



Techno Science Africana Journal

Journal homepage: www.technoscienceafricana.com



EFFECTS OF MANAGED BURNING ON AVIAN DIVERSITY AND ABUNDANCE IN YANKARI GAME RESERVE, NIGERIA

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ARTICLE INFO

ABSTRACT

Keywords:

Avifaunal,
Sudan Savannah,
Point-count,
Burnt,
Unburnt points,
Managed-Burning.

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The effects of fire on the avifaunal diversity and abundance was studied in a Sudan Savannah habitat in the Yankari Game Reserve, North-central Nigeria. Bird survey point count was carried out at 700 points laid out systematically within 7 grids of 4 km² each, covering both burnt and unburnt areas. A total number of 7350 birds of 133 species in 46 families were recorded. Mean number of birds per point was 10.50±0.23, Results revealed that, mean number of birds in burnt points was 10.45±0.26 and 10.79±0.47 in unburnt points. There was a higher bird diversity at burnt than unburnt points, there was also significantly higher bird diversity and abundance between points managed with early than late, relative to the end of the wet season, burns. This study shows that both fires itself and the timing of the fires affect the diversity and abundance of birds. In this respect, and if managed burning is carried out, early fires should be the main option in the Yankari Game Reserve (YGR) and possibly elsewhere.

INTRODUCTION

Savannah environments constitute the largest physical ecosystems in Southern, Central and West Africa sub-regions (Solbrig and Young 1993; Mistry, 2000). The high frequency of dry lightning storms over the continent of Africa

creates a unique fire climate and fire has a long history in the evolution of African savannah ecosystems (Eriksen, 2007). Fire does not only influence the total biomass of savannah systems it also markedly influences their structure.

Fire plays an important role in maintaining grasslands against invasion by trees. It has been suggested that herbivory contribute to this role of fire by feeding more on fire-sensitive, less flammable species. By leaving the most flammable species, the animals contribute to the future reburning of the area and the maintenance of habitat suitable to them (Kimmins, 1997). In perennial grasslands, where grasses form clumps or 'bunches', fire is important in maintaining high net productivity. Following a fire, perennial grasslands quickly replace lost biomass and add new growth. In the absence of fire, the senescing grass tillers (stems) shade the clump and reduce photosynthesis (Meffe *et al.*, 1994). In temperate and boreal parts of North America, species of large mammals favoured by fire includes: hare (*Lepus* species), black bear (*Ursus americanus*), coyote (*Canis latrans*), beaver (*Castor* species), white deer (*Odocoileus virginianus*) and black deer (*Odocoileus hemionus*). Birds such as the wild turkey (*Melegris gallopavo*), ring-necked pheasant (*Phasianus colchicus*), bob-white quail (*Colinus virginianus*), short-tailed grouse (*Tympanuchus phasianellus*), ruffed grouse (*Bonasa umbellus*), and some of the waterfowl are benefited by fire. On the contrary, birds like the spruce grouse, which depend on dense forests are adversely affected (Kimmins, 1997). O'Reilly *et al.* (2006) reported a greater Shannon diversity index in burnt than unburnt parts of a central Kenyan reserve; however, there was no significant difference in abundance. It was observed by Alan *et al.*, (2006) in an Australian tropical savannah that mortality of dominant trees increased linearly with

increasing fire intensity while grass layer vegetation was resilient with fire having no detectable effect on either the diversity or floristic composition. It was also shown that fire had greater effect on individual animal species than was indicated by group functional response, there was however, no significant effect on the abundance of most common grasshopper species. Studies have also shown that birds respond differently to fire and grazing (e.g. Alexis, 2006; Bock and Block, 2005).

Despite the importance of fire in savannah ecosystems, most fire studies have focused on vegetation. Less attention has been paid to the effects of fire on faunal diversity (Parr & Chown 2003). YGR has a long history of bushfires (Green 1989; Birdlife International 2007), and fire is still used as a management tool. This work, investigated the effects of fire on the diversity and abundance of bird species in YGR. This was by checking the diversity and abundance of bird species in burnt and unburnt points in the savannah of the Reserve, comparing areas treatment with early fire (early burns) and those with late fire treatment (late burns). And by checking the relationships between vegetation variables and bird species diversity and abundance at burnt and unburnt points.

