Nest predation in logged and unlogged sites
in Kirindy Forest, Madagascar

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Abstract

Forest exploitation has been shown to increase bird nest predation rates mainly in temperate climates, but there is no such a clear support for this hypothesis in tropical forests. In this study we examined nest predation in logged and unlogged sites in the dry deciduous forest of Kirindy (Madagascar) at the end of dry season. An important effect on nest survival was found for the forest type and nest type. Nests in the canopy suffered from different proportions of predation and type of predator than ground nests. Both canopy and ground nests were preyed upon more often in logged forest, but the effect was more significant for terrestrial nests. The overall percentage of predation was almost 50% higher in the site with logging history. The most abundant predators in both types of forest were birds, rodents and a Narrow-striped Mongoose (*Mungotictis decemlineata*). The most significant effect for bird predation was found in ground nests, for rodent predation in canopy nests. We provide hypotheses about possible changes in predator composition and abundance linked to nest survival caused by human disturbance in unique dry seasonal forest habitat in Madagascar.

INTRODUCTION

Deforestation is one of the biggest threats for global biodiversity (Primack, 2004). The most endangered forest types are found in the tropical regions (Turner, 1996; Whitmore & Sayer, 1992). Negative effects on the ecosystem have also strong influence on organisms and relationships among them (Hilton-Taylor, 2000). A rapid decrease in forest coverage and diversity can be seen most easily in biodiversity hotspot areas (Myers *et al*., 2000). Madagascar is one of the most exceptional hotspots with very high variability of ecosystems and organisms and extreme level of endemism (Ganzhorn *et al.*, 2001).

Most research on the effects of forest management on biodiversity in Madagascar has focused on the eastern rainforests (Raxworthy & Nussbaum, 1994; Vallan, 2003; Watson *et al.*, 2004). However, dry deciduous, spiny or littoral forests also represent unique ecosystems with high diversity and level of endemism. One of the most ignored habitats in past was a dry deciduous forest in the western part of the island (WWF, 2001). Most efforts in conservation were done for tropical rainforest, leaving just a little attention to dry deciduous forests (Lerdau *et al.*, 1991). Globally it belongs to the most threatened biomes in the world and the area in Madagascar was reduced to 3 % of its original coverage (Smith, 1997). Logging is one of the biggest threats for the last forests in western Madagascar (Putz *et al.*, 2000).

Birds were commonly used as an indicating taxon for assessing the impact of logging in tropical forest habitats (Barlow *et al.*, 2006; Felton *et al.*, 2008). The species richness and diversity comparison between disturbed and undisturbed habitats is not the only way how to study the bird communities. Many studies have focused on the nest predation, especially linked to the edge effect (Gates & Gysel, 1978; Paton, 1994; Lahti, 2001). In this study artificial nests were used to examine the nest predation linked directly to the type of forest. The loss of nest protection from predators especially for terrestrial bird species was suggested to be linked with the logging effect (Cody, 1985; Hirons & Johnson, 1987). This can directly lead to the increased predation on nests (Blake & Karr, 1984).

Using artificial eggs is a good method to compare the relative predation rates between different habitats (Roper, 1992). Our aim was to examine nest predation in logged and unlogged sites in Kirindy forest, which is one of the last big remaining areas of dry deciduous forest in Madagascar. Hawkins & Wilme (1996) detected that the densities of potential nest predators differ significantly between logged and unlogged forest in this area. The other objective was to determine the most common type of predators and examine whether terrestrial and arboreal nests are different in vulnerability.

METHODS

Study site

We studied nest predation in logged and unlogged sections of Kirindy Forest in the Menabe region of western Madagascar from November 30 to December 6, 2013. The ending of almost 9 months long dry season was chosen, because for most of the bird species in dry deciduous forest it is a start of the breeding season. Kirindy Forest includes about 10,000 ha of deciduous dry forest managed by the Centre National de Formation, d'Etudes et de Recherche en Environnement et Foresterie (CNFEREF), Morondava. Both logged and unlogged sites covered about 1.5 ha.

