Journal of Research in Forestry, Wildlife & Environment Vol. 12(2) June, 2020
E-mail: jrfwe2019@gmail.com; jfewr@yahoo.com
http://www.ajol.info/index.php/jrfwe
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ISBN: 2141 – 1778
Awoyemi et al., 2020

PATTERNS IN AVIAN NEST PREDATION IN NORTH-CENTRAL NIGERIA: AN EXPERIMENTAL STUDY

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ABSTRACT

This study investigated the nest predator community and factors contributing to avian nest predation in the Amurum Forest Reserve and some surrounding farmlands, north-central Nigeria, May 2015. A total of 240 artificial nests were randomly and equally placed; elevated in shrubs and on ground vegetation within different habitats. Of this total, 160 nests were visited every third day (visited nests) while 80 nests were only visited on the last day of the experiment to determine their fate (unvisited nests). We tested the effect of vegetation parameters on the Daily Survival Rate (DSR) of visited nests as well as the influence of visitation on the predation probability of the two groups of nests. Overall, 69% of the artificial nests were predated and the potential predators captured on camera traps were the African Giant Pouched Rat Cricetomys gambianus, Tantalus Monkey Chlorocebus tantalus and Black Rat Rattus rattus. DSR was significantly influenced by nest position only in the rocky outcrop and savannah, although it seemed higher for the elevated nests in all the habitats. We found no significant effect of the vegetation parameters on DSR. The significantly lower predation probability recorded for visited compared to unvisited nests suggests that nest predators in the study area tend to avoid areas that are frequently visited by humans, an indication of anthropogenic impacts and anti-predation strategy. The findings of this study can enhance our understanding of potential nest predators in the study area as well as how nesting behaviour of bird species can influence predation risk.

Key words: *Daily Survival Rate, nest predation, model egg, camera trap, predation probability*

INTRODUCTION

An understanding of the factors that influence population trends is important for bird conservation. Nest predation is one of such factors, often being the single most important driver of variation in reproductive success (Little *et al.* 2015). Although the main direct cost associated with nest predation is the loss of offspring, nest predators can produce additional indirect effects mainly through behavioural and physiological changes (Jones *et al.* 2006; Ibáñez-Álamo *et al.* 2011; Ibáñez-Álamo and Soler, 2012). Arboreal- and ground-nesting birds are likely to be at risks from different predators, with the overall risk also varying with habitat, region, season, time of day and nest form (Wilcove, 1985; Trine, 1998; Willson *et al.* 2001). To reduce the risks of predation, birds use different vegetation variables to conceal their nests (Sofaera *et al.* 2012).

Studies aimed at investigating avian nest predation have used artificial nests and eggs to unravel some aspects of natural nest predation experienced by birds nesting in similar habitats (e.g. Söderström *et al.* 1998; Sedláček *et al.* 2014). Although this method has been criticised, partly because artificial nests tend to suggest higher predation rates than real nests (Berry and Lill, 2003; (Burke *et al.* 2004), artificial nests are useful in cases where real nests are not readily available in sufficient numbers, and predation cannot be inferred from nest remains (Larivière, 1999). This technique has also been useful in determining the influence of researchers on the reproductive outputs of birds (Rodway *et al.* 1996). For instance, studies have shown how some predators use cues (e.g. human scent, frequency of visits to nest sites and begging calls by nestlings) to locate and depredate avian nests (Leech and Leonard, 1997) and those that avoid nesting areas that are frequently visited by humans (Miller and Hobbs, 2000; Francis *et al.* 2012). These suggest that patterns in nest predation rate could be dependent on the types of predators present in a particular region and habitat.

These studies were mainly conducted in temperate areas, suggesting the need for more tropical data, particularly those conducted in the sub-Saharan Africa, for comparison. In the present study, we experimentally investigated nest predation in a tropical environment, to identify nest predators, compare predation rates across nest positions and habitats, and test the effects of nest concealment and visitation rate on predation risk.