MATERIALS AND METHODS

Study site

This study was conducted between April and June 2008 at the YGR (10° 30' E, 9° 45' N) located in the North Central part of Nigeria. The Reserve is in the Sudan Guinea Savannah vegetation zone, covering an area of 2244 km² at an altitude of 150-750 m. (Figure 1)

Location of Yankari Game Reserve in Bauchi State, Eastern Nigeria

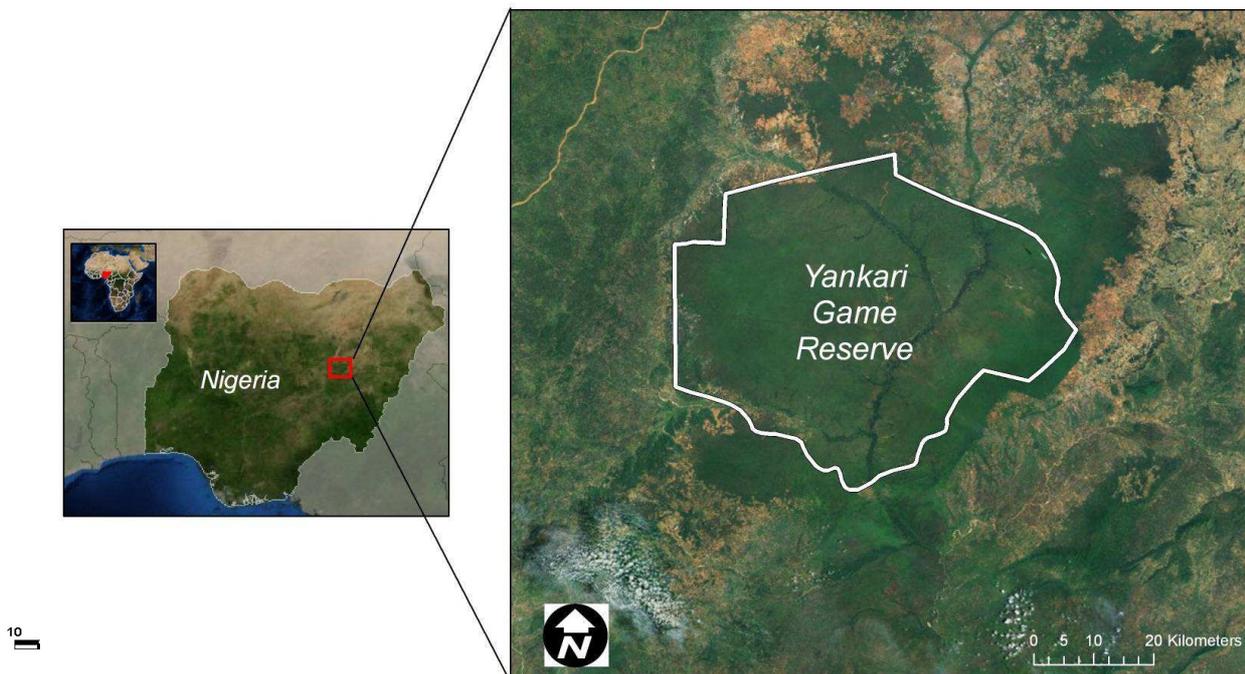


Figure 1: A Satellite image of the Map of Nigeria showing the location and map of the study site (Google Earth, 2013)

The reserve is bisected by the River Gaji. The two major habitat types that occur within the reserve are dry savannah woodlands and riparian vegetation, which includes areas of *Fadama*.

Common woodland trees include *Azalia africana*, *Burkea africana*, *Isobertia doka*, *Combretum glutinosum* and *Anogeissus leiocarpus*. *Gardenia aquilla* and *Dichrostachys glomerata* are frequent in the shrub layer while *Hyparrhenia involucrata* and *Hyparrhenia bagirmica* are dominant in grasses. In riparian forest *Khaya senegalensis*, *Vitex doniana*, *Acacia sieberiana*, *Tamarindus indica* among others are common (Geerling 1973; Birdlife International 2007).