Artificial nests

The nests used in this study were produced from old, abandoned nests collected from the Sakalava Weaver (*Ploceus sakalava*). Thirty nests were put on the ground, 30 in the canopy between 78 to 179 cm high. Artificial eggs were produced with modelling clay (approximately 3 cm long) and there were two of them in each nest. Ten ml of raw mixed chicken egg was added to include 'smell effect' of our nests. Damaged or missing nest and eggs were replaced daily. A thin layer of sand was sifted around the ground nests to enable us to see the footprints of predators. In addition to footprints and nest damage, we recorded bite-marks on the artificial eggs.

Transects

There were 6 transects in both sites (unlogged and logged forest) and each of them comprised 5 nests. Three transects in both sites had 3 ground nests and 2 canopy nests and vice-versa. The distance between transects was 30 metres. Each transect was 80 metres long with 20 metres distance between each nest. Canopy cover and stem density in a 1 m circle around nest were measured, and height of the canopy was estimated for every nest. Twelve nests were put 2 metres from Piste Conoco, the main road connecting the field camp with research grids. Other nests were deeper in the forest up to 82 metres. We assessed predation of each nest each morning between 7:00-9:30 for 7 days. For two nests we used camera traps Bushnell HD (model 119437) during three days of study.

Analyses

We used Generalised Linear Models (GLM) to access the effects of forest type and nest type on nest predation. To avoid temporal pseudoreplication we conducted analyses on the mean probability of nest predation over the study period. Thus we treated each nest as an independent sample. First we examined total predation and then looked at effects of most common predator types. As data were proportions or counts we used poisson or quasipoisson GLM for all analyses. All analyses were conducted in R 2.10.1 with BiodiversityR package.

RESULTS

In total there were 111 predation events in 7 days. The GLM analysis showed that the forest type ($F_{1,56} = 11.33$, $p = 0.0014$) and type of nest ($F_{1,52} = 11.33$, $p = 0.0014$) affected nest predation. The overall percentage of nest predation in both sites was 26.4 %. The average percentage was much higher (34.76 % compared to 18.1 %) in the logged site ($F_{1,58} = 10.7$, $p = 0.0018$). In both sites the ground nests experienced higher predation (Figure 1). The distance to edge ($p = 0.36$), canopy cover ($p = 0.13$) and number of stems ($p = 0.57$) were not related to nest predation. The effect of the forest type was higher in the ground nests, but there was tendency for higher predation also in the canopy nests. In logged forest the average number of predation events for one nest was 1.66 in canopy type and 3.2 in ground type. The unlogged site showed different pattern with 0.86 for canopy nests and 1.66 for ground nests. There was no interaction between forest type and nest type.
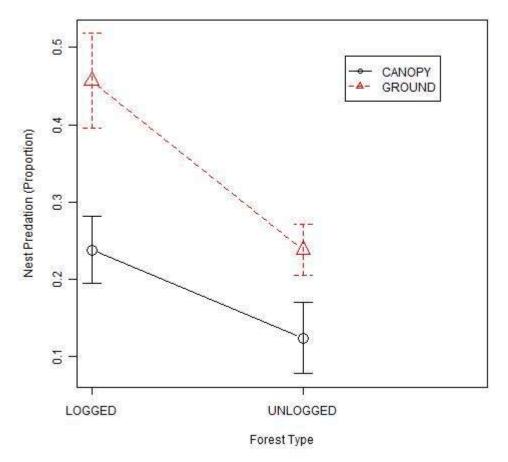
Figure 1. The effect of the forest type connected with percentage of predation on ground and canopy nests and the average percentage of ground and canopy nests in both sites, the error bars represent standard errors.

