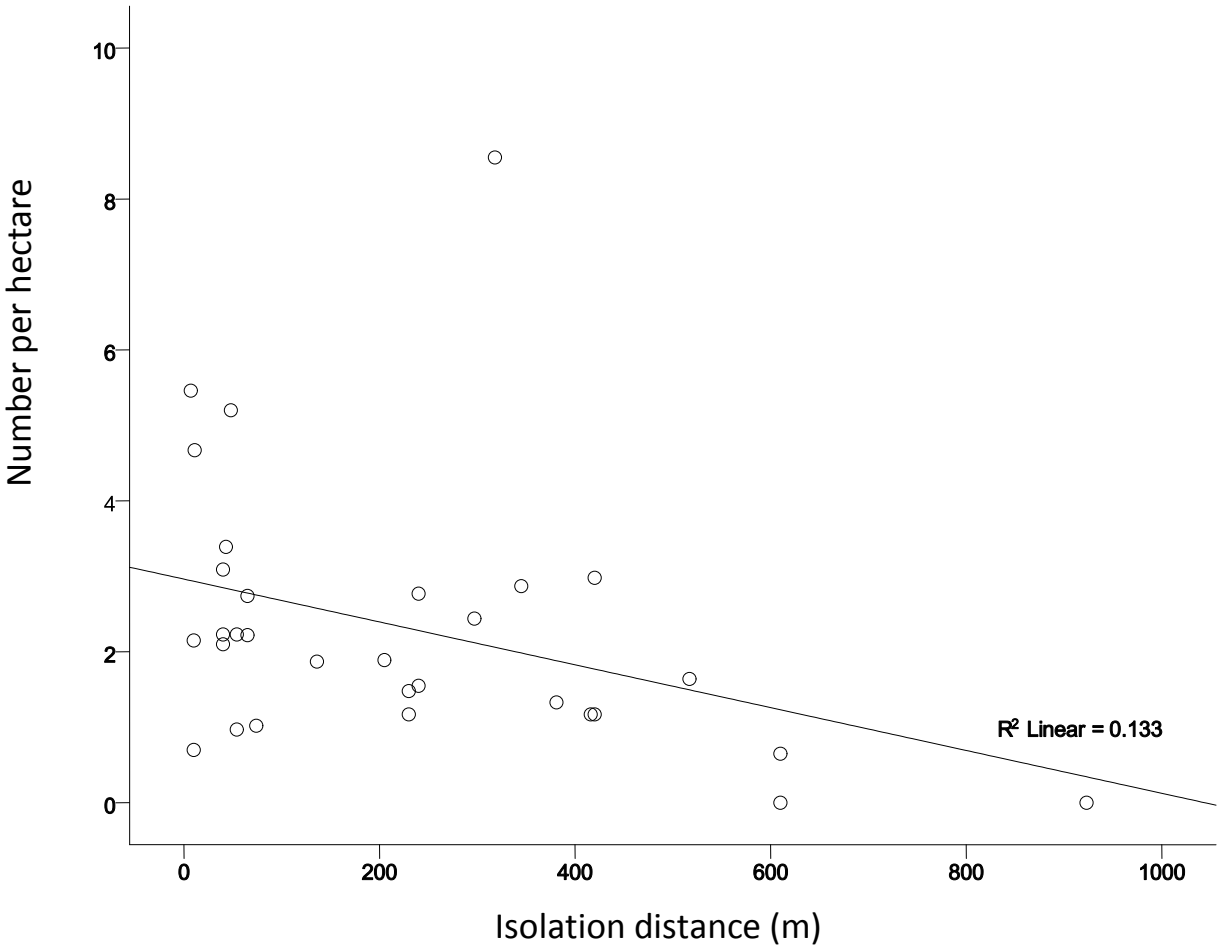

Fig. 6: Density of Yellow-breasted Boubou in relation to isolation distances.

Discussion

A significant difference was found in the mean densities of Cameroon Montane. But graphically, differences in densities of the Cameroon Montane Greenbul occurred only in the less disturbed forest patches compared to the other forest land use types. Patches having houses inside as well as farming and nomadic activity had the lowest densities. The unprotected forest patches in forest land use types 3, 4 and 5 had the least densities. This may have to do with the different levels of disturbance of the forest patches where densities of endemic species have been found to positively correlate with vegetation complexity and food availability [25, 26]. This is also in accordance with results from other studies by [27, 28].