About 337 species of birds have been recorded (Ezealor 2002). Of these, 130 are

resident, 50 are Palearctic migrants and the rest are intra-African migrants that move locally within Nigeria and or Africa.

Bird survey

Point count was used in this survey **Error! Reference source not found.** Points surveyed were laid out systematically in the savannah within seven grids with an area of 2 x 2 km each. Each grid had 100 points 200 meters apart. This was carried out using Map Source and a Garmin® GPS 60 (Garmin® Ltd 2006).

The Garmin® GPS 60 was used to locate all points within each grid. About 25 points were surveyed daily. Two minutes settling time was observed before bird counts were made at each point for 3 minutes. All birds seen and heard were recorded (Borrow & Demey 2004).

The surveys were conducted within the hours of 6.00 A.M and 11.00 A.M each day.

Vegetation measurement

Vegetation variables were measured around each point trees greater than 2 m tall (with trunk diameter > 10 cm – trees) were counted within a 100 m² quadrat.

Four 4 m² quadrat were selected randomly within each 100 m² quadrat and the following measurements were taken: Percentage ground cover to the nearest 5% (estimated by eye), the number of saplings (small trees taller than 1 m with trunk diameter ≤ 10 cm). Circumference of tree at breast height (CBH) (Manu et al., 2007). Number of flowering and fruiting trees. Number of bushes (≤1 m tall and 2 m in diameter). Number of shrubs (< 1m tall and <2 m in diameter).

Burnt points were taken as those burned early (early burns) in the dry season (immediately after the rains) and late dry season (late burns, just before the rains). While unburnt points were taken as those parts which fire did not extend to either during early burns or late burns.

Data analyses

One sample Kolmogorov Smirnov (1 Sample K-S) test was performed to check for normal distribution of data. Total number of birds was calculated by adding number of birds seen and heard. Bird species diversity was calculated using the Shannon-Wiener diversity index (H) as given in equation 1 below

$$H = -\sum_{i=1}^S P_i \ln P_i$$

-----equation
1

Where P_i is the ith proportion of individual species and S is the total number of species in the community (i.e. diversity) (Begon et al., 1996).

One Sample K-S test showed that bird species diversity and abundance did not conform to a normal distribution (diversity: Z=2.277, N=700, P<0.001, abundance: Z=3.136, N=700, P<0.001), therefore, non-parametric tests were used. Mann-Whitney U test was done to test bird species diversity and abundance in burnt and unburnt points, it was also used to check the effect of fire and time of burning on bird species diversity and abundance. Mann-Whitney U test is used to determine whether two independent samples have been drawn from populations with same distribution, it is the equivalent of the parametric unpaired t-test. As in all non-parametric tests, only ranks of measurements are used instead of actual measurements. (Arora et al., 2012; Ogbeigu, 2005). Multiple Linear regression analysis was used to determine the effect of vegetation variables on bird species diversity and abundance. Vegetation variables were the independent variables while bird species diversity and abundance were the dependent variables. The Enter method was used. Data analysis was done using Statistical Package for Social Sciences (SPSS) version 20 (IBM Cooperation and licensors, 2011)

Null hypothesis

1. Fire have no significant effect on the diversity and abundance of bird species in YGR
2. There is no significant difference between bird species diversity and abundance in burnt and unburnt points in the YGR

3. Timing of fire treatment have no significant effect on the diversity and abundance of bird species in YGR
4. There is no significant relationship between Vegetation variables bird species diversity and abundance in YGR

RESULTS

A total number of 7350 birds of 133 species and 46 families were recorded at

the 700 points (within the 7 grids). The mean number of birds recorded per point was $10.5 \pm SE$ (N = 700).

Effects of fire on bird species diversity and abundance

Mann-Whitney U test showed a significant variation in species diversity between burnt and unburnt points ($Z = -2.279, P < 0.05$). There was however, no significant variation in species abundance ($Z = -1.144, P > 0.05$) (Figures 1 and 2).