MATERIALS AND METHODS

Study Area

The experiment was conducted within the Amurum Forest Reserve and some surrounding farmlands in Jos, north-central Nigeria (9°53'N, 8°59'E, Fig. 1), from 13 to 31 May 2015. The reserve covers c. 300 ha, comprising three habitat types, including gallery forest, savannah and rocky outcrop. Two endemic birds, Jos Plateau Indigobird *Vidua maryae* and Rock Firefinch *Lagonosticta sanguinodorsalis* occur in the reserve, qualifying it as an Important Bird and Biodiversity Area (Ezealor, 2001). *Danielia oliveri*, *Parkia biglobosa*, and *Vitex doniana* are common tree species found in the reserve but Maize *Zea mays*, White Fonio *Digitaria exilis*, and Guinea Corn *Sorghum bicolor* are grown in the surrounding farmlands (Atuo and Manu, 2013). The farmlands are interspersed with trees, shrubs and bushes, thereby providing good nest sites for birds.

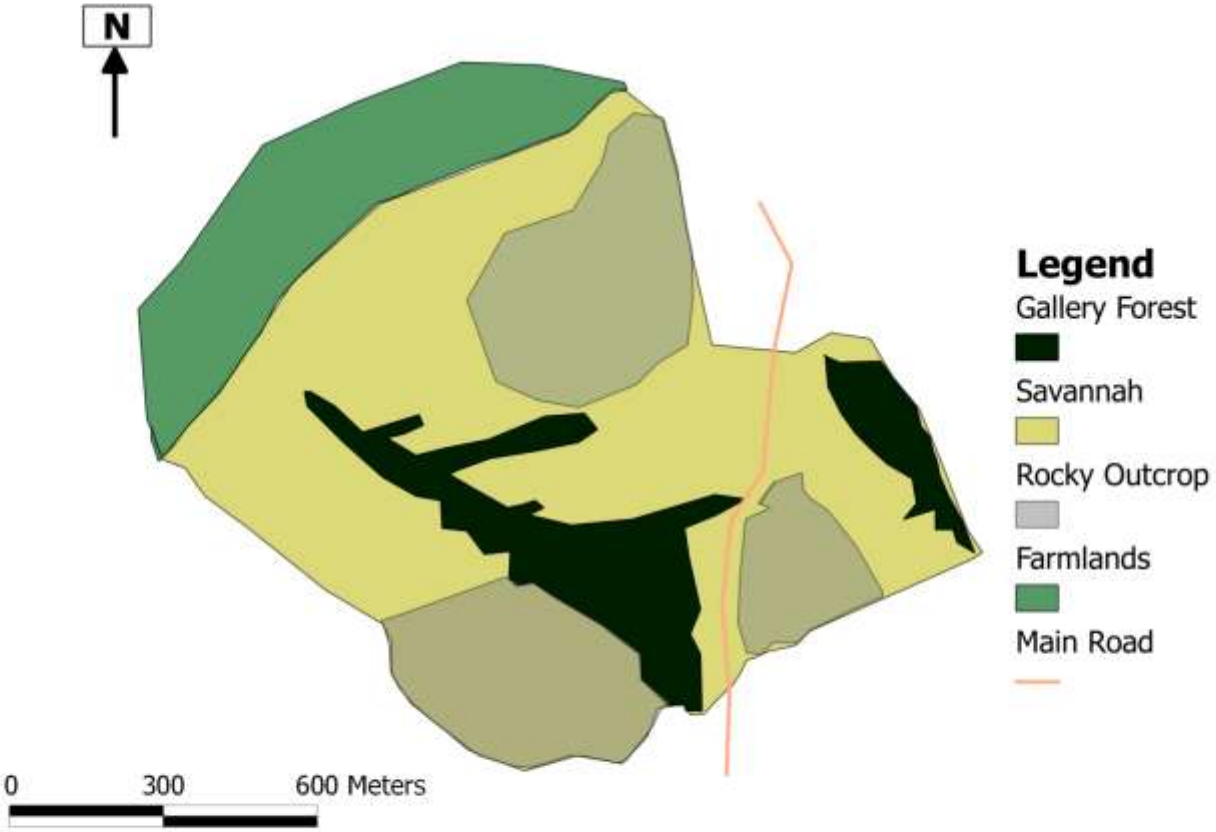

Figure 1: The map of Amurum Forest Reserve and the surrounding farmlands showing the four habitat types.

