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IMPACT OF FIRE ON WOODY PLANTS UTILIZE BY BIRDS FOR NESTING IN A SAVANNA WOODLAND

Turshak, L. G.[1], Da'an, S.A[2]. and Chaskda, A.A[2].

[1] Biological Sciences Techniques, Department of Science Laboratory Technology, University of Jos, Nigeria.
[2]Department of Zoology, University of Jos, Nigeria.
***Corresponding Author:** *longtongturshak@yahoo.com*

ABSTRACT

The phenomenon of fire and vegetation evolved long time ago. Due to man's activity, fire has assumed even an important dimension compared with other environmental variables in shaping the composition, biomass, structure, function and distribution of plant communities, including animal populations that dependent on them, especially in the savanna woodland ecosystem. This study investigates fire and its implication on trees and tree species utilized by birds for nesting in the Yankari Game Reserve, Nigeria. The study was carried out in Yankari Game Reserve (9°45'N 10°30'E), 100 km south east of Bauchi town, Bauchi State, Nigeria. The reserve covers a total area of 2, 244 km², in the east-central part of Nigeria. Line transect was used to record densities of vegetation and bird nest variables. Ninety transects of 1000 m long were placed randomly in the Savanna woodlands. Tree species and bird nests were identified and recorded along each transect. Density estimate of these variables were carried out at 100 m section along the transect line. All the variables were measured within a 20 x 20 m plot. Our findings showed that fire generally had negative impact on woody plants in the Yankari Game Reserve. More woody plants were affected during the late burning regime compared to the early regime. Higher density of death and stunted trees were recorded in the burnt areas of the Reserve. Birds appear to adapt well to the fire regime practiced in the Reserve. The Combretum tree species was most adversely affected by fire compared with other woody plants. Late fire regime was implicated to cause direct death and stuntedness in most woody plants perhaps due to its intensity. Many studies have shown that late fire regimes are hotter and more detrimental to woody plants. We recommend a review in policy of the burning regime to fit in with the ecological reality of the game reserve.

Key Words: Fire, Nest, Trees, Woody Plants, Savanna, Woodland, Seasons

INTRODUCTION

Determining the extent to which ecological systems are experiencing anthropogenic disturbance and change in structure and function is critical for the long-term conservation of biological diversity (Canterbury *et al.* 2000; Erikson, 2007). The phenomenal relationship of fire and vegetation has evolved a long time ago. Due to human activities, fire has assumed an important dimension compared with other climatic variables in shaping the composition, biomass, structure and distribution of plant communities, including animal populations depending on them (Erikson, 2007), particularly in the savanna ecological system (NCF and WWF 1987). Fire occurs mainly in the dry season at different times of the year in different parts of the world. It can occur at the beginning, middle or end of the dry season with markedly different ecological effects. The ecological effects of fire vary enormously according to the time of year, the quantity, condition and distribution of the fuel, the prevailing climatic conditions, the severity and intensity of the fire, the slope aspect and elevation, the vegetation and soil type (Kimmins, 1997).

Early dry season fires are rarely hot, and quantities of unburned grass stubble are left standing. This will not

support another fire in the same dry season. Early season fires are not a danger to the woody plants, however, they are detrimental to perennial grasses (Rose Innes, 1971; NCF and WWF 1987). When they are still partially green, they have not completed transferring their food reserves from leave to storage in the roots. Burning these perennial grasses could lead to loss of their food reserves. If there is enough moisture in the soil to induce sprouting again, it will be at the expense of these partially replenished root reserves. This further put stress on the grasses if they are grazed. Continual treatment of this phenomena year after year will results in eventual death of the perennial grasses (Rose Innes, 1971; NCF and WWF 1987).

Late season fires are not harmful to the perennial grasses because they do not sprout until after the rains have begun. But woody plants often sprout long before the first rains. The newly sprouted shoots are susceptible to burning at this season. Late season burns are extremely hot, damaging tree trunks and branches and the soil is exposed to isolation and erosion (Rose Innes 1971; NCF and WWF 1987).

