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The Effect of Fragmentation and Land Use Types on Bannerman's Weaver *Ploceus bannermani* (A Globally-Threatened Bird Species) on the Obudu Plateau, Southeast Nigeria

Dami, Filibus Danjuma[1, 2 *], Georgina Samuel Mwansat[2], Shiiwua, A. Manu[1,2]
1. A.P. Leventis Ornithological Research Institute, University of Jos, P.O. Box 13404, Jos, Nigeria.
2. Department of Zoology, University of Jos, P.M.B 2084, Jos, Nigeria.
* Corresponding author: damidanjuma@yahoo.com

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Abstract
The Obudu Plateau is one of the most important single sites in Nigeria for globally-threatened bird species e.g., Bannerman's Weaver *Ploceus bannermani*. 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 study examined how land use and fragmentation affect Bannerman's Weaver on the Obudu Plateau. Birds heard or seen, and their distances were recorded from points laid 100 meters apart in forest patches that varied in their categories (less disturbed, completely protected, and partially protected, houses inside, farming inside and degraded by nomadic activity). No significant differences in the densities of Bannerman's Weaver in the different forest patch categories: weavers were more common in protected patches and less common in unprotected patches. Patch size had a significant positive effect on the density of Bannerman's Weaver while isolation distance had no significant difference. Patch size reduction as a consequence of fragmentation therefore negatively affected Bannerman's Weaver. Those 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.
Keywords: Fragmentation, Threatened bird species, Bannerman's Weaver, Obudu Plateau, Forest land use types.

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 (FAO, 2001). 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 (FAO, 2005). Forest loss exposes the remaining forest to the process of fragmentation.

Fragmentation is the process of subdividing a continuous suitable habitat into smaller patches thereby altering its original configuration (Andren 1994, Villard *et al*. 1999). Fragmentation is the most important threat to forested ecosystems (Bierregaard, Jnr. *et al*. 2001) and can occur naturally through fire (Pickett & Thompson, 1978) and windfall (Foster 1980) but the most important and large-scale cause is the expansion of human land use (Burgess & Sharp, 1981). Habitat fragmentation has been implicated as a primary factor in the loss of bird species (Wilcove *et al*. 1986) 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 (Boudjemad *et al*. 1999).

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 (Wilcove *et al*. 1986), thereby increasing the vulnerability of biota to environmental and demographic threats (Franklin *et al*. 2002, Murcia 1995, Rental *et al*. 1998, Rolstad 1991, Wilcove *et al*. 1986). Reduction in habitat leads to species loss (Beier, *et al*. 2002, McArthur & Wilson 1967, Wethered & Lawes, 2003) and montane species are disproportionately threatened because they tend to occupy smaller areas initially compared to the lowland forest (Brooks *et al*. 1999). Isolation of forest patches disrupts distribution patterns 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 (Amburl & Temple 1983, Ewers & Didham 2006, Lynch & Whigham 1984).

The Obudu Plateau is the most important single site in Nigeria for globally threatened bird species (BirdLife International 2003). 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 (Ezealor 2002). 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. The Bannerman's Weaver has a global status of vulnerable (Stattersfield *et al*., 1998). Numbers are not known but the species occurs along edges of thin strips of forest in deep ravines on the Obudu Plateau (Collar and Stuart, 1985). The major threat to the species is forest clearing for cultivation and overgrazing by cattle, sheep, goats and horses, woodcutting and fires (Collar and Stuart, 1985). Although forest destruction may appear to benefit the species in short time by providing more open habitat, as this in turn is degraded to grassland the birds may entirely disappear (Collar and Stuart, 1985). This paper describes how fragmentation (particularly patch size and isolation distance) and forest land use type's affects the density and distribution of Bannerman's weaver on the Obudu Plateau. This is the first study to assess the effects of fragmentation and land use of montane forest on Bannerman's weaver of the Obudu Plateau, Nigeria.

Materials and Method

Field Survey

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, south eastern 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 (Ezealor, 2001).

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. Six 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 program, points were laid out systematically to cover the forest interior, forest edge and surrounding grasslands. 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 numbers of points are as shown in Table 1.

