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# Comparison of Nest Predation in Two Riparian Habitats

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## ABSTRACT

Clearing of riparian habitat in Monteverde, Costa Rica is prohibited up to 50 meters from the bank of the waterway. Unfortunately, this regulation is often disregarded, and forests bordering streams are cleared for a variety of purposes. Deforestation creates edge effects where there once was continuous forest, and it has been shown that rates of avian nest predation are higher on forest edges. In this study, I examined the proportions of eggs removed or damaged from artificial nests in four riparian habitats. Two of the chosen sites were forested, and two had been cleared for human use. The artificial nests contained two quail eggs and four clay eggs. The study lasted nine nest nights, and after the morning of each I returned to the site to census the nests and collect any bitten clay eggs for predator identification. I found no significant differences among predator types in the four sites. Contrary to my expectations, though, I found that the site with the greatest proportion of eggs removed or damaged was a forested site. The second forested site and one of the deforested sites were comparable in terms of nest predation proportions. The results of my study did not support my predictions that, in deforested sites, both nest predation and the incidence of bites by predators that thrive in human-modified habitats – coatis and opossums among them – would be significantly higher. Nonetheless, both the use of artificial nests and predators' search behavior modification in response to high frequency of occupied nests may have affected the results of this study. Future studies should concentrate on these two factors before reaching any conclusions on the impact of riparian deforestation on avian nest predation.

## INTRODUCTION

Riparian habitats in Costa Rica are formally protected under the Ley Forestal up to 50 meters if in steep terrain (Ley Forestal 7575, Artículo 33). However, these regulations are frequently flouted, with the result that it is fairly simple to find degraded riparian habitat.

In rural parts of Monteverde, where terrain is steep and therefore the banks of streams should be protected up to 50 meters, riparian habitats are often cleared for agriculture or to provide pastureland. This clearing necessarily modifies the habitat, disrupting delicate ecological interactions; previous studies have found higher rates of avian nest predation along the habitat edges that are created when forest is cleared (Batary 2004).

The effect of clearing riparian habitats on nest predation is interesting to examine because it gives insight into the species composition of these areas. Moreover, as a primary cause of nesting mortality for numerous bird species, nest predation can act as a lens into the overall health of an avian population; if rates of predation are too high, certain bird populations could become severely threatened (Martin 1987).

In this study, I sought to evaluate the efficacy of riparian protection regulations by comparing proportions of disturbed nests in forested versus deforested habitats, as well as

the incidence of bites by different species of predators. Through these experiments, I hoped to make inferences about the health and species composition of both forested and deforested riparian habitats. I expected to find higher rates of nest predation in the deforested sites, and lesser incidence of bites made by species like squirrels and mice that prefer habitats with high tree density.

## METHODS AND MATERIALS

### Study Sites

I included four riparian sites in my study, two of which were forested, and two of which were deforested. The first of the deforested sites had been cleared for pastureland. The banks of the stream had tall grasses growing on them, which were periodically cut down to prevent them spreading into the pasture. The first of the forested sites was located along the same waterway, but on the opposite side of a roadway, where the land had not been cleared. The second of the deforested sites occupied a cleared hillside bordering one side of a stream. The second forested site was located along the same waterway, and was directly adjacent to the second deforested site.

### Comparison of Nest Predation Rates

I built nine nests for each site, with each nest consisting of four artificial clay eggs colored and shaped like quail eggs, and two actual quail eggs. Quail eggs have been used in similar experiments assessing nest predation in the Neotropics because they are both small and commercially available in large quantities (DeGraaf and Maier 1996). I distributed these nests along the ground of the four sites, at various

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**Figure 1.** Study sites. Clockwise from top left: Forested 1, Deforested 1, Forested 2, Deforested 1

elevations and proximity to the waterway. I returned the morning following setting up the nests to census the number of eggs – both quail and artificial – removed from the site, as well as the number of artificial eggs displaying bite marks, sign of a predator having bitten the artificial egg and rejected it upon realizing it was inedible. I repeated this

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**Figure 2.** Artificial nest containing both clay and quail eggs

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methodology for nine “nest nights,” or cycles of placement and census of nests.