Nest construction and egg modelling

We mimicked the open cup nests and stained white-cream eggs of the Common Bulbul *Pycnonotus barbatus* and Yellow-throated Longclaw *Macronyx croceus* breeding in shrubs and low grasses, respectively in the area during the experimental period (Nwaogu *et al.* 2019). The nests were constructed using dried grasses and tendrils; woven and twisted into open cup nests, similar to those of our focal birds (mean height = 2.5 ± 0.2 cm; mean wall thickness = 0.75 ± 0.1 cm; mean length = 12 ± 1.1 cm; mean width = 13 ± 1.1 cm). A combination of Common Quail *Coturnix coturnix* eggs (mean mass = 10.1 ± 0.8 g; mean length = 3.21 ± 0.3 cm; mean width = 2.41 ± 0.2 cm) and model eggs (mean mass = 9.6 ± 0.5 g; mean length = 3.40 ± 0.2 cm; mean width = 2.21 ± 0.3 cm) was used to simulate natural eggs following Sedláček *et al.* (2014). The model eggs were constructed from modelling clay, which could be penetrated by any potential predators, given that the shell of quail eggs was thicker than those of our focal birds. The impression (mark) left on the model eggs was then used to determine predation events while camera traps were used to identify predators. All error measures presented here are Standard Deviation.

Nest placement

Two hundred and forty nests were used for this experiment. Of this total, 160 nests were visited every third day, between 0700 and 1200 hrs (termed Visited Nests) to record Daily Survival Rate (DSR), which is commonly used to estimate the rate of nest predation (Miller and Hobbs, 2000). The remaining 80 nests were only visited at the end of the experiment to determine if investigators' visits to nest sites influenced the probability of predation (termed Unvisited Nests). For Visited Nests, 40 artificial nests were randomly placed in each of the four habitat types (gallery forest, savannah, rocky outcrops, and farmlands). Twenty of these nests were placed on low grasses (termed Ground Nests) and the remaining twenty in shrubs (termed Elevated Nests). The Unvisited Nests were also randomly placed in each of the four habitats (i.e. 20 nests per habitat, with ten on ground vegetation and ten in shrubs). Each nest in the study area contained four eggs (2 quail and 2 model eggs) following Sedláček *et al.* (2014). All elevated nests were placed in the fork of branches on trees or shrubs at 2 ± 0.3 m above ground level.

A minimum distance of 30m was maintained between each nest to guarantee independence. This distance was chosen after considering the density of natural nests of the focal species. Gloves were used while handling eggs and nests to reduce the effects of human scent on them. All nest sites were marked with the Geographic Positioning System to determine their location during subsequent visits. The artificial nests were recorded as predated if any of the eggs had scratches or cracks, were broken or missing. The experiment lasted for 19 days, reflecting the average laying and incubation periods of our focal species (Elgood *et al.* 1994).

Camera trapping and vegetation measurement

Four camera traps (Wildview Xtreme2) were used to systematically monitor 60 nests, with each habitat receiving a camera trap. We used cryptic straps to secure the cameras to trees at 1 m above the ground level and ensured that they point at nests from the south, to minimize the effects of sun rays on the images captured (Bengsen *et al.* 2011). A minimum distance of 10 m was maintained between each camera trap and focal nests. During visits to the nest sites, the memory cards of the camera traps were retrieved, data downloaded to a computer and the memory cards replaced. This process took 5 minutes.

For vegetation assessment, we placed a 10 x 10 m quadrat around each nest to quantify indices of concealment, including the average tree height, shrub and tree abundance, and percentage grass and canopy covers (Chaskda and Mwansat, 2014). This was done on the first day of nest exposure, before visitation started.

Data analyses

The DSR, which not only considers nest predation but how long a particular nest survived before being predated, was estimated for all exposed nests (Mayfield 1961; Miller and Hobbs, 2000): $dsr = 1 - [\frac{d}{exposure}]$

Where d = day of predation event; exposure = total number of days a nest was expected to survive. All nests were expected to survive until the end of the experiment, so all nests had the same exposure value of 19 days. For Unvisited Nests, predation rate was classified as either zero (survived nests) and one (predated nests).