Table 1. Forest patch, their categories and number of points

S/N	Forest Patch	Category	No. of points
1	Avasie Agese	3	15
2	Apergili	4	14
3	Baker's camp	5	12
4	Becheve Nature Reserve	1	34
5	Becheve Nature Rserve Extension	1	24
6	Boka's	5	9
7	Emba	2	18
8	Ettoto	4	30
9	Golf course	2	25
10	Grotto	2	12
11	Holy Mountain	3	17
12	Intact	2	5
13	Mile One	3	8
14	Mile one extension	5	6
15	Okezor	5	15
16	Yaya A	5	3
17	Yaya B	5	3
18	Yaro B	5	4
19	Yaro A	5	4
20	Yaro overside	5	5
21	Fulani Area	5	10
22	Kejeku	2	23
23	Farm Fresh Forest	5	4
24	Woodwork Forest	5	7
25	Aeroplane Field A	5	5
26	Aeroplane Field B	5	4
27	Usmaila Forest	5	8
28	Anape A forest	2	16
29	Aeroplane C Forest	5	6
30	Okpazange	2	13
31	Balegete	0	30

A different forest patch was 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. All 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 follow those for point counts as in Bibby *et al.*

2.2 Statistical Analysis

Densities of Bannerman's Weaver were estimated in each of the 31 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 GLM using R statistics version 2.15.2 was used to test the effect of patch size and isolation distance and different land use types on the density of Bannerman's Weaver in the different forest patches.

Results

A full model that considered all variables (patch size, isolation distance and the various land use types, categories 0-5) showed that only patch size had a significant effect on the density of Bannerman's Weaver (Table 2).

Table 2. GLM of Density, Patch size, Isolation distance and Land use types

Coefficients	Estimated	Std. Error	t value	p value
(Intercept)	-0.46	0.74	0.63	0.54
Patchsize	0.03	0.02	2.11	0.05*
Isolationdistance	0.0002	0.0003	0.57	0.58
Category 1	0.35	0.47	0.75	0.46
Category 2	0.47	0.61	0.77	0.45
Category 3	0.5	0.65	0.77	0.45
Category 4	0.18	0.59	0.3	0.77
Category 5	0.64	0.67	0.96	0.35

*- significant

Effects of Different Patch Sizes on Density of Bannerman's Weaver

The simple model with just patch size is the most parsimonious and showed that there was a significant increase in the mean density of Bannerman's Weavers and patch size ($F_{1, 24}$=8.48 p=0.008, adjusted R^2=0.23) (Figure 1). Table 3 shows the density of Bannerman's Weaver in each forest patch. Bannerman's Weaver was not recorded in Yaya A, Yaya B, Mile One Extension and Aeroplane Field B forest patches. The minimum forest patch size in which Bannerman's Weaver was found was about 0.7ha.