To compare proportion of eggs removed or damaged from the sites, I established the average proportions across three categories: quail eggs removed, clay eggs removed or damaged, and total eggs removed or damaged. I then used a Wilcoxon Rank Sum test to compare these three categories of proportions in each of the four sites.

Each morning that I returned to the study sites to census the nests, I also collected any artificial eggs displaying bite marks. I later identified the predator that had made each bite, grouping the data for Forested Sites 1 & 2 and Deforested Sites 1 & 2. I evaluated the relationship between bite incidence and site using a Chi-Squared test.

### **Additional Observations**

After taking a census of the nests from the fourth nest night, I began to suspect that some predators, particularly in Forested Site 2, had modified their behavior in response to high density of nests. In several nests where clay eggs had been bitten for the first two nights, now the quail eggs were removed but the clay eggs were completely untouched. To avoid a bias in the proportions of eggs removed or damaged, I began to place disturbed nests in new sites starting on the fifth night. I took this change into account by calculating proportions in each of the three categories for the first four nights and then the final five nights. I then compared these proportions for each of the sites using an F-test.

## **RESULTS**

Both the average proportion of quail eggs removed and the composite proportion of eggs removed/damaged in Forested Site 2 were significantly higher than those of the three other sites. The proportion of clay eggs removed/damaged in Forested Site 2, however, did not differ significantly with that of Deforested Site 1. In all three categories, the differences in the proportions of eggs removed/damaged from Deforested Site 2 and Forested Site 1 were statistically negligible. The proportion of eggs removed/damaged in Deforested Site 1 was consistently higher than that of Deforested Site 2; the same was true of Forested Site 2 in comparison to Forested Site 1 (Table 1).

### **Comparison of Incidence of Bites**

A Chi-Square test yielded no statistically significant differences in observed versus expected incidence of bites for each predator species in forested and deforested sites (Figure 3).

### **Additional Observations**

I used an F-test to look for variance in the proportions of eggs removed or damaged from the four sites during nights one through four and that of nights five through nine. I found no significant variance in the average proportion of quail eggs removed, artificial eggs removed/damaged, or total eggs removed/damaged among any of the sites ( $df = 1$ , critical F-value = 647.8).

## DISCUSSION

The fact that the highest proportion of quail eggs removed and composite damage occurred in a forested site contradicts my predictions for this study. I expected to find the greatest proportion of eggs removed or damaged in the deforested sites, based on previous research on the impacts of edge effects and habitat fragmentation on avian nest predation (Batary 2004). However, Forested Site 2 was adjacent to a cleared site, Deforested Site 2; previous studies have found that nest predation may also be affected in forested areas by type of land use on bordering fragments (in the case of this study, the cleared riparian site) (Small and Hunter 1988).

In considering what factors may have contributed to my results differing from my expectations, it is important to take into account both the limitations of artificial nest usage in examining nest predation and to consider the possibility that predator search behavior adapted to my study sites. The artificial nests were less camouflaged than real nests, and so they may have been more attractive to visual predators (Martin 1987). In addition, predators may become visually accustomed to a certain species' nests, developing a "search image" and increasing the overall efficiency with which they forage. Since my nests were all identical in composition and very similar in appearance, I may inadvertently have created a situation in which predators were able to learn quickly precisely what sorts of nests to look for (Martin 1988). This effect may have contributed to the pattern of egg removal in Forested Site 2.

Predator search behavior is both density- and reward frequency-dependent. Predators may modify their behavior, increasing their foraging intensity, if the frequency of nests containing eggs is high; this finding is supported by data from experiments using both real and artificial nests (Martin 1988). All my nests were occupied, and their density was relatively high. This could have intensified searching behavior in predators, because it facilitated a high reward rate. Unnaturally high predation rate, therefore, may have biased the results of this study (Martin 1988).

This study's scope was not species-specific; nest predation rates were generalized, and the effects of riparian deforestation on particular avian species were not examined. This would be a good next step in comparing the health of the study sites. There is concern that conversion of forest to pastureland reduces the availability of nesting habitat for birds that prefer the forest interior for nesting, threatening certain avian species (Lindell 2003). This threat would not necessarily be shown in a study that looks at overall nest predation without distinguishing between the nests of particular species.