Fire selection exerts an influence on the distribution of savanna trees. Some species possess protective coverings of thick bark or reproduce vegetative by suckers from shallow root systems (NCF and WWF 1987). Fire can be used as management tool in the Sudan and Guinea savanna zones. Annual fires set early in the growing season after the first rains, with trees sprouting but grass still remain dormant, may result in more open grassland after a few years, as woody plants must have been killed off. This may be good for grazing species, but harmful to perennial grasses if done on a yearly basis (NCF and WWF 1987).

This project came as a result of observation during a study of mammals and primates of the Yankari Game Reserve where the whole reserve was burnt. The fire regime seems to be carried out haphazardly. The fires are set between November and February of every year. A good number of the tree species in the reserve were observed to be death or having scars from the adverse effect of the fire. These trees were visibly wounded or stunted in their growths. Few bird nests were recorded in the reserve that stimulates an interest of whether or not the fire interferes with their breeding activities through damage to their nests. The aim of this study was to investigate the effects of fire on trees (woody plants) and tree species utilised by birds for nest and also to determine the impact of fire on some floristic components of the reserve. And to present the findings of the research to the managers of the reserve with the view to re-assessing the fire regime currently being employed. The objectives are to assess the impact of fire on tree species (woody plants), bird nests and some floristic components of the Reserve.

MATERIALS AND METHODS

Study site

This study was carried out in Yankari Game Reserve (longitude 9°45'N latitude 10°30'E; Figure 1), 100 km south east of Bauchi town in Bauchi State, Nigeria. The reserve covers a total area of 2, 244 km², in the east-central part of Nigeria. The reserve records an average annual rainfall of about 900 to 1000 mm, which occurs between April and October (Crick and Marshall 1981). The peak of the rain fall generally occurs in August. Prevailing winds are from the south west and temperatures are moderate (18^oC to 33^oC) during the wet season (NCF and WWF 1987).

Yankari Game Reserve lies within the Sudan Savanna Zone (Geerling, 1973) of Nigeria with a vegetation made up of swampy flood plain bordered by patches of forest, gallery forest and riparian forest, woodland Savanna (Crick and Marshall 1981). Yankari was designated and opened as Nigeria's biggest National Park in 1991 (but is now a game reserve). Yankari Game Reserve is the most popular destination for tourists in Nigeria and therefore plays a crucial role in the development and promotion of ecotourism in Nigeria (Odunlami, 2000). The Reserve is bisected by the River Gaji. Some common woodland tree species include *Afzelia africana, Burkea africana, Pterocarpus erinaceus, Isoberlina doka, Monotes kestingii, Combretum glutinosum, Detarium microcarpum* and *Anogeissus leiocarpus. Gardenia aqualla* and *Dischrostachis glomerata* (Geerling, 1773; Ezealor, 2002).

About 337 species of birds have been recorded (Ezealor, 2002). Of these, 130 are resident, 50 are pale arctic migrants and the rest are intra-African migrants that move locally within Nigeria and/or

Africa. The birds in the reserve include the Saddle-billed Stork (*Ephippiorhynchus senegalensis*), Martial Eagle (*Polemaetus bellicosus*), Abyssinina Ground Hornbill (*Bucorvus abyssinicus*), Narina's Trogon (*Apaloderma narina*) among others (Olokesusi, 1990).