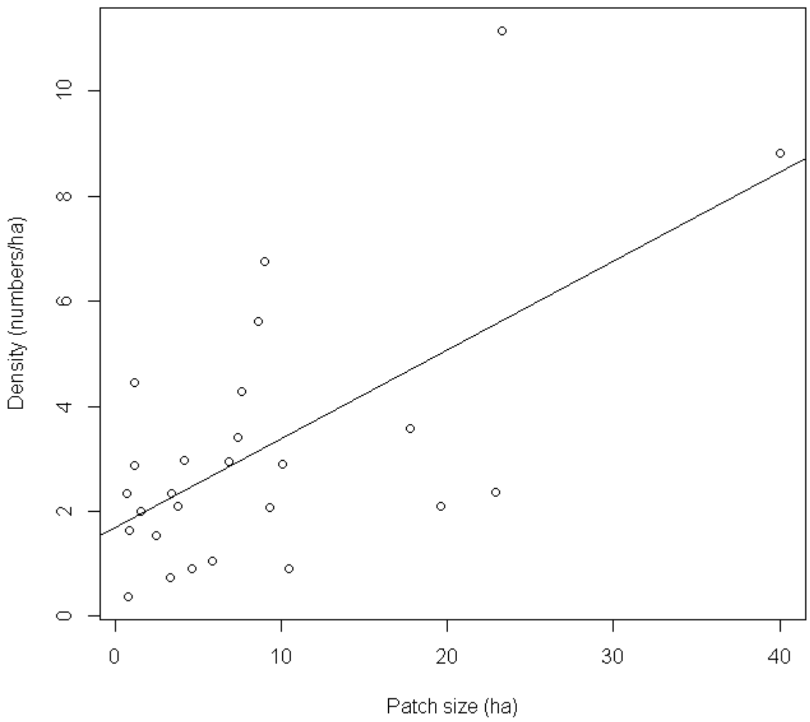

Figure 1. Density of Bannerman's Weavers in relation to forest patch size

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Table 3. Density of Bannerman's Weavers in Different Patch Sizes and Isolation Distances

Forest Patch	Patch size (ha)	Isolation distance (m)	Density of Bannerman's Weaver (Numbers/hectare)
Yaya B	0.3	610	0
Yaya A	0.5	923	0
Mile One Extention	0.7	381	0
Yaro B	0.7	420	2.34
Intact	0.8	205	0.38
Aeroplane Field B	0.8	240	0
Mile One	0.9	517	1.64
Yaro Overside	1.2	345	2.87
Farm Fresh Forest	1.2	48	4.46
Yaro A	1.6	923	1.99
Aeroplane Field A	1.7	318	0
Aeroplane Field C	2.5	240	1.55
Woodwork Forest	3.3	54	0.74
Usmaila Forest	3.4	230	2.34
Fulani Area	3.8	416	2.11
Grotto	4.2	10	2.96
Boka's	4.6	7	0.91
Apergili	5.9	40	1.05
Avasie Agese	6.9	610	2.94
Okpazange	7.4	65	3.4
Baker's camp	7.6	297	4.28
Anape A Forest	8.6	318	5.62
Okezor	9	11	6.75
Holy Mountain	9.3	230	2.07
Kejeku	10.1	65	2.89
Emba	10.5	74	0.9
Golf Course	17.8	10	3.58
Etto	19.6	40	2.1
Becheve Nature Reserve	22.9	54	2.36
Becheve Nature Reserve Extension	23.3	48	11.15
Balegete	40	43	8.83

Effects of Isolation Distance on Density of Bannerman's Weaver

Table 3 shows the density of Bannerman's Weaver in each forest patch in relation to isolation distance. The minimum isolation distance in which no Bannerman's Weaver density was calculated was 610 m. There was no significant change in the density of Bannerman's Weaver with isolation distance P=0.58 (Table 2) and the density of the species decreased with increase in isolation distance (Figure 2).