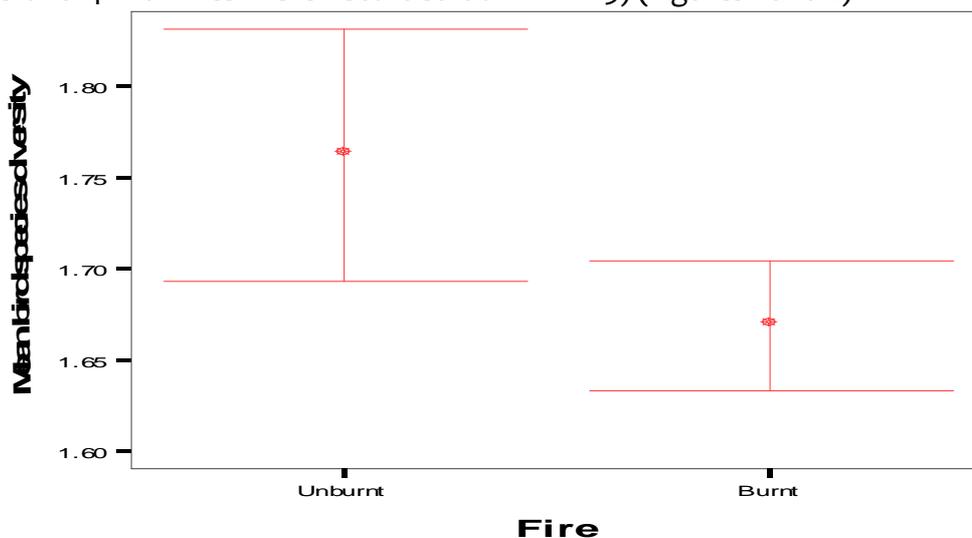


Figure 2: Effect of Fire on mean bird species diversity ($\pm SE$)

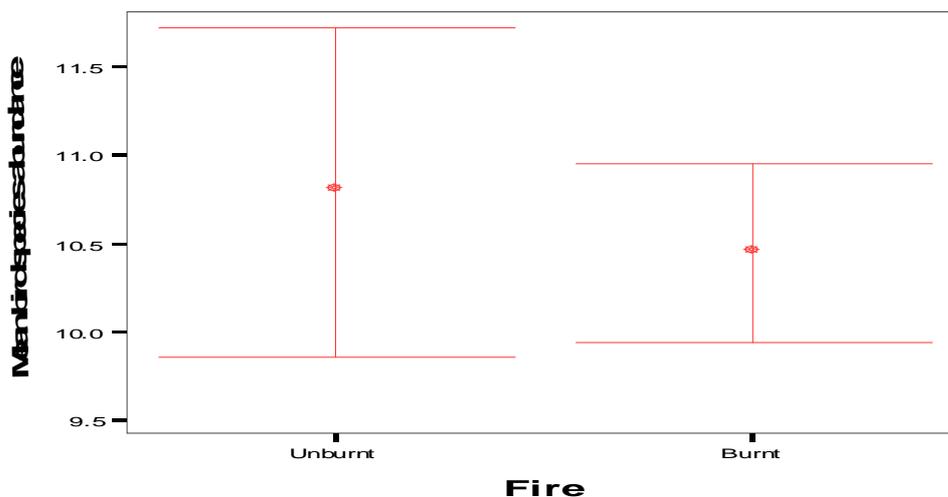


Figure 3: Effect of Fire on mean bird species abundance ($\pm SE$).

There was significant variation in species diversity between early burns and late burns (Mann-Whitney U test: $Z = -3.307$, $P <$

0.05), there was also a significant variation in species abundance (Mann-Whitney U test: $Z = -2.187$, $P <$