Although quail eggs and clay or plasticene eggs are commonly used in nest predation experiments, differences in predation rates between real and artificial nests do exist. Of particular concern to this study is that a previous study found that the quail eggs in nests with plasticene eggs marked by mice were in fact, upon video recording, found to have been removed by raccoons (Thomas and Burhans 2004). This finding opens the door to the possibility that the numerous mice markings were not necessarily indicative of predation by mice species. Only one species of raccoon is found in the Monteverde area, and since no raccoon bites were recorded throughout the study, it is unlikely that raccoons were the predators of these mice-marked nests. However, the findings of Thomas and Burhans might suggest that, in this study, the mice bites were misleading because the actual predation of quail eggs was carried out by other mammals, such as coatis or squirrels.

The incidence of mouse bites in forested sites was not statistically greater than that in deforested sites, but, outside of statistical analysis, the incidence of bites in forested sites was relatively high. Regardless of whether or not it was the mice who actually removed the quail eggs, the relatively high incidence of mouse bites in the forested sites may speak to an overall greater abundance of mice in those habitats. Of the four species of pocket mice found in Costa Rica, all but one prefer well-forested habitats; only *Liomys salvini* is found in brush or weedy fields (Reid 2009).

The expected incidence of opossum bites was about half that of the observed incidence in deforested sites. *Didelphis marsupialis*, which is abundant in Costa Rica, favors disturbed areas and rural garbage dumps, two indicators of human presence. Moreover, the *D. marsupialis* is frequently found by stream banks (Reid 2009). These three factors could explain the unexpectedly high incidence of opossum bites in the deforested sites.

Five species of squirrel are found in Costa Rica, but one is endemic to the Guanacaste Mountains. These four species are diurnal and spend most of their time in trees, descending to the ground mainly for feeding. Because they need trees, they may be more readily seen in forested areas, and two of the species found in Monteverde – the Montane Squirrel and Red-tailed Squirrel – are especially associated with secondary growth, which could explain the (albeit not statistically significant) greater incidence of squirrel bites in the forested sites in this study (Reid *et al.* 2010).

The results of this study, while not supporting my hypothesis that nest predation would be higher in deforested sites, instead suggest a new possibility altogether: that riparian sites, be they forested or cleared, function as forest fragments. Riparian sites, if they exist in areas modified by humans for agricultural purposes, are not likely to represent healthy forests, even if they remain forested, simply because the surrounding areas are cleared. For this reason, it may be best to consider the potential of these riparian sites to function as corridors, linking larger, healthy forests that are not interrupted by agriculture. Forested riparian habitats in otherwise deforested areas could have great value as refuges for meso-predators, which in turn serve as prey for larger mammals at higher trophic levels. In this manner, riparian habitats could have tremendous conservation value, and should be protected accordingly.

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**Table 1. Pairwise comparisons of the eggs from deforested sites (D1 and D2) with forested sites (F1 and F2). Critical q-value = 2.78;  $p < 0.05$ . Composite proportion combines proportions of quail eggs removed and clay eggs removed/damaged.**

**(a) Proportion of Quails Eggs Removed**

<b>Comparison</b>	<b>Rank Difference</b>	<b>Standard Error</b>	<b>q-value</b>
D1 vs. D2	99.5	31.6	3.15
D1 vs. F1	60	31.6	1.90
D1 vs. F2	107.5	31.6	3.40
D2 vs. F1	39.5	31.6	1.25
D2 vs. F2	207	31.6	6.55
F1 vs. F2	167.5	31.6	5.30

