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Effects of early and late-dry season fires on mortality, dispersal and breeding of malimbe *Malimbus scutatus* in the Southern Guinea savannah

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ABSTRACT

Inappropriate use of fire in the guinea savannah is one of the main processes threatening its biodiversity and despite its importance in shaping savannah, it remains poorly understood how the frequency, seasonality and intensity of the fire interact to influence the activities of bird species. While species adversely affected by fire have been documented, empirical studies that seek to identify the ecological mechanisms that underpin this decline are rare. This paper examined the effects of early- and late-dry season fires and a control on the mortality, dispersal and breeding of malimbe *Malimbus scutatus* in Ikwe Wildlife Park and also tested whether the early fire area became a refuge after the late fire. None of the fire treatment caused any increase in mortality. Individuals relocated short distances to unburnt habitat following both fires. Some birds use the early fire area after the late fire. Mayfield (1975) method of estimations of daily egg-survival probability showed no difference ($P > 0.05$) among the treatments, whereas the daily probability of nestling survival was significantly lower in the late fire area. Results suggested that the reproductive output of malimbe was low following late-dry season fire, and this is the main mechanism that explains their decline. This study provides support for the idea of using early-dry season prescribed burning to limit the effect of late-dry season fire on malimbe.

Keywords: inappropriate use, threatening, biodiversity, seasonality, poorly understood, nestling survival.

INTRODUCTION

The broad structural and floristic change in the guinea savannah habitats is inferred to be the principal cause of the loss in vertebrate biodiversity, and mostly suggested that fire is a key process causing change (Murphy et al., 2009). Inappropriate use of fire in the guinea savannah is one of the main processes threatening the biodiversity (Andersen et al., 2003) and despite its importance in shaping savannah, it remains poorly understood how the frequency, seasonality and intensity of the fire interact to influence the activities of bird species (Ensliu et al., 2000). While the set of species adversely affected by fire has been well documented, empirical studies that seek to identify the ecological mechanisms that underpin these declines are rare (Woinarski, 1999).

Other processes, such as predation, overgrazing or disease may be acting (Woinarski et al., 2004). Fire is an inevitable and natural process in savannahs worldwide

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because of prolific wet season growth (particularly grass) followed by dry-season curing (Usman, 2002). He further reiterated that there has been a dramatic increase in the frequency, scale and intensity of fires in the guinea savannah in recent years.

Fires that occur later in the dry season, when grass fuel is most cured, are typically more intense and cover much larger areas than those that burn earlier (Andersen et al., 2003). For these reasons, late fires are perceived to be more threatening to biodiversity, infrastructure and livestock than those that burn earlier. Prescribed burning early in the dry season is widely practiced by land managers to reduce fuel loads, create refuge for biodiversity and livestock and for generally creating the landscape heterogeneity that has long been thought important for maintaining biodiversity (Parr and Andersen, 2006). Early fires also release fewer greenhouse gases (Russell-Smith et al., 2004).

Here we present results of a study that employed an accurate ecological approach to examine the effects of early and late fire on malimbe. In this study, we examined the effects of three treatments (unburnt, early fire and late fire) on the mortality, dispersal and breeding of malimbe as well as to find out whether individuals affected by a late season fire use areas burnt earlier in the same year as a refuge.

MATERIALS AND METHODS

Study site and experimental design

The study was conducted in Ikwe Wildlife Park between Oct.-April, 2010 and Oct.-April, 2011. The park is located in the southern guinea savannah belt and lies between latitude 7^0 26 and 7^0 30'^{N} and longitude $8^0$37'^{E} and covers approximately 2,500 ha of land. The park is fenced off the road and the adjacent to Igbor village, to prevent wild animals from wondering to the village and the main road.

Three main microhabitats of the park are woodland savannah, grassland savannah and riparian vegetable all located within the contiguous stretch of the park (Egwumah, 2005). The riparian forest occupies about 20% of the park and composes of matured trees and where the forest is not disturbed, several trees attain the height of up to 12 m. Dominant trees are *Berlinia grandiflora, Annona senegalensis, Ficus ardisiordes, Kigelia africana, Acacia polycantha* and *Syzygium guinensis*. The tree tops carry an array of epiphytes and liana, which represent a complex plant community. The woodland vegetation makes up about 60% of the park and it is composed of the following woody trees; *Prosopis africana, Parkia biglobosa, Daniella oliveri, Vitex doniana* and *Vetellaria paradoxia*. The undergrowth is a mixture of annuals and perennials, forbs and grasses like *Imperata cylindrica, Pennisetum pedicellatum, Hyparrhenia involerata, Loudetia flavida, Panicum maxima* and *Tridax procumbens.*

There are two distinct seasons in the southern guinea savannah as described by Usman (2002). These are dry season which runs from October to March and rainy season which is within April and September. Three populations (unburnt, early burnt and late burnt treatment) were identified in areas that have common fire history, floristic and structural similarity.

Observation of a typical end of dry season in southern guinea savannah is characterised by a relatively small total area of early prescribe burns intermingled with large areas of late burn. The two experimental fires (early and late burn) were put together, whereas the edge of the unburnt control population was located 500 away. Birds in each population areas were censused at 70 different point count locations in riparian (which serves as control) 90 ha woodland savannah (early fire) 50 ha and grassland savannah (late fire) 80 ha. Investigation into mortality, dispersal and breeding we used a BACI, (before-after control-impact) experimental design.

Experimental fires were contained by fire tracing around the perimeter (width 20 m) and burning the fire in the morning for early fires. Moisture content was 20.3% (n=13; ± 4.6% s.d) for *Imperata cylindrica* and 20.7% (n=13, ±4.8% s.d) for *Panicum maxima*. Late fire lit mid-morning and fuel moisture was 4% (n=11± 1.7% s.d) in *Imperata cylinderica* and 7.9% (n=8; ±3% s.d) in *Panicum maxima*. Fuel moisture content was calculated by weighing fresh grass samples on digital scales and after oven-drying for 36 hours. Early fire burnt 70% of the defined 50 ha area, while late fire burnt 98% of the defined 80 ha area, which is typical of fires at this time of year.

Mortality, dispersal and breeding

To determine fire-induced mortality and dispersal, we recorded the locations of the birds using GPS at each point where census has taken place. This was done in the morning and afternoon for two months before and two months after each experimental fire and also for the control population in the riparian vegetation.

For mortality analysis, we compared pre-and post-fire repeated observation to determine the number of birds that had disappeared from each population by the end of each post fire period. Post-fire period was approximately one month after each fire. We tested the significant of the observed differences by using chi-square test. Any differences between control and treated populations could be due to the effect of the fires, arising from fire-induced mortality.

Malimbe in the study area breed in the wet season. They incubate their clutch (3 eggs) for 14 days and nestlings remain in the nest for 12 days. The globular roughly woven nests are suspended from a palm frond or shrubs. Nests were searched by following nest-building individual and search effort was equal among treatments. To minimise disturbance, nests were visited weekly when clutch size, brood size and progress were recorded using an improvised periscope.

Breeding success was calculated for all nests by the Mayfield (1975) method of estimating the daily probability of survival for eggs and nestlings. Differences among population in the daily probabilities of survival for each stage (incubation and nestling) were examined by using standard analysis of variance. Nest heights above ground (in cm) were recorded. Subset of complete nests were oven-dried and weighed (in g) where clutches or broods were observed and assessed whether population could explain variation in these attributes, by using standard least-squares regression.

RESULTS

Mortality, dispersal and breeding

There was no significant difference ($p>0.05$) in the number of birds that disappeared after each fire compared with the control population. Four birds disappeared in the post-early fire period from both control and treatment populations (n=16 and 30 respectively, early *versus* control, contingency analysis: $\chi^2_1= 0.55$, P=0.46) whereas six birds disappeared from the control population in the post-late fire period (n=44) and four birds from the treatment in the same period (n=57; contingency analysis $\chi^2_1=1.4$, P=0.24). For birds seen in burnt habitat, the mean distance to unburnt habitat was 12m and this distance was significantly ($p<0.05$) smaller than the 70 randomly allocated points (n=46, $t_{144 = -2.37}$, P=0.22) which showed that individual remained near unburnt cover when using the burnt area.

Calculated daily survival probabilities for 50 nests that had either eggs or chicks were carried out. Survival probabilities was equal among treatments during the incubation stage (n=598 egg days $F_{2, 30} = 0.61$, P=0.55); whereas the probability of nestling survival was significantly lower for the late fire

treatment than either the unburnt or early fire treatment (n=487 nesting days; $F_{2, 25}$=3.67, P=0.04; Fig 1).

There were significant ($p<0.05$) differences in the substrate height and mass of nests among the populations. Pairs in the unburnt population nested frequently in shrubs and never in trees (n=88; $X^2_6 = 24.3$, P=0.005; Fig 2).

Nests in the late fire area were higher than those in the unburnt area, whereas nest height in the early fire area was intermediate (n=52; $F_{2, 49} = 4.2$, P = 0.02; Fig 3).

Nests in the unburnt area were significantly heavier than nests in the early fire area, whereas nest in the late fire area were intermediate in mass (n=40; $F_{2, 37}$ =5.0; P=0.01; Fig 3).

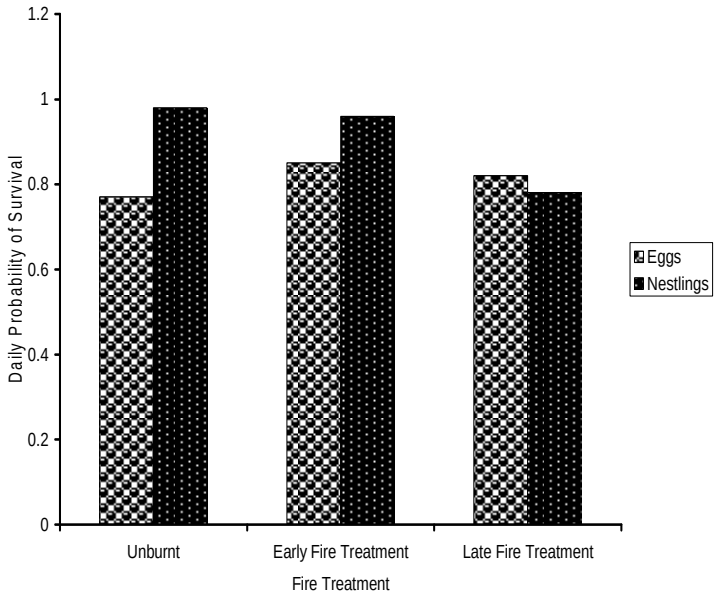

Figure 1: Estimations of daily survival probabilities for malimbe eggs and nestlings in three populations.

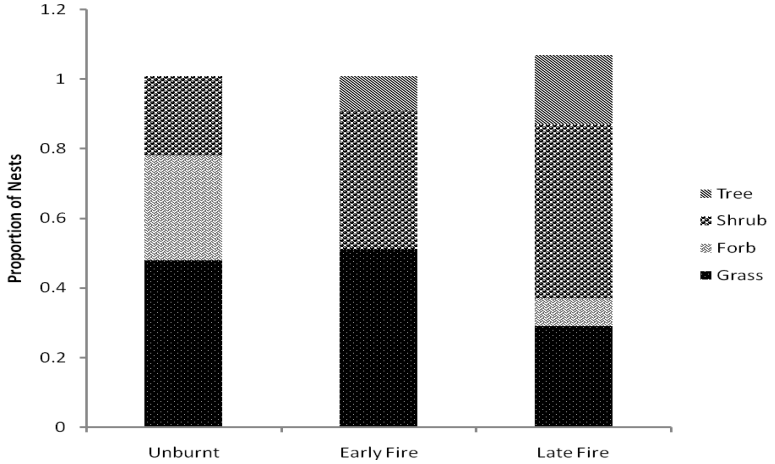

Figure 2: Variation in the Malimbe nest site among unburnt, early fire and late fire treatments.

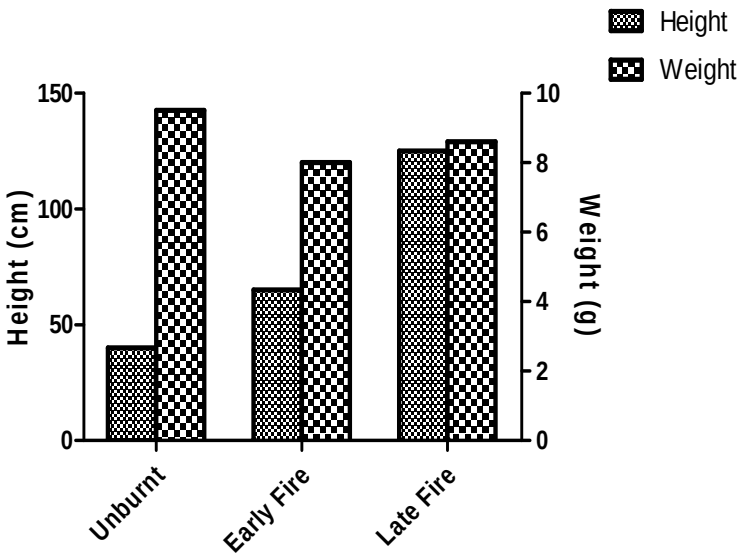

Figure 3: The effect of unburnt, early fire and late fire treatments on nest weights and height in Malimbe.

DISCUSSION

Despite fire being identified as a threatening process in Ikwe Wildlife Park ecosystem, little empirical evidence exists to explain why some bird species are negatively affected. Results of this work shows that the absence or decline of malimbe following fire in guinea savannah as demonstrated by this study may be due to (a) short distance dispersal away from burnt areas which is due to short-term effect of early and late fires and (b) reduced reproductive output in subsequent breeding seasons after late-dry season fires. These assertions are not at variance with the findings of Valentine et al. (2007).

There was no evidence to suggest that the mortality of adults caused population decline in malimbe following fire. It was expected that individuals will be incinerated by fire, a conclusion reached by Humple and Holmes (2006). Census results showed that fire-affected individuals relocated to adjacent unburnt habitat, and used unburnt patches within the burnt areas. Birds also used burnt habitat, but remained close to unburnt habitat while doing so. Behavioural observations showed that early burnt area was used only for foraging and resting and it is important to note that early burnt areas are used more by malimbe in a typical late-dry season fire affected habitat, where unburnt habitat is rare. This was also observed by (Egwumah, 1998). These findings are in line with those of (Russell-Smith et al., 2003; Price et al., 2007) while working in the savannah region of Australia.

Pairs nesting in the late fire-treatment area showed lower reproductive output for the season than the pairs nesting in unburnt and early burnt habitat. This was due to starting late shorter breeding opportunities, and lower daily survival probabilities. The difference in reproductive output is likely to be related to vegetative cover, though we did not collect data to show difference in the rate of regeneration between early and late treatment.

Survival probabilities of eggs were equal among the three populations, although nestling survival was significantly lower in habitat burnt late. It was suggested that reduced cover in the late fire area made visit to nest by attending parents more conspicuous to predators and that explains lower nestling survival rate. This idea was not at variance with those of Martin et al. (2000). Pairs sought for nesting site whenever they could find it, even if it meant nesting in trees, which also explains the significant difference ($p<0.05$) in nest height between treatments.

Conservation implication

Putting everything together, these results supported the idea that prescribed early burning in the dry season to combat extensive late-dry season fire is likely to benefit Malimbe and other species, if only unburnt habitat is retained nearby. We do not suggest that complete fire exclusion will benefit malimbe or other savannah birds, because as Higgins (2007) showed that such long term fire exclusion may cause detrimental changes to habitat via wood thickening. As discussed earlier, in addition to using the early fire area the majority of late fire residents rely on adjacent unburnt habitat for specific behaviours presumably to avoid potential predation risks. This highlights the need for land managers to use prescribed burning in a way that creates multiple well-spaced unburnt habitat patches that have a high chance of escaping from late-dry season fires a theme echoed by Audersen et al. (2005).

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