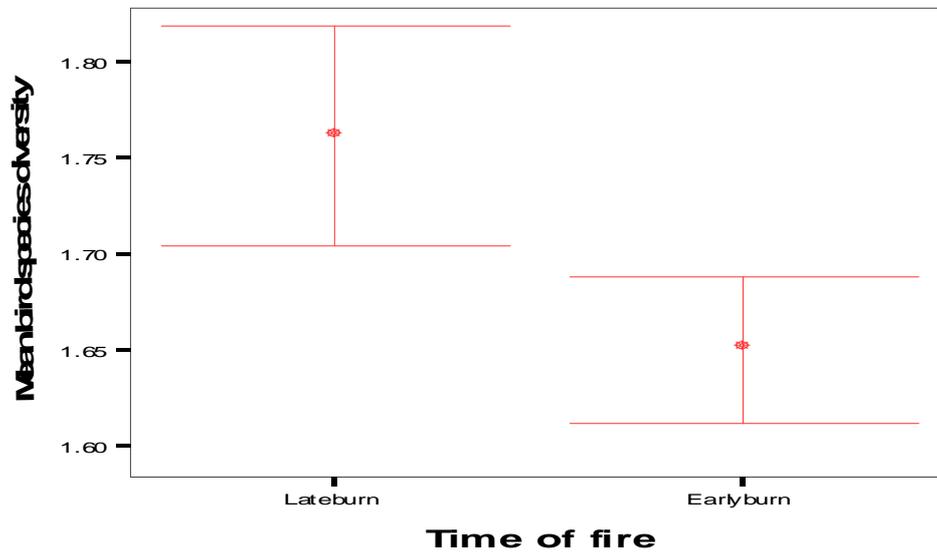


Figure 4: Effect of time of fire treatment on mean bird species diversity (\pm SE).

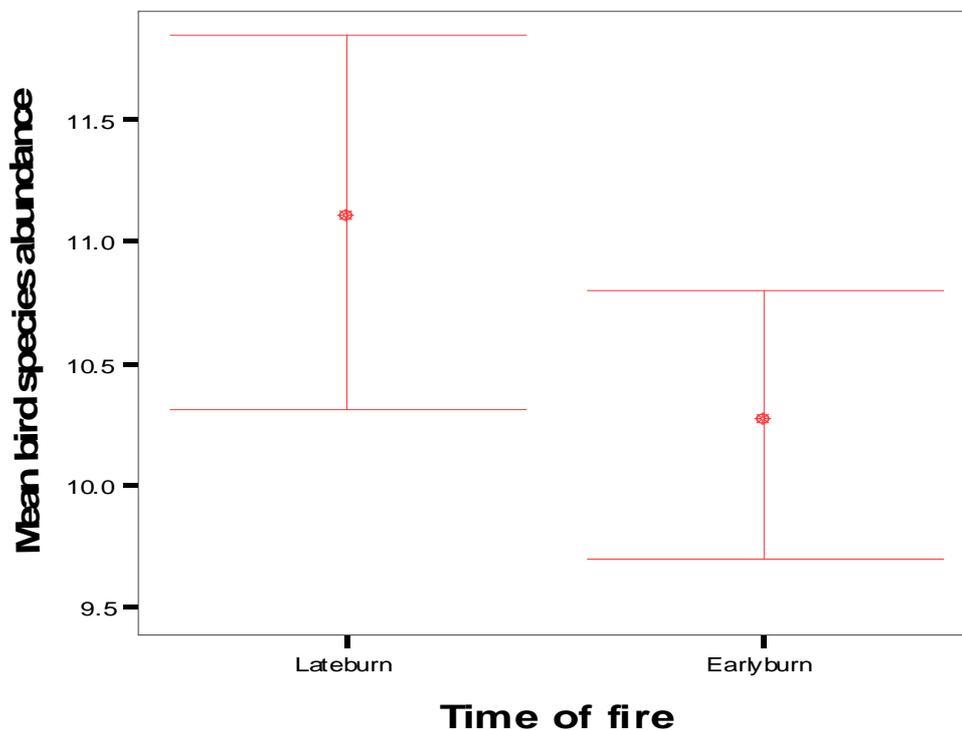


Figure 5: Effect of time of fire treatment on mean bird species abundance (\pm SE).

Effects of vegetation variables on bird species diversity and abundance

The following vegetation variables were included in the model for Linear regression analysis: Number of fruiting trees, number of flowering trees, number of bushes, number of saplings, and circumference of trees at breast height.