We then fitted a Binomial Logistic Regression in R statistical package (R Development Core Team, 2013), to test the effects of habitat type, nest position, average tree height, shrub abundance, tree abundance, percentage grass cover and percentage canopy cover on DSR. Further, the predation probability of Visited and Unvisited Nests was tested using the Binomial Logistics Regression. The possible interaction terms were included in all models. Using the stepwise backward elimination method (Crawley, 2013), variables with the highest p values were removed and the procedure repeated until the best model was attained. All the subsequent models were compared using the Akaike's Information Criteron (AIC) (Burnham and Anderson, 2002) and the best model was selected as the one with the least AIC value. Statistical significance was considered at p value < 0.05.

RESULTS

A total of 166 (69%) of all exposed nests (n = 240) was predated. Of the 60 nests monitored with camera traps during the experimental period, 50 were predated (Table 1; Figures. 2 - 4). The predators of five nests were not filmed by the cameras, though we found peck impressions on model eggs, which suggested avian nest predators.

Table 1: Frequency of nest predators captured by camera traps across the habitat types

Predator/habitat	Gallery forest	Savannah	Rocky outcrop	Farmlands
African Giant Pouched Rat *Cricetomys gambianus*	2	6	8	5
Tantalus Monkey *Chlorocebus tantalus*	11	5	2	0
Black Rat *Rattus rattus*	0	2	1	3
Unknown	0	0	1	4

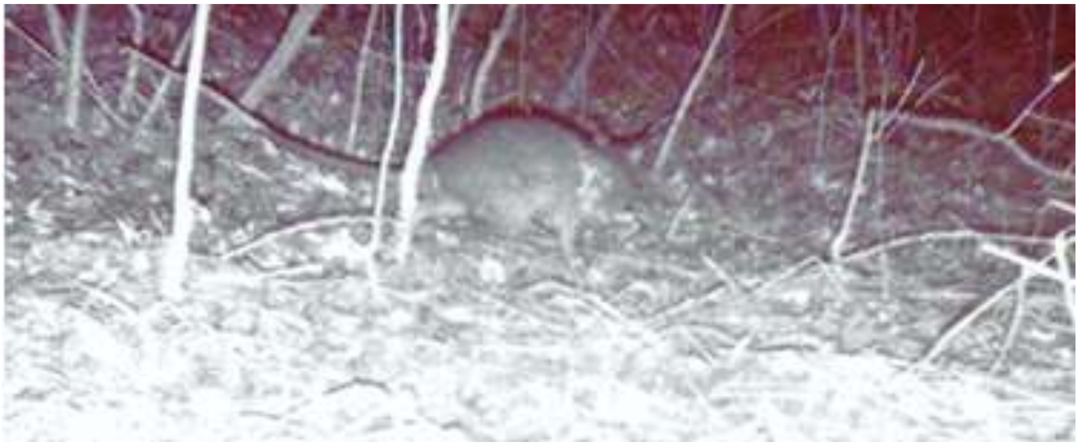

Figure 2: African Giant Pouched Rat filmed predating an artificial Ground Nest during the experiment.

Figure 3: Tantalus Monkey filmed predating an artificial Elevated Nest during the experiment

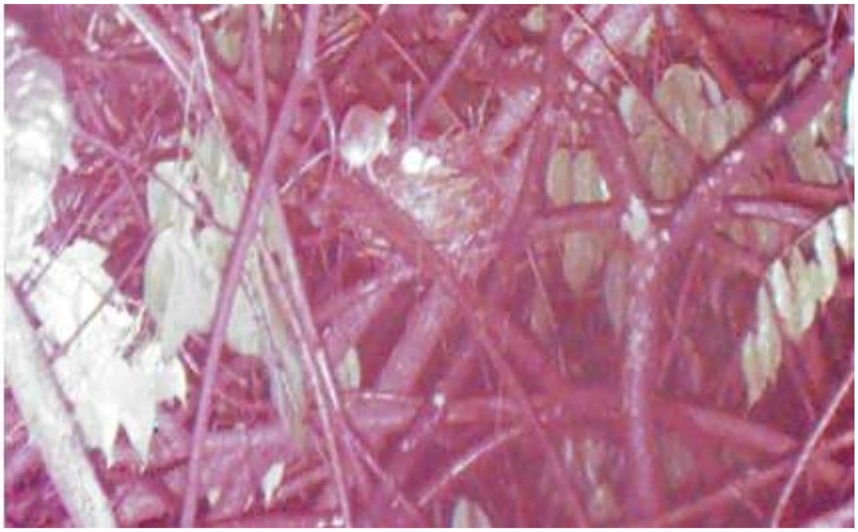

Figure 4: Black Rat filmed predating an artificial elevated nest during the experiment.

Result of the interaction between habitat type and nest position shows that DSR was significantly higher for elevated than ground nests in both rocky outcrop and savannah (Table 2; Fig. 5).

Table 2: Daily Survival Rate and the interaction between habitats and nest position.

Variables	Estimate	Std. error	z-value	*P*
Intercept	-0.619	0.469	-1.32	0.187
Gallery forest	1.238	0.663	1.867	0.062
Rocky outcrop	1.282	0.665	1.928	0.054
Savannah	1.194	0.661	1.807	0.071
Ground	0.779	0.649	1.201	0.23
Gallery forest x Ground nest	-1.117	0.919	-1.215	0.225
Rocky outcrop x Ground nest	-3.483	1.065	-3.269	**< 0.001**
Savannah x Ground	-3.256	1.039	-3.133	**0.002**

Akaike Information Criterion = 202.78; Significant p values are indicated in bold. Farmland and Elevated nest are set as the intercept in the model.

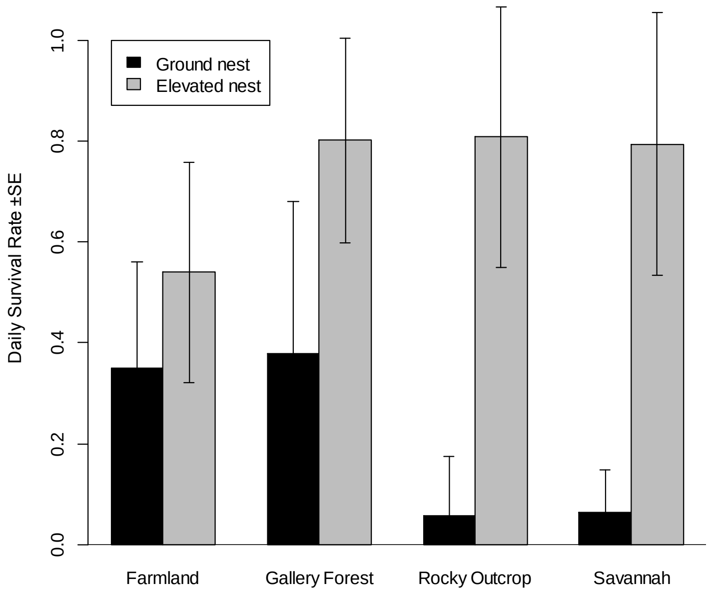

Figure 5: Daily Survival Rate and the interaction between habitat types and nest position.

None of the nest concealment parameters significantly influenced DSR for both Elevated and Ground Nests and were not retained in the final model, but the probability of nest predation was higher for Unvisited than Visited Nests (Table 3; Fig. 6).

Table 3: Probability of predation between Visited and Unvisited nests.

Variables	**Estimate**	**Std. error**	**z-value**	***P***
Intercept	2.197	0.3726	5.896	< **0.001**
Visited nest	-1.38	0.4102	-3.363	< **0.001**

Significant p values are indicated in bold.
Unvisited nest is set as the intercept in the model.

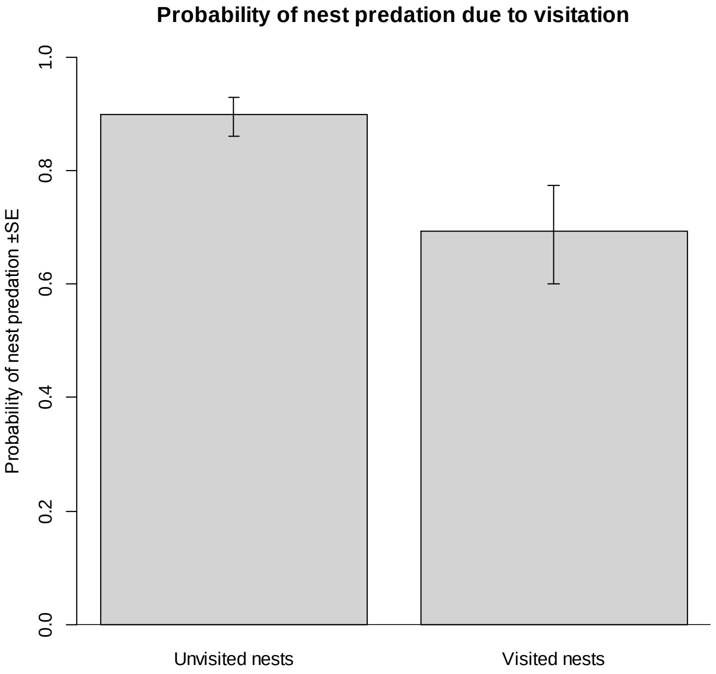

Figure 6: Probability of predation between Visited and Unvisited Nests.

DISCUSSION

We found various marks on the model eggs, suggesting avian, mammalian and reptilian predators, similar to the findings of Söderström *et al.* (1998). Since camera traps did not film these events, we could not identify the nest predators and so did not include them in our results. One advantage of using model eggs is that it could be penetrated by all potential predators and predation events determined. Camera traps recorded time of predation events and indicated that the African Giant Pouched Rat *Cricetomys gambianus* and Black Rat *Rattus rattus* predated mainly at night while the Tantalus Monkey *Chlorocebus tantalus* predated nests in early mornings, indicating that birds in our study area might have anti-predation strategies for different kinds of nest predators. The use of camera traps proved more effective and reliable in our study than model eggs as predators could be identified to species level.

For visited nests, DSR was significantly higher in elevated than ground nests in the rocky outcrop and savannah. This trend might have resulted from the open nature of these habitats, which predisposes the nests to higher predation from arboreal nest predators such as birds and snakes that are less likely to be affected by near-ground vegetation cover (Söderström *et al.* 1998). Although we did not find significant effects of any vegetation parameters in this study, grass cover may provide an effective camouflage for ground nests (Martin and Joron, 2003), consequently enhancing the breeding output of ground-nesting birds. While we ensured that our artificial nests mimicked the natural nests of the focal birds, we could not manipulate the effects of incubating and provisioning parents defending their nests, as well as their odour. Hence our results may be biased against those predators that use visual and olfactory cues to locate and depredate nests (Eggers *et al.* 2005), and should be interpreted with caution, as they may not present perfect surrogates for natural predation rate (Berry and Lill, 2003).

Further, researchers quantifying breeding success of birds could influence nest predator communities by causing "scary effects" (Ibáñez-Álamo *et al.* 2012), which was confirmed during our study. We found that the predation probability (whether a nest will be predated or not) was higher for Unvisited than Visited nests. This suggests that the nest predators in our study area avoid areas that could expose them to predation by higher predators, which has been previously reported (Francis *et al.* 2012).

CONCLUSION

This study highlights the efficiency of potential predators of real avian nests in the study area. In addition to the capability of depredating nests irrespective of the time of day, nest predators in the study area also avoid areas that are frequently visited by humans; an anti-predation strategy and indication of anthropogenic impacts. The anti-predation strategy of breeding birds in the area is also demonstrated in their choice of habitat and nest position. Our findings have provided useful information in understanding some aspects of natural nest predation and the impacts of researchers on animals, which can serve as an effective tool for promoting bird conservation.

Acknowledgments

The A.P. Leventis Ornithological Research Institute (APLORI) granted the lead author a scholarship for an MSc in Conservation Biology (2014 - 2015), during which the research that led to this paper was conducted: we are grateful! The authors also thank Shiiwua Manu, Sam Ivande, Mark Wilson and Juan Diego Ibanez-Alamo for their assistance with data analyses as well as comments on an earlier draft of this manuscript. Taiwo C. Omotoriogun demonstrated the use of camera traps while Jonathan Azi and Abraham Yeboah assisted with fieldwork. This is contribution number 156 from APLORI.

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