The densities Yellow-breasted Boubou did not vary significantly with different forest land use types. The densities were similar in the different forest land use types. These species were always found at the edge of the forest or in secondary thickets (personal observation), which might explain their high densities in the unprotected forest patches. Koh et al. [29] found that for a given amount of unavoidable deforestation in landscapes undergoing development, extinction risk could be minimized by improving the habitat quality of the matrix. In tropical forests, this could be achieved by allowing farmland and

degraded forest patches to regenerate to secondary forests or by facilitating the succession of young secondary forests to old-growth forests.

There was a significant difference between the mean density of Cameroon Montane Greenbul and forest patch sizes. Brooks et al. [17] showed that as patch size is reduced, endemics species to an area (as seen for Obudu Plateau) are at risk of global extinction. Yellow-breasted Boubou had higher mean densities in medium and small forest patch sizes, probably because it was always found in secondary thickets that make up the medium and small forest patch sizes. Densities of Cameroon Montane Greenbul and Yellow-breasted Boubou (although minimal) were found to increase with an increase in patch size. This agrees with the findings of other authors [3, 15, 16, 30-32].

Statistically, there was no significant difference between the mean densities of Cameroon Montane Greenbul and isolation distance. This might be because of the fact that isolation distance between the forest patches was less than 1km. This agrees with other studies which demonstrated that the distance between forest patches has an effect on the number of bird species (33-35] and is prone to extinction [18- 20].

Different forest land use types on the Obudu Plateau have been found to affect the endemic bird species in various ways. Forest patches with greater disturbance had lower densities of the species. Fragmentation negatively affected the endemic bird species. The density of bird species was higher in larger forest fragments while increase in isolation distance between the fragments showed a decrease in the density of bird species. It is recommended that partially protected forest patches should be completely protected so that the protected forest patches will be large, and allow regeneration to occur in the newly protected patches. Also, trees native to the Obudu Plateau should be planted and maintained on the Ranch to serve as connections or corridors. Finally, forest blocks should be planted with exotic and native trees that will be used by the community for their timber and firewood to reduce the pressure on indigenous trees in the forest patches.

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References

(1) FAO. 2001. *Global Forest Resources Assessment 2000, Main Report.* FAO Forestry paper 140. FAO, Rome. Pp 562

(2) FAO. 2005. *Deforestation continues at an alarming rate*. FAO Newsroom, Rome.

(3) Andren, H. 1994. Effects of habitat fragmentation on birds and mammals in landscapes with different proportions of suitable habitat: a review. *Oikos* 71: 355-366.

(4) Villard, R., Trzcinski, M. K. and Merriam, G. 1999. Fragmentation effects on forest birds: Relative influence on woodland cover and the configuration on landscape occupancy. *Conservation Biology* 13: 774-783.

(5) Bierregaard, Jr. R.O., Gascon, C., Lovejoy, T.E. and Mesquita, R. 2001. *Lessons from Amazonia: The Ecology and Conservation of Fragmented Forest.* Yale University Press, London. 478pp.

(6) Pickett, S.T.A. and Thompson, J.N. 1978. Patch dynamic and design of nature reserves. *Biological Conservation* 13: 27-37.

(7) Foster, R.B. 1980. *Heterogeniety and distribution in tropical vegetation. Conservation biology: an evolutionary-ecological perspective*. Sinuar, Sunderland, MA. Pp 453.

(8) Burgess, R.L. and Sharp, D.M. 1981. *Forest island dynamics in man dominated landscapes*. Springer-Verlag, New York, U.S.A. 239pp.

(9) Wilcove, D.S., McLellan, C.H. and Dobdon, A.P. 1986. Habitat fragmentation in the temperate zone, pp237-256. *In*: *Conservation Biology: The science of scarcity and diversity*. Sinauer, Sunderland, MA.

(10) Boudjemad, K., Lecomte, J. and Clobert, J. 1999. Influence of connectivity on demography and dispersal in two contrasting habitats: An experimental approach. *Journal of Animal Ecology* 68: 1207-1224.

(11) Rolstad, J. 1991. Consequences of forest fragmentation on the dynamics of bird populations: Conceptual issues and evidence. *Journal of the Linean Society of London, series B*, 249-263.

(12) Murcia, C. 1995. Edge effects in fragmented forest: Implication for conservation. *Tree* 10: 58-62.