Interestingly the effect of the forest type and nest type was opposite in two most abundant predators, which were the only ones to attack both types of nests. The higher bird predation was detected in both types of nests in both sites, but the effect of the nest type was significant ($F_{1,56}$ = 13.39, p = 0.0006) with higher predation in ground nests (Figure 2.). Effect of the forest type was also significant ($F_{1,56}$ = 4.64, p = 0.035). In case of rodent predation, the most important effect was found for canopy nests. The predation was significantly higher ($F_{1,56}$ = 7.8, p = 0.007) in the logged forest. The effect of nest type (Figure 3) was also significant ($F_{1,56}$ = 7.8, p = 0.007). Distance to edge ($F_{1,56}$ = 5.08, p = 0.028) and canopy cover ($F_{1,56}$ = 7.6, p = 0.008) were other factors with significant effects on rodent predation. More nests predated by rodents were found with increased distance to edge and increased canopy cover. There was no interaction between forest type and nest type for rodent or bird predation.
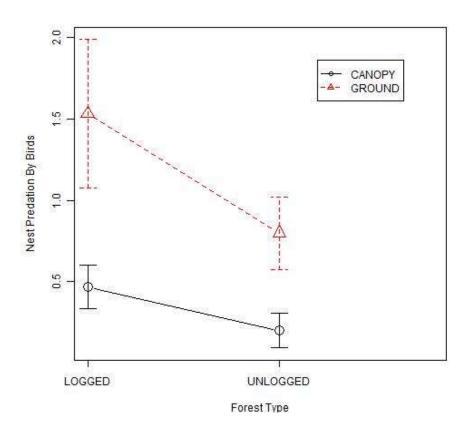
Figure 2. The effect of the forest type and nest type connected with number of nests predated by birds, the error bars represent standard errors.
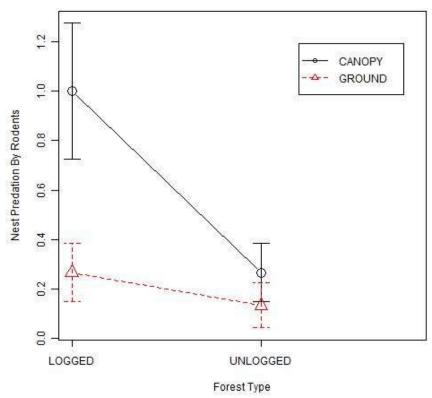

Figure 3. The effect of the forest type and nest type connected with number of nests predated by rodents, the error bars represent standard errors.

The proportion of each predator was analysed for both sites. There were no differences in type of predation. The most abundant predators were birds (41 % in logged and 40 % in unlogged forest). The second highest number of predated nests was by rodents (26 % in logged and 29 % in unlogged). There was another important predator, the Narrow-striped Mongoose (*Mungotictis decemlineata*) with 16 % of nest predation proportion in logged forest and 18 % in unlogged forest. Snakes represent 6 % of predation in logged and 5 % in unlogged site. Only one nest was predated by skinks in each site, but the proportion of predated nests was different (1 % in logged and 3 % in unlogged forest). We were not able to determine the type of predator in 10 % of nests in logged and 5 % of nests in unlogged site (Figure 4).
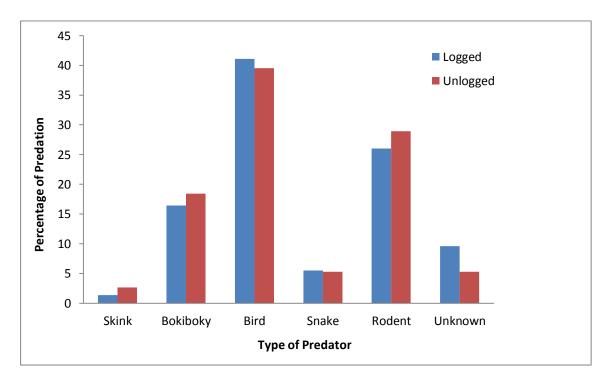

Figure 4. Percentage of each predator in logged and unlogged site.