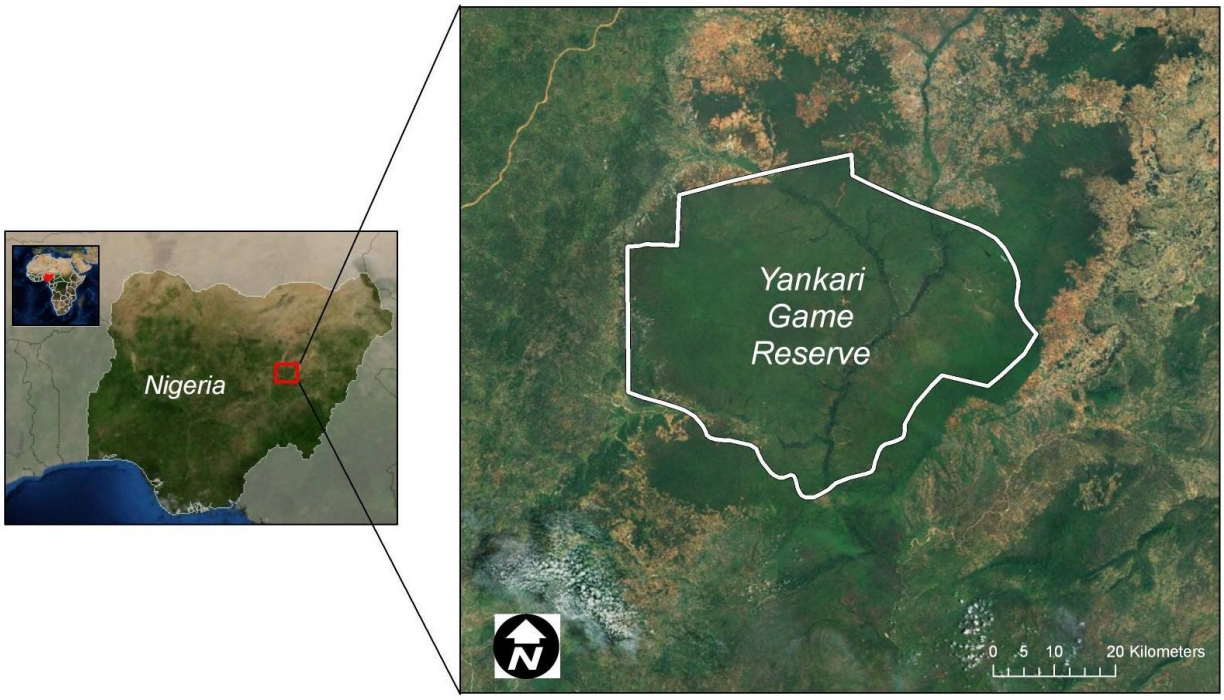

Figure 1. Map of Nigeria showing the Yankari Game Reserve, Bauchi State

Data Collection

Line transect as described by Bibby *et al.* (2000) was used to record densities of vegetation and bird nest variables. Ninety transects of 1000 m long was selected by random stratification in the Savanna woodlands. The following variables were recorded at each 100 m section along the transect line:

1. density of wounded trees (caused by fire), trees with visible scars due to fire,
2. density of stunted trees (caused by fire), trees whose growth are affected by fire,
3. density of death trees (caused by fire),
4. density of wildlings or saplings (young growing woody plants of equal to or less than one meter in height),
5. density of trees (woody plants greater than one meter and above),
6. density of old (non active) and new (active) bird nest.

Tree species and bird nests were identified and recorded along each transect. Density estimate of these variables were carried out at each 100 m section along the transect line. All the variables were measured within a 20 x 20 m plot. A tree is considered when the circumference at breast height (CBH) is 50 cm; below that height is a wildling (sapling). A wildling or sapling in this study was measured one meter and below in height (modification from Kent and Cooker 1996 and Bibby *et al.* 2000). All variable were counted within a 100 m width strip to allow for density estimate. Field work for data collection lasted for a period of four months before and after the fire. When a nest was found, its location was marked using the Global Positioning System (GPS) and the nest was given an identification number (ID) and the following variables recorded: date, location (tree species), nest height in trees, height of tree in which nest was located**.** Woody plants were identified using Arbonnier (2002).

Statistical analysis

Data collected was found to conform to a normal distribution hence, parametric statistics were used for analysis. Student T-test was used to test the effect of fire on woody plants, while paired sample T-test was used to test the effect of fire regime on some measured floristic components of the reserve. Paired sample T-test was also used to test the effect of fire regime on bird nests density, one-sample Test was used to test the effect of tree height on choice of tree for nesting. One way ANOVA was used to compare mean number of old and new nests seen in areas treated with the different fire regimes. Data analysis was done using Statistical Package for Social Sciences (SPSS version 21).