(13) Franklin, A.B., Noon, B.R. and George, T.L. 2002. What is the effect of fragmentation on birds in western landscapes? *Studies in Avian Biology* 25: 20-29.

(14) Ranta, P., Blom, T., Niemela, J., Joensun, E. and Siitonen, M. 1998. The fragmented Atlantic rain forest of Brazil: Size, shape, and distribution of forest fragments. *Biodiversity and Conservation* 7: 385-403.

(15) McArthur, R.H. and Wilson, E.O. 1967. *The theory of island biogeography*. Princeton University Press, Princeton, New Jersey. 203pp.

(16) Wethered, R. and Lawes, M.J. 2003. Matrix effects on bird assemblages in fragmented Afromontane forest in South Africa. *American Naturalist* 104: 373-388.

(17) Brooks, T.M., Pimm, S.T., Kapos, V. and Ravilious, C. 1999. Threat from deforestation to montane and lowland birds and mammals in insular South-east Asia. *Journal of Animal Ecology* 68: 1061-1078.

(18) Amburl, B. and Temple, S.A. 1983. Area-dependent changes in bird communities and vegetation of southern Wisconsin forest. *Ecology* 64: 1057-1068.

(19) Ewers, R.M. and Didham, R.K. 2006. Confounding factors of species responses to habitat fragmentation. *Biological Review* 88: 117-142.

(20) Lynch, J.F. and Whigham, D.F. 1984. Effects of forest fragmentation on breeding bird communities in Maryland, USA. *Biological Conservation* 28: 287-324.

(21) BirdLife International. 2003. *Endemic Bird Areas of the World*. Barcelona and Cambridge, UK: Lynx Edicions and BirdLife International. 846pp.

(22) Ezealor, A.U. 2002. *Critical Sites for Biodiversity Conservation in Nigeria*. Nigerian Conservation Foundation, Lagos. 110pp.

(23) Ezealor, A.U. 2001. Nigeria. In Fishpool, L. D, C. & Evans, M. I., eds. *Important bird areas of Africa and associated islands: priority sites for conservation.* Newbury and Cambridge, UK; Pisces Publications and BirdLife International (BirdLife Conservation Series No. 11). 673-692pp.

(24) Bibby, C.J., Burgess, N.D., Hill, D.A. and Mustoe, S.H. 2001. *Bird Census Tecniques.* Academic Press, London. 302pp.

(25) Terborg, J.M. and Weske, J.S. 1969. Colonization of secondary habitats by Peruvian Birds. *Ecology*, 50, 765-782.

(26) Marsden, S.J. and Pilgrim, J.D. 2003. Factors affecting the abundance of parrots and hornbills in pristine and disturbed forests on New Britain. *Ibis*, 145, 45-53.

(27) Fjeldsa, J. 1999. The impact of human disturbance on the endemic avifauna of the Udzungwa Mountains, Tanzania. *Bird Conservation International*, 9, 47-62.

(28) Schiotz, A. 1981. The Amphibia in the forested basement hills of Tanzania: A biogeographical indicator group. *African Journal of Ecology*, 19, 205-207.

(29) Koh, L.P., Ming Lee, T., Sodhi, N.S. and Ghazoul, J. 2010. An overhaul of the pecies–area approach for predicting biodiversity loss: incorporating matrix and edge effects. *Journal of Applied Ecology*, 47, 1063–1070.

(30) Newmark, W.D. 1991. Tropical forest fragmentation and the local extinction of understory birds in eastern Usambara Mountains, Tanzania. *Conservation Biology* 5 67-78.

(31) Beier, P., Van Drielen, M. and Kankam, B.O. 2002. Avifauna collapse in West African forest fragments. *Conservation Biology* 16: 1097-1111.

(32) Fahrig, L. 2003. Effects of habitat fragmentation on biodiversity. *Annual Review of Ecology, Evolution and Systematics* 34: 487-515.

(33) Vuillemier, F. 1970. Insular biogeography in continental regions. The northern Andes of South America. *American Naturalist* 104: 373-388.
(34) Johnson, N.K. 1975. Controls of bird species on montane islands in Great Basin. *Evolution* 29: 545-557.
(35) Opdam, P., Van Dorp, D. and Ter Braak, C. J. F. 1984. The effect of isolation on the number of woodland birds of small woods in the Netherlands. *Journal of Biogeography* 11: 473-478.