DISCUSSION

Previous studies have demonstrated that in temperate regions the intact forest habitats were found to have less nest predation than the forest edges and exploited forests (Andrén & Angelstam, 1988). However, the studies from tropical forests do not show such a clear support for this hypothesis (Gibbs, 1991; Carlson & Hartman, 2001). Our study of nest predation was the first in the Kirindy dry deciduous forest and the results are similar to those of studies in temperate climates.

The nests in logged forest experienced almost 50 % higher predation. There is an evidence of higher abundance of introduced predators in the habitats under human disturbance, such as Rat (*Rattus rattus*) in western Madagascar (Ganzhorn, 2003). The proportion of rodent predation on nests in our

study was significantly higher in the site with logging history mainly in canopy nests, so we suggest that increased disturbance of the forest may lead to higher vulnerability of local bird communities to invasive species.

We also found that couas (*Coua gigas*, *Coua coquereli*) are important predators of ground nests at Kirindy. Raherilalao & Goodman (2011) remarked that *C. gigas* can prey on eggs. The analysis of footprints, marks on artificial eggs and video from camera trap in our study indicated that *C. gigas* is an important predator in both types of forest. This is contradictory to findings of Chouteau (2004), which suggest that *C. gigas* is affected by forest degradation with resulting lower population density. However, the Coquerel's Coua (*C. coquereli*) was found to have a bigger population density in the logged parts of the forest in the same study, so we do not exclude the possibility of importance of this predator in the system. A difference between population densities in logged and unlogged forest were found in other possible bird predators, such as Rufous Vanga (*Schetba rufa*) (Langrand, 1990).

The higher proportion of predation on the ground nests in logged forest is comparable to previous studies (Cody, 1985; Hirons & Johnson, 1987). The possible explanation is an increased visibility and more types of predators on the ground floor of the forest. The significance of the forest type was detected also for canopy nests (most important for rodent predation), suggesting that there can be higher densities of predators in the disturbed forests. Another explanation could be the presence of same density, but higher foraging success of predators. The difference in density may be possibly caused by the presence of invasive predators, but additional studies will be needed to prove that.

Many studies focus on changes in forest structure caused by exploitation (Johns, 1986; Guariguata & Ostertag, 2001; Whitehurst *et al.*, 2009). Changes in Kirindy Forest were found to be much lower than in rainforest habitats (Deleporte *et al.*, 1996). We found no significant effect of distance to edge, canopy cover (except in rodents) or stem count on nest predation in our study. Thus, these factors seem to be not so important for describing the differences between logged and unlogged areas in this habitat.

The general diversity of predators was quite similar to what we were expecting before our study. The Narrow-striped Mongoose (*Mungotictis decemlineata*) was found to be an important predator on the ground (footprints, observations of predation on real ground nests), but it is also known to climb and forage for prey in the canopy (Garbutt, 2007). We were not able to study the impact of this predator on canopy nests. The snakes from genus *Leioheterodon* were found to prey on different type of nests on the ground (nests of *Oplurus cuvieri*) and can have a bigger proportion in predation in general in the wet season. The shift from the long dry season came after our study was conducted (just two rainy days in three weeks in the location), so there is a possibility of underestimating the importance and

proportion of some types of predators. This can be applied especially or reptiles (skinks, snakes) and tenrecs. We suggest that even some species of lemurs can pose a threat for bird nest. Especially the nocturnal *Mirza coquereli* is known to prey on small vertebrates (Garbutt, 2007). A study covering a larger area of both types of forest and longer time scale including both dry and wet season will be needed for better understanding of the relationships between nest survival and predators in Kirindy Forest. The application of camera traps can help to understand the variability and proportion of different nest predators and threat represented by invasive species, such as *Rattus rattus*.

To conclude, we found a significant effect of the type of forest history on nest predation in Kirindy Forest. The results show that forest logging has important implications for species composition and abundance, which was studied in bird nest predation here. This can be used as a background for future studies focused on nest predation not only in dry deciduous, but also other types of tropical forests.

ACKNOWLEDGEMENTS

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