RESULTS

Impact of fire on tree species and some floristic components in the reserve

Fire had a significant effect on the different species of woody plants recorded in the reserve (student t-test; $t=36.5$, $df=179$, $p<0.001$). The woody tree species most affected are mainly the genus *Combretum*, *Balanites*, *Ziromthes*, *Anogeissus*, *Crosopteryx* and *Acacia* in decreasing order (Figure 2).

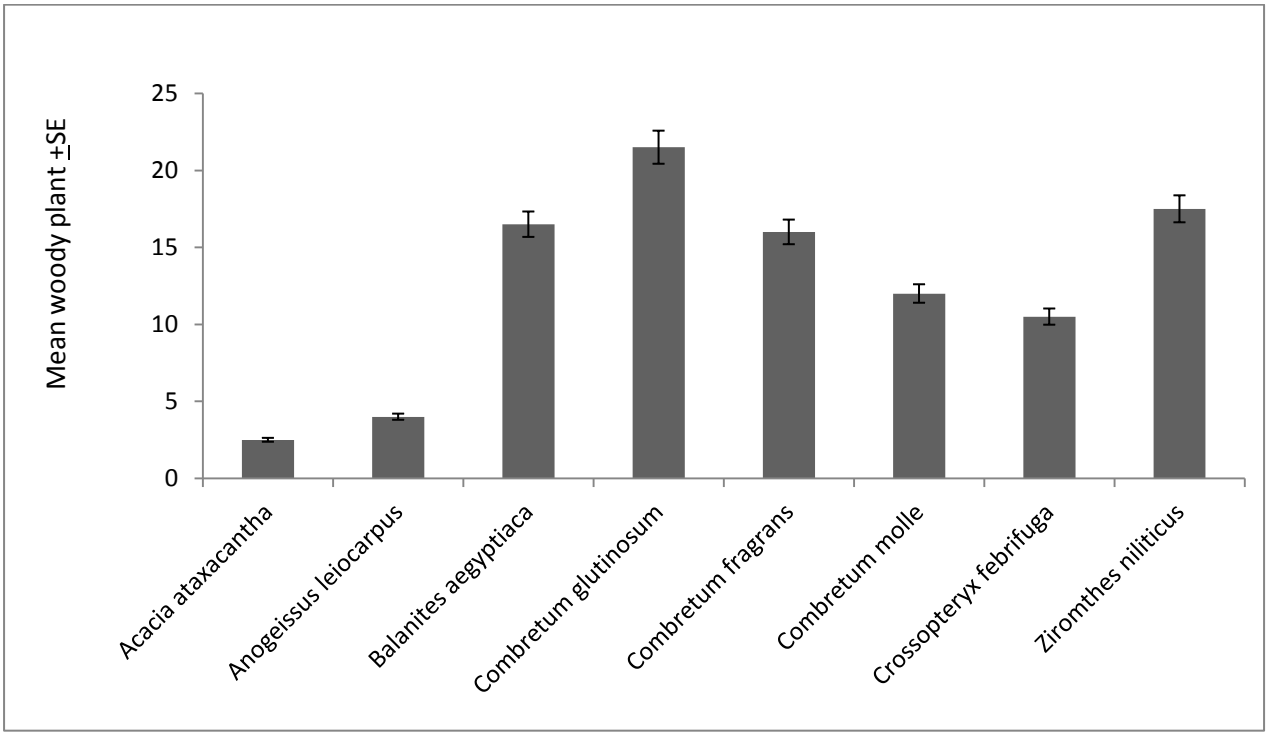

Figure 2. Density of death woody plant species caused by fire (Filed Survey 2010)

Except for density of wounded trees and wildlings, fire caused significantly high densities of death trees, stunted trees, life trees, shrub, bushes and mean number of nests in the burnt than in the unburnt part of the reserve (Table. 1). Late fire regime had a significant effects on the density of death trees (paired-sample t-test; $t=-8.886$, $df=74$, $p<0.001$), density of stunted trees (paired test; $t=-2.985$, $df=74$, $p<0.001$). However, no fire regimes had a significant effect on the density of wounded trees in the reserve (paired test; $t=1.191$ $df=74$, $p=0.237$).