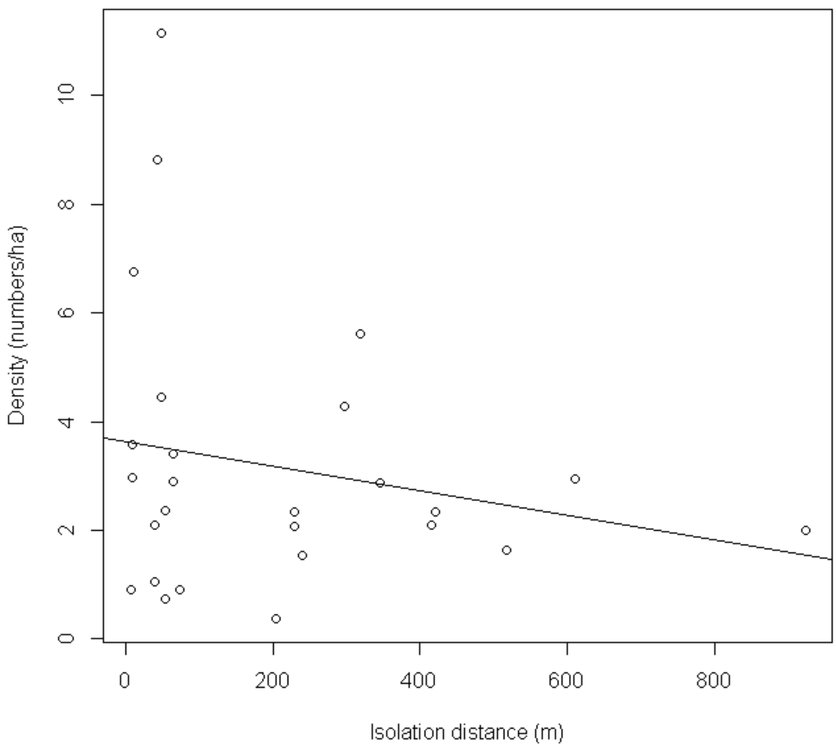

Figure 2. Density of Bannerman's Weaver in relation to isolation distance

Effects of Land Use Type on Bannerman's Weaver

There was no significant difference in the mean density of Bannerman's Weaver in the different forest land use types (Categories 0-p=0.54;1-p=0.46; 2-p=0.45; 3-p=0.45; 4-p=0.77 and 5-p=0.35) (Table 2). The less disturbed forest patch category had the highest density while the forest patch with houses had the least (Figure 3). An outlier was found with Okezor forest patch. Balegete forest patch, which is less disturbed, had the highest density of 8.83 Bannerman's Weavers per hectare while Intact forest patch, partially protected had the lowest density of 0.38 Bannerman's Weavers per hectare. Mile one extension forest patch, farming inside and Yaya A, Yaya B, Aeroplane A, Aeroplane B forest patches that are degraded by cattle grazing activities had 0 density of Bannerman's Weaver per hectare.

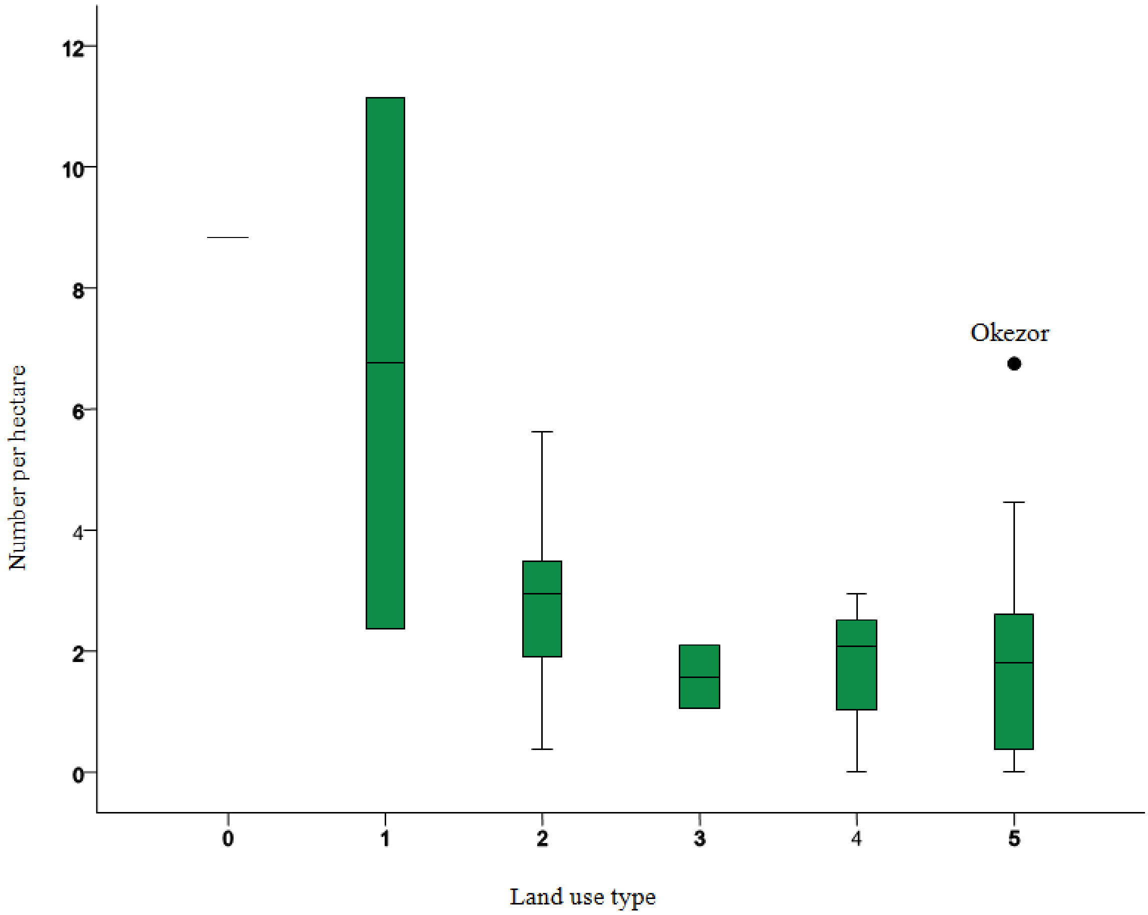

Figure 3. Density of Bannerman's Weaver in Different Forest Patch Categories

Legend:

- = Outlier

0= Less disturbed forest; 1= Completely protected forest patch; 2= Partially protected forest patch; 3= Houses inside forest patch;4= Farming inside forest patch and 5= Forest patch degraded by grazing activity

Discussion

Effects of patch size on Bannerman's weaver

Densities of Bannerman's Weavers were found to increase with an increase in patch size significantly (Figure 1 and Table 3). This agrees with the findings of MacArthur and Wilson (1967), Andren (1994), Newmark (1991), Beier *et al.* (2002), Fahrig (2003) and Wethered and Lawes (2003). Bannerman's Weavers like large forest patches, even though they are edge species. Smaller patches have less edge and so small populations, hence increased extinction risk. This follows conventional theory except the Bannerman's Weavers are edge species, which we expect to be less resilient to patch size changes. Also, unlike true oceanic islands, terrestrial islands are not surrounded by a uniformly hostile matrix. Animals venturing outside of patches may find sufficiently good conditions to live and reproduce rendering the notion of the patch less relevant (Prugh, *et al.* 2008). Another factor is how isolated these forest patches are from other patches, Yaya A and Yaya B are more than 600 meters isolated from other forest patches (Table 3) which might explain the absence of the species in them.

Effects of isolation of forest patch on Bannerman's Weaver

There was no significant difference in the mean density of Bannerman's Weaver with isolation distance. The species are edge species, so they find it easy to disperse through the matrix and thus isolation distance has no significant effect on them but as the distance increase, the density of the species decrease.

Bannerman's Weavers and Different Forest Land Use Types

There were differences in the mean densities of Bannerman's Weaver in less disturbed, completely protected and partially protected forest. Partially protected forest had the highest mean number. This is probably because Bannerman's Weaver is an edge-loving species and the partially protected forest patches have openings in the forest due to timber and firewood extraction by the community. This created gaps in the forest patches that served as good habitats for the species and thus the high mean density. Other studies showed similar results. For example Collar and Staurt (1985) said that although forest destruction benefits the Bannerman's Weaver in the short term by providing more open habitats (as seen in partially protected and other degraded forest patches), the forest patches are eventually degraded to grasslands which are unsuitable for the species, and may cause them to go locally extinct. This is seen in the mean lower densities of forest patches with houses inside, farming activities and degraded forest by nomadic activities (Figure 3).

Amongst the unprotected forest patch categories, forest patches with farming activity had higher mean density of the species than forest patches with houses inside and those degraded by nomadic activities (Figure 3). Again continuous farming and activities of cattle grazers open up the forest in various degrees thereby creating edges that become convenient habitat for the Bannerman's Weaver.

The mean density of the bird species was higher in the protected forest patches than the unprotected forest patches. This agrees with the findings of Daily *et al.,* (2001) where higher bird numbers were recorded in native protected habitats.

But perhaps the main threat to Bannerman's Weaver population on the Obudu Plateau is the destruction of nests by children (pers. obs.). The nests are usually built at the edges of forests and children were seen collecting eggs from the nest. They also trapped adult birds sitting on eggs. This is clearly seen in the mean density in forest patches with houses inside (Figure 3). Protection of the partially protected forest patches may help address the activities of these children. There should also be some conservation education to school children and people of the Obudu Cattle Ranch about the significance of Bannerman's Weaver and other bird species and the need to protect them.

Conclusion

Fragmentation negatively affected the threatened 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. Bannerman's Weavers were less affected by forest disturbance because they are edge species and disturbance creates edges.

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