There was no significant relationship between vegetation variables and species diversity in burnt points ($F_{5, 582} = 0.882, P > 0.05, R^2 = 0.008$). But there was significant relationship between vegetation variables and species abundance ($F_{5, 583} = 2.882, P < 0.05, R^2 = 0.024$). Specifically, bird species diversity and abundance had a negative relationship with number of bushes and number of saplings.

There was no significant relationship between vegetation variables and species diversity in unburnt points ($F_{5, 104} = 0.426, P > 0.05, R^2 = 0.020$). There was also no significant relationship between vegetation variables and species abundance ($F_{5, 104} = 1.884, P > 0.05, R^2 = 0.083$). However, bird species diversity and abundance had positive relationships with Number of fruiting trees, number of flowering trees, number of bushes and number of saplings.

DISCUSSION

The observed difference in bird species diversity between the burnt and unburnt areas and the absence of such difference in mean bird species abundance between the two areas suggests that fire is a factor affecting the diversity of bird species in the Reserve. This agrees with several works that have been conducted (c.f. O'Reilly *et al.* 2006, Alan *et al.* 2006 and Alexis 2006). However, in the research by O'Reilly *et al.*, (2006), a higher diversity index in burnt than unburnt parts areas have been reported. The higher mean bird species diversity in unburnt areas compared to the

burnt areas may indicate lack of immediate resources for majority of birds to explore after fire. This may be because the resource exploited by these species may have been depleted by fire, therefore such have to look for other suitable and probably higher quality habits (Chaskda, 2011). Though not significant, bird species abundance was also higher in unburnt areas, this may be due to the fact that while only a few species have been shown to benefit from treatments with fire, many others are adversely affected (Kimmins, 1997). Also, because of the highly mobile nature of birds, species not directly benefited by fire may quickly fly away in the case of any fire treatment (Elgood *et al.* 1994; Cresswell *et al.*, 2009) to unburnt areas thereby increasing the abundance of such unburnt areas.

There was no significant relationship between vegetation variables and bird species diversity, vegetation variables however, had significant relationship bird species abundance at burnt points. This suggests that the abundance of certain bird species is affected by these vegetation variables (Chaskda, 2011). It was observed that bird species diversity and abundance had a negative relationship with number of bushes and saplings, this further suggests that more bushes and saplings probably limit the diversity and abundance of some of the bird species while decreasing number of bushes and saplings as a result of fire probably favour some (Kimmins, 1997). Although, there was no significant relationship between vegetation variables and bird species diversity and abundance in unburnt points, bird species diversity and abundance had positive relationships with Number of fruiting trees, number of flowering trees, number of bushes and number of saplings.

This may be because these vegetation variables provide resources such as fruits, nectar, and cover for some of the birds depending on their feeding guilds and behaviours. This is important in keeping with life histories of bird species (Roff, 1992) especially breeding success (Abdul, 2003). Investigations on the specific response of bird species diversity and abundance according to their feeding guilds in relation to fire and other savannah faunal taxa may explain for more variations and is hereby recommended (Elgood *et al.* 1994; Smith & Smith 2006).

Conclusion

Since the Reserve has suffered from the effect of intensive dry season bush fires for well over 30 years among other conservation issues, it has become pertinent for management actions to take effect immediately (NCF and WWF 1987; Green 1989; Birdlife International 2007). Therefore, we recommended that early burn fire regime should be practised in the

Reserve and elsewhere, this may ensure intermediate disturbance (Connell & Slatyer 1977; Sousa 1984; Ricklefs, 1990; Begon *et al.*, 1996; Maffe & Carrol 1994). This may also aid in checking unprecedented dry season bush fires initiation by poachers and herdsmen known for threatening the general survival of avifauna and biodiversity in the Reserve. More long time studies that focus on specific species, feeding guilds and the fire ecology of YGR are also recommended.

Acknowledgment

We thank the A.P. Leventis Ornithological Research Institute (APLORI) for funding this research work. We also thank those who greatly assisted us in the field: our colleagues Onoja Joseph, Zianab Oiza and Longtong Turshak, our driver Mr Haladu Idi and Mr Adamu Dogonruwa our Ranger. The immense contributions of our colleagues at APLORI during this work are hereby acknowledged.

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