Table 1. Effects of Fire on measured floristic components in burnt and unburnt areas

	Pair variable	T	df	P
Pair 1	Density of death trees	-10.068	89	<0.001
Pair 2	Density of stunted trees	-4.062	89	<0.001
Pair 3	Density of wounded trees	1.416	89	0.160
Pair 4	Density of life trees	0.681	89	<0.001
Pair 5	Density of wildlings	-3.807	89	0.497
Pair 6	Mean number of nest	-3.814	89	<0.001
Pair 7	Density of shrubs	3.823	89	<0.001
Pair 8	Density of bush	6.667	89	<0.001

(Field survey 2010)

Impact of fire on bird nests in the reserve

There was a significant difference in the mean density of bird nest between burnt and unburnt areas of the reserve (paired-sample t-test; t=-3.814, df=89, p<0.001; Figure 3). There ware more nest recorded in the burnt area compared with the unburnt.

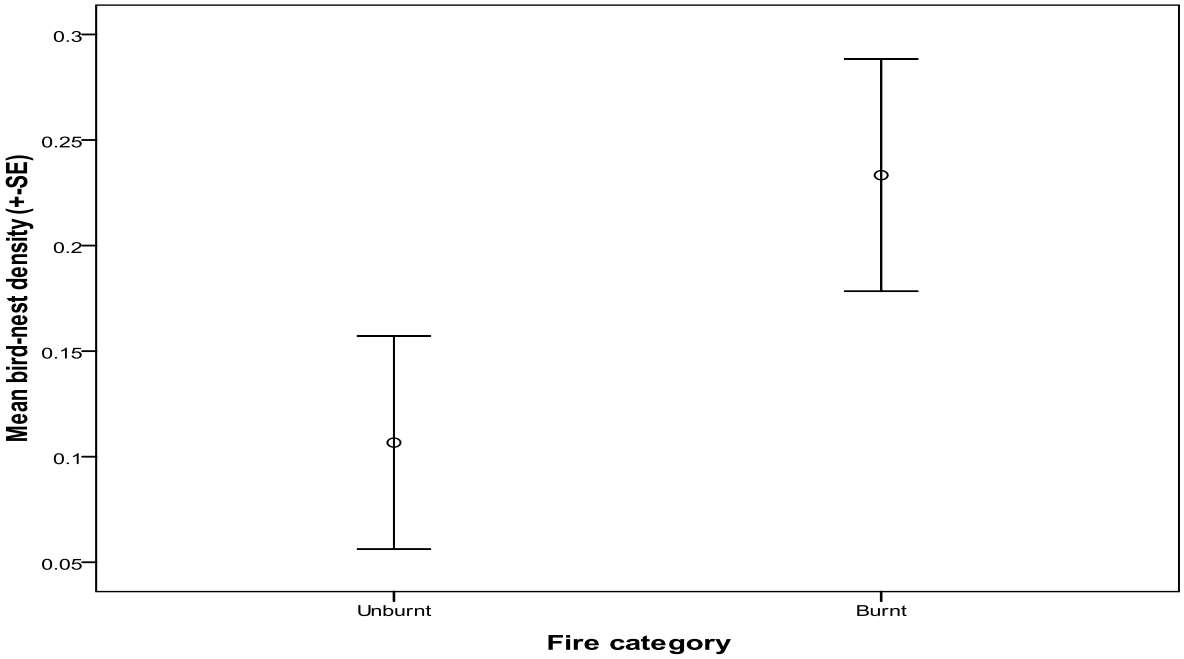

Figure 3. Mean bird-nest density (Field Survey 2010)

There was also a significant difference in the choice of height by which birds establish their nest in trees (One-sample t-test; t=31.783, df=153, p<0.001), and the height of trees that birds choose to build their nest (One sample t-test; t=30.332, df=153, p<0.001). Majority of birds established their nest on the following plant species, *Combretum glutinosum*, *Combretum fragrans, Ziromthes noliticus, Balanites aegyptica, Combretum molle, Crosopteryx fabrifuga, Anogeissus leiocarpus and Acacia ataxacantha* in a decreasing order (Figure 4).

A comparison of the mean number of old and newly built bird-nests in burnt and unburnt areas indicates that there was no significant difference ($F_{152, 142}$=0.802, t=-0.74, p=0.941). However, most birds established their nest in trees at 5.4 m height.

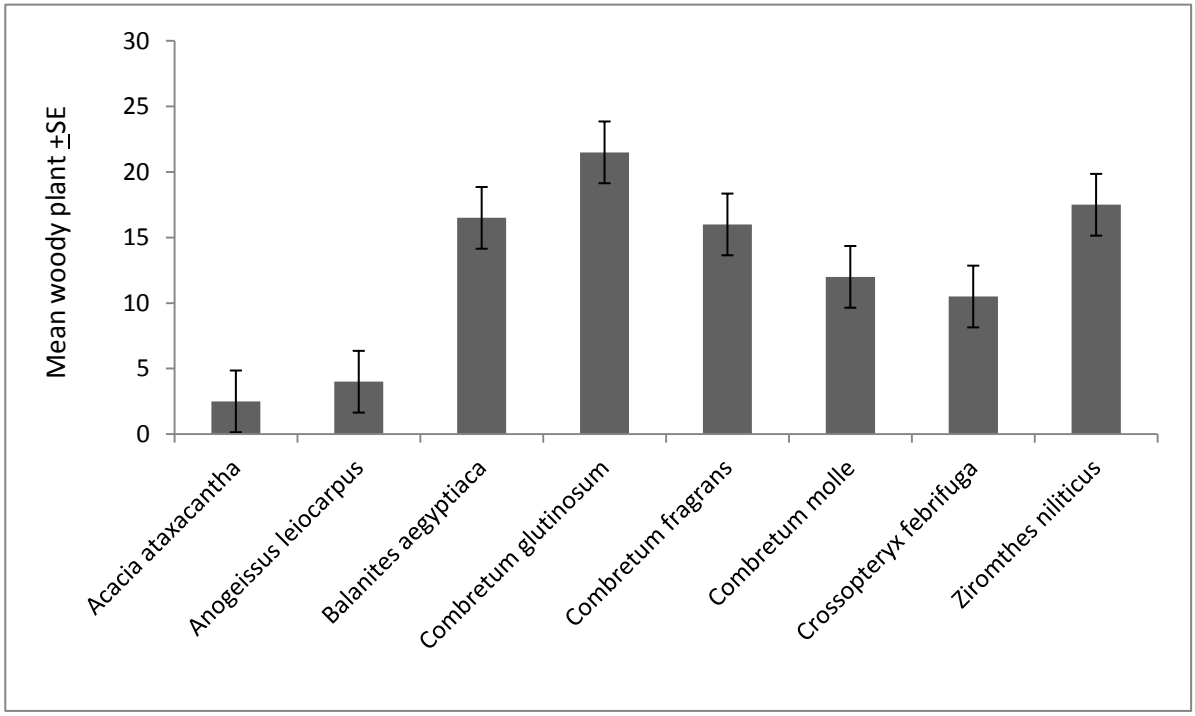

Figure 4. Mean woody plants preferentially utilized by birds for nesting (Field Survey 2010)

DISCUSSION

Impact of fire on tree species and some floristic components in the reserve

Fire has been shown to cause direct decline in the cover of woody vegetation by killing trees or reducing them to smaller sized classes (Andy, 1993). Fire had a significant effect on the different species of woody plants recorded in the reserve. This implies that there were significantly more tree species killed or damage by fire in the burnt area of the reserve compared with the unburnt area. The most affected of the plant species by fire are shown in Figure 4, the tree species affected are mainly of the genus *Combretum, Balanites, Ziromthes, Anogeissus, Crossopteryx, Acacia, and Afzelia.* The Yankari Game Reserve is said to be dominated by the Combrataceous woody plants. This perhaps explains why it tops the list of woody plants from the reserve most vulnerable to fire. These results concur with that of Miller & Silander (1999), where fire also had a significant effect on the vegetation composition and diversity of two species of *Puya* in Paramo, Northern Ecuador, preventing the habitat from attaining its true climax of a forest. The negative effects of fire on woody plants over time could eventually change the vegetation of the reserve, with possible replacement of the present woodlands with alien species.

Furthermore, there were significantly higher death and stunted trees in late burn compared with early burnt, this was also true for density of death and stunted trees between burnt and unburnt area, where a significantly higher number of death trees in burnt area of the reserve were recorded compared with the unburnt area. However, fire did not impact significantly on wounded trees neither between late and early burn, nor between burnt and unburnt. This suggests that the fire intensity caused direct death and stunted growth to most woody plants. Many studies have shown that late fire regimes are hotter and detrimental to woody plants (NCF & WWF 1987; Baxter & Getz, 2005). This is important, since the woodlands of Yankari Game Reserve has suffered drought between 1983 and 1986 (NCF & WWF 1987). Perhaps early burn regime should be adopted in the reserve, and the burn should be carried out once every three or four years. The establishment of fire breaks in the early dry season is very crucial; this could help in curbing illegal fire set up by poachers and pastoralists.

There was a significant effects of fire on other floristic components of the reserve except for density of wildlings. Higher tree density, shrub density, bush density, percentage grass cover, percentage bear ground in the burnt area compared with the unburnt area. These results are expected especially that the late burns are carried out when the grasses are dried (Baxter and Getz 2005) Wildlings are shorter plants compared with trees; one would expect the hottest situation slightly above the wildling height compared with trees which are taller.

Impact of fire on bird nest in the reserve

There are a lot of factors that interferes with the breeding activities of birds, one of which is fire, particularly in the guinea savanna region (Stutchbury and Morton, 2001). Fire had a significant impact on bird nest in the reserve. There were significantly more bird nest recorded in the burnt area of the reserve compared with the unburnt area which perhaps suggests that breeding birds have learned to avoid fire from burning their nest by establishing nests after the fire regimes. It means that breeding birds have become adapted to the fire regimes; they do this by maximizing their fitness in breeding after the fire regimes. The genus *Combretum* commonly use for nesting, unfortunately, are the woody plant species mostly affected by fire. The preferred woody plants use for nesting activity in decreasing order include *Combretum glutinosum, Combretum fragrans, Ziromthes noliticus, Balanites aegyptica, Combretum molle, Crosopteryx fabrifuga, Anogeissus leiocarpus and Acacia ataxacantha*. *Combratum* species may be in use by birds for establishing their nests is probably due to suitability and availability in the reserve. Observation showed that the woody plant can be as long as 5 m high.

There was no significant difference in the mean number of old (non-active) and new (active) nests. Most of the non-active nests were used in the last breeding season, some of which are refurbished for a new breeding season. The nests were established almost to the top of the tree where fire in some cases during the dry season is unable to reach. This could be a strategy to avoid uncontrolled fire occurrence, by this; birds are able to renew the nests in the next season easily, thereby minimizing energy usage in building a new nest.

CONCLUSION

This study indicates that breeding birds have well adapted to the fire regime at the Yankari Game Reserve as they breed after fires have been set. In addition to this, fire impacts negatively on the woody plants of the reserve most of which are combretum species commonly utilised by birds for nesting. Based on the findings of this study, the following conservation action plans are recommended in order to address conservation issues relating to fire. Firstly, we recommend that the early fire regime be practiced as this study afirmed that early fire regimes does not impact adversely on woody plant density compared with late fire regime. Early fire regime could be set up between late October and Early January, beyond which may adversely affect woody plants. It will be best to burn the reserve in three or four year interval to maintain natural status quo of the savanna woodland system. The early fire regime system has the advantage of avoiding incidental fire set up by poachers and herdsmen, particularly during the late dry season when fire has a more devastating effects on woody plants.

Secondly, the importance of fire breaks throughout the reserve cannot be overempahsised. Creating fire breaks will help to prevent fires set by poachers, hunters and herdsmen that intrude the reserve illegally. Thirdly, an educational awareness campaign should be organised for the adjoining communities of the game reserve. This is to inform them of the negative implication of indescriminate setting of fires. Setting up a site support group in the adjoining communiteis may help to put a watchfull eye on illegal activities in the reserve. The importance of local community conservation support group can not be overemphasised.

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