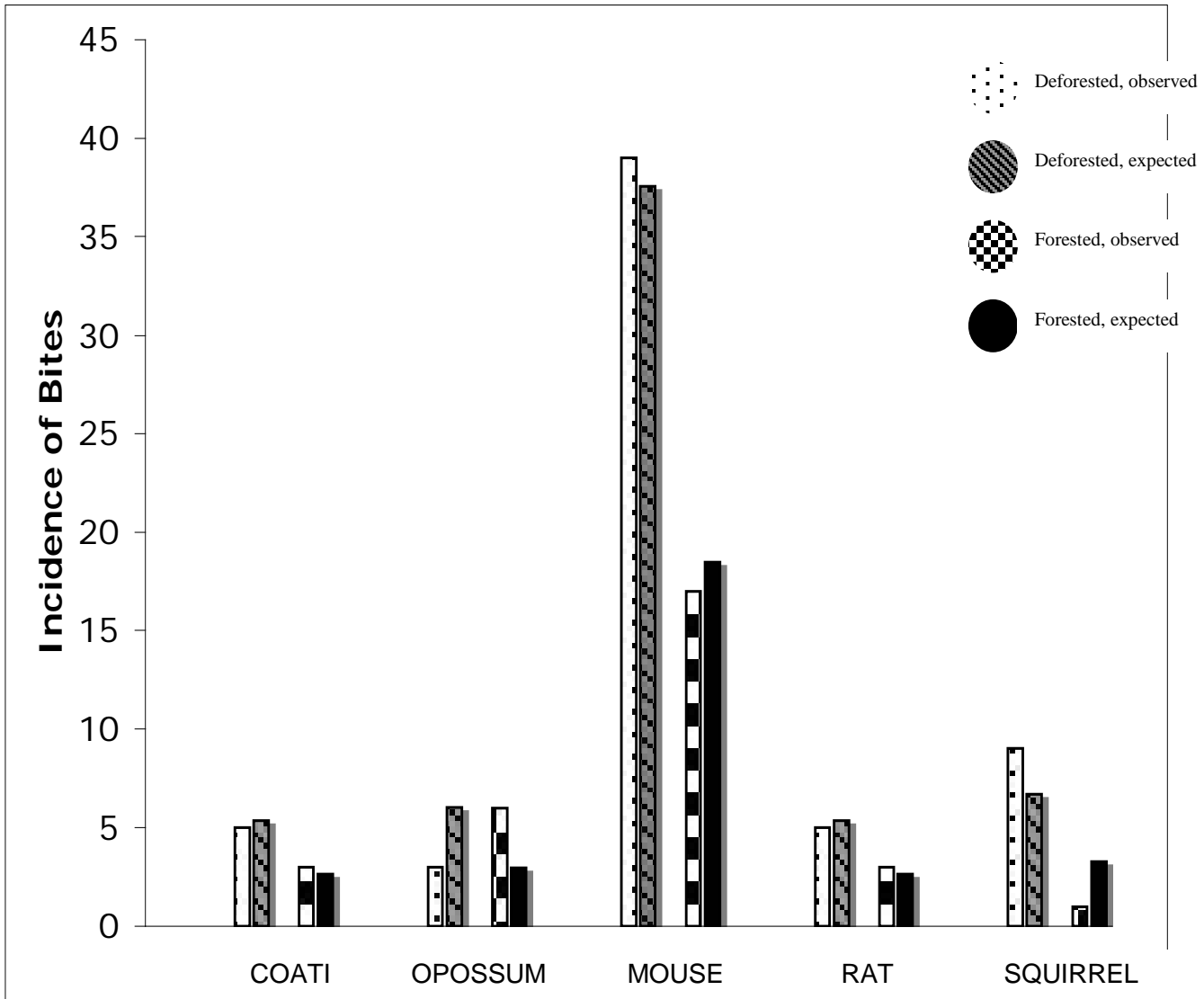
**(b) Proportion of Clay Eggs Removed/Damaged**

<b>Comparison</b>	<b>Rank Difference</b>	<b>Standard Error</b>	<b>q-value</b>
D1 vs. D2	136	31.6	4.30
D1 vs. F1	69.5	31.6	2.20
D1 vs. F2	49.5	31.6	1.57
D2 vs. F1	66.5	31.6	2.10
D2 vs. F2	185.5	31.6	5.87
F1 vs. F2	119	31.6	3.77

**(c) Composite Proportion of Eggs Removed/Damaged**

<b>Comparison</b>	<b>Rank Difference</b>	<b>Standard Error</b>	<b>q-value</b>
D1 vs. D2	116	31.6	3.67
D1 vs. F1	67	31.6	2.12
D1 vs. F2	89	31.6	2.82
D2 vs. F1	49	31.6	1.55
D2 vs. F2	205	31.6	6.49
F1 vs. F2	156	31.6	4.94





**Figure 3. Incidence of bites.** Chi-squared value = 7.33; df = 4; critical  $\chi^2 = 